

ISSN 1512-5173 (štampano izdanje)
ISSN 2637-1510 (online izdanje)

ČASOPIS ZA MAŠINSKO INŽINJERSTVO
JOURNAL OF MECHANICAL ENGINEERING

MAŠINSTVO

GODINA / VOLUME / 18

| BROJ / NUMBER / 3 - 4

| JULI - DECEMBAR / JULY - DECEMBER / 2021.



<http://www.mf.unze.ba/masinstvo>

MAŠINSTVO

ČASOPIS ZA MAŠINSKO INŽENJERSTVO
JOURNAL OF MECHANICAL ENGINEERING

GODINA (VOLUME) 18, BROJ (NUMBER) 3-4, ZENICA, JULI - DECEMBER /JULY - DECEMBER/ 2021.

Osnivač i izvršni izdavač (Founder and Executive Publisher):

Mašinski fakultet Univerziteta u Zenici / Faculty of Mechanical Engineering of University of Zenica
Fakultetska 1, 72000 Zenica
Bosna i Hercegovina / Bosnia and Herzegovina

Tel.: + 387 32 449 134; 32 449 128

Fax: + 387 32 246 612

E-adrese: hfuad@mf.unze.ba
emir.djulic@mf.unze.ba

Glavni i odgovorni urednik (Editor-in-Chief):

dr. sc. Fuad Hadžikadunić

Urednički odbor (Editorial Board):

dr. sc. Malik Čabaravdić (B&H), dr. sc. Sabahudin Jašarević (B&H), dr. sc. Safet Brdarević (B&H), dr. sc. Jože Duhovnik (Slovenija/Slovenia), dr. sc. Milan Rackov (Srbija/Serbia), dr. sc. Milan Jurković (Hrvatska/Croatia), dr. sc. Sabahudin Ekinović (B&H), dr. sc. Nedeljko Vukojević (B&H), dr. sc. Darko Petković (B&H), dr. sc. Ibrahim Plančić (B&H), dr. sc. Adrian Tulbure (Rumunija/Romania), dr. sc. Manuella Kadar (Rumunija/Romania), dr. sc. Alojz Ivanković (Irsko/Ireland), dr. sc. Joan Vivancos (Španija/Spain), dr. sc. Ivo Čala (Hrvatska/Croatia), dr. sc. Slavko Arsovski (Srbija/Serbia), dr. sc. Albert Weckenmann (Njemačka/Germany), dr. sc. Marinko Aleksić (Crna Gora/Montenegro), dr. sc. Rainer Lotzien (Njemačka/Germany).

Časopis je evidentiran u evidenciji javnih glasila pri Ministarstvu nauke, obrazovanja, kulture i sporta Federacije Bosne i Hercegovine pod brojem 651.

Časopis u pretežnom iznosu finansira osnivač i izdavač. Časopis MAŠINSTVO u pravilu izlazi u četiri broja godišnje. Rukopisi se ne vraćaju.

Časopis objavljuje naučne i stručne radove i informacije od interesa za stručnu i privrednu javnost iz oblasti mašinstva i srodnih grana vezanih za područje primjene i izučavanja mašinstva.

Posebno se obrađuju sljedeće tematike:

- > mehatronika, automatizacija i robotika,
- > tehnologija prerade metala, plastike i gume,
- > projektovanje i konstruisanje mašina i postrojenja,
- > projektovanje proizvodnih sistema,
- > energija i ekologija,
- > održavanje sredstava za rad i sistema,
- > kvalitet, efikasnost sistema i upravljanje proizvodnim i poslovnim sistemima,
- > informacije o novim knjigama,
- > informacije o naučnim skupovima,
- > informacije s Univerziteta.

Recenzentski odbor (Review Committee):

dr. sc. Malik Čabaravdić, dr. sc. Ibrahim Plančić, dr. sc. Nedeljko Vukojević, dr. sc. Amra Talić-Čikmiš, dr. sc. Safet Isić, dr. sc. Ernad Bešlagić, dr. sc. Fuad Hadžikadunić, dr. sc. Mustafa Imamović, dr. sc. Mustafa Hadžalić, dr. sc. Edin Begović, dr. sc. Faruk Unkić, dr. sc. Sabahudin Jašarević, dr. sc. Milan Rackov, dr. sc. Nusret Imamović, dr. sc. Marinko Aleksić

Časopis izlazi tromjesečno. (The journal is published quarterly).

Lektura (Copy-editing and Proofreading):

Lamija Subašić

Tehnički urednici (Technical Editors):

mr. Emir Đulić, Emir Čaplja

Stampa (Print):

Grafički studio Feta-grand Zenica

Uređenje zaključeno (Preparation ended on):

31.12.2021.

The journal is registered in the list of public journals at the Ministry of Science, Education, Culture and Sport of the Federation of Bosnia and Herzegovina under No 651.

The journal is mostly financed by the founder and publisher. The journal MAŠINSTVO is generally published four times a year. Manuscripts are not returned.

The journal publishes scientific and professional papers and information of interest to the professionals and industry subjects in the field of mechanical engineering and branches related to the field of application and study of mechanical engineering.

The following topics are treated in particular:

- > mechatronics, automation and robotics,
- > metal, plastic and rubber processing technology,
- > design and construction of machines and facilities,
- > design of production systems,
- > energy and ecology,
- > maintenance of means for working and systems,
- > quality, system efficiency and management of production and business systems,
- > information on new books,
- > information on scientific conferences,
- > information from the University.

RIJEČ UREDNIKA

Poštovane kolegice i kolege,

u toku procesa pripreme, pored izuzetno otežanih okolnosti rada i djelovanja u 2021. godini zbog situacije izazvane COVID-om, koja je trajala tokom, ali i nakon spomenutog perioda, ovaj broj je imao u svom izdavanju i određene poteškoće tehničke prirode, te je sve to uvjetovalo štampanje s određenim vremenskim pomakom.

Pored kvaliteta radova, dajući prioritet kontinuitetu izdavanja, u ovom broju nudimo vam pet radova iz različitih tematskih oblasti: prikaz metodologije modeliranja karte buke korištenjem podataka nadgledanja preduzeća u cilju određivanja utjecaja industrijske buke na ukupnu buku u okolišu, kao i izradu konfliktne karte buke; prikaz analize i proračuna trakastog transportera kao nezaobilazne komponente transportovanja velike količine materijala u realnoj industriji; prikaz primjera procesa upravljanja rizicima definiran prema smjernicama standarda ISO 10006:2017; prikaz pristupa u kreiranju kvalitetne mrežne infrastrukture i ključnih koraka u identificiranju slabih tačaka mrežne infrastrukture; prikaz idejnog rješenja i kreiranja spektrometra koji se može koristiti kao odlično sredstvo za pokazne eksperimente u školama i za realizaciju jednostavnijih projekata u kojima je potrebno na brz i jednostavan način dobiti informaciju o spektru svjetlosti.

U cilju predstavljanja naučno-istraživačkih i stručnih kapaciteta časopis slijedi nove trendove i prakse u multidisciplinarnim područjima.

U sklopu odjeljka "Upustvo za autore" date su osnovne smjernice za pripremu i pisanje radova, te sve uvažene kolegice i kolege ljubazno pozivamo da uzmu učešće u objavljivanju rezultata svojih naučno-stručnih istraživanja u okviru ovog časopisa, a koji predstavlja značajan projekt Mašinskog fakulteta Univerziteta u Zenici i priliku za predstavljanje naučno-istraživačkih i stručnih rezultata istraživanja iz naglašenih i srodnih tematskih oblasti, pogotovo za naše mlade kolegice i kolege sa svih univerziteta i ostalih srodnih institucija.

U posebnim odjeljcima nastavlja se tradicija predstavljanja naučno-istraživačkih i privrednih kapaciteta iz okruženja.

INTRODUCTION BY THE EDITOR-IN-CHIEF

Dear colleagues,

During the process of preparing, undertaken in some very difficult circumstances of work and activity in 2021, due to the COVID that lasted during and after the mentioned period, this issue faced certain obstacles of a technical nature, as well, in the course of its publication, and consequently the printing had to be delayed for some time.

In addition to the quality of the papers, prioritizing the continuity of publication, in this issue we offer you five papers from different thematic areas: presentation of the noise map modeling methodology using company monitoring data in order to determine the impact of industrial noise on the overall noise in the environment, as well as the creation of a conflict noise map; presentation of the analysis and calculation of the belt conveyor as an indispensable component of transporting a large amount of material in real industry; presentation of an example of a risk management process defined according to the guidelines of the ISO 10006:2017 standard; presentation of approaches in creating quality network infrastructure and key steps in identifying weak points of network infrastructure; presentation of the conceptual solution and creation of a spectrometer that can be used as an excellent tool for demonstration experiments in schools and for the implementation of simple projects, when it is necessary to obtain information about the spectrum of light in a quick and simple way.

In order to present scientific-research and professional capacities, the journal follows new trends and practices in multidisciplinary areas.

The 'Guidelines for Authors' section provides basic instruction for preparing and writing papers, and we kindly invite all esteemed colleagues to take part and publish their scientific and professional research results in this journal, which is considered as a significant project of the Faculty of Mechanical Engineering of University of Zenica and gives the opportunity for presenting scientific research and professional research results from highlighted and related thematic areas, especially to our young colleagues from all universities and other related institutions. In special sections, the tradition of presenting scientific-research and economic capacities continues.

*S poštovanjem,
Fuad Hadžikadunić, glavni i odgovorni urednik*

*Sincerely,
Fuad Hadžikadunić, Editor-in-Chief*

SADRŽAJ

1. MODELIRANJE KARTE BUKE ZA POSLOVNU ZONU "BUKVA-VILA" U TEŠNJU Imamović, N.; Kadušić, E.; Birdahić, V.	... 3
2. PRORAČUN I PRIMJENA TRAKASTOG TRANSPORTERA U RUDNIKU „KAKANJ“ Bajramović, K.; Bajramović, I.	... 13
3. UPRAVLJANJE PROCESIMA RIZIKA U PROJEKTIMA PREMA SMJERNICAMA ISO 10006:2017 Babić E.; Jašarević, S.	... 31
4. STVARANJE KVALITETNE MREŽNE INFRASTRUKTURE U CILJU USPJEŠNOG POSLOVANJA Redžibašić, M.	... 39
5. FABLBOV SPEKTROMETAR SA PRIPADAJUĆOM OPREMOM Karamehmedović, E.; FabLab Team	... 47

UPUTSTVO ZA AUTORE	... 53
---------------------------	--------

CONTENTS

1. NOISE MAP MODELING FOR THE BUKVA-VILA BUSINESS ZONE IN TEŠANJ Imamović, N.; Kadušić, E.; Birdahić, V.	... 3
2. CALCULATION AND APPLICATION OF BELT CONVEYOR IN THE KAKANJ MINE Bajramović, K.; Bajramović, I.	... 13
3. RISK MANAGEMENT FOR PROJECTS ACCORDING TO ISO 10006:2017 Babić E.; Jašarević, S.	... 31
4. CREATING A QUALITY NETWORK INFRASTRUCTURE FOR THE PURPOSE OF SUCCESSFUL BUSINESS Redžibašić, M.	... 39
5. FABLBOV SPEKTROMETAR SA PRIPADAJUĆOM EQUIPMENT Karamehmedović, E.; FabLab Team	... 47

INSTRUCTION FOR AUTHORS	... 53
--------------------------------	--------

MODELIRANJE KARTE BUKE ZA POSLOVNU ZONU “BUKVA-VILA” U TEŠNJU

NOISE MAP MODELING FOR THE BUKVA-VILA BUSINESS ZONE IN TEŠANJ

Nusret Imamović
Emina Kadušić
Vehid Birdahić

University of Zenica,
 Faculty of Mechanical
 Engineering

Ključne riječi:
 buka u okolišu, bukomjer,
 karta buke, iNoise, QGIS,
 mjere zaštite od buke

Keywords:
 environmental noise,
 sound level meter, noise
 map, iNoise, QGIS, noise
 protection measures

Paper received:
 13. 10. 2021.

Paper accepted:
 31. 12. 2021.

REZIME

Poslovna zona „Bukva-Vila“ predstavlja prostor za odvijanje različitih poslovnih aktivnosti i nastala je kao rezultat preliminarnog prostornog planiranja i organizovanog razvojnog koncepta privređivanja poduzetnog lokalnog stanovništva, na jedinstvenom području sa razvijenom infrastrukturom i blizinom užeg centra grada Tešnja. Sa razvojem Zone dolazi i do povećanja nivoa buke na ovom području. Ovaj rad predstavlja izradu karte industrijske buke korištenjem podataka dosadašnjeg nadgledanja preduzeća u cilju određivanja utjecaja industrijske buke na ukupnu buku u okolišu, kao i izradu konfliktne karte buke korištenjem rezultata vlastitih mjerena.

Stručni rad

SUMMARY

The Bukva-Vila Business Zone is a place for various business activities and it was created as a result of preliminary spatial planning and organized development concept of the enterprising local population, in a unique area with developed infrastructure and proximity to the center of Tešanj. The development of the Zone caused the increase of the noise levels in this area. This paper presents the development of industrial noise map using data from previous monitoring of companies to determine the impact of an industrial noise on total environmental noise, and as well as, the development of a conflict noise map using results of own measurements.

Professional paper

1. INTRODUCTION

Noise is a big problem in today's urban environment and everyday life. Although it is an indispensable part of life, if it is not moderate in its intensity. It significantly impairs human health, what reflects in increased stress levels, blood pressure, hypertension, sleep disorders, etc. According to the Directive on the identification and management of environmental noise 2002/49/EC, environmental noise is considered to be unwanted or harmful to human health and environment sound outside caused by human activity, including noise emitted by: road, rail and air traffic and noise from areas with industrial activities [1]. Inadequate spatial planning can lead to increased noise levels in residential areas. Spatial planning in this case should be based on the calculations, projection, measurement and modelling of noise parameters in the environment. For this reason, noise maps are made as a graphical

representation of existing or projected noise levels in the observed area. The most common data that a noise map can contain are values exceeding the allowed limits, the estimated number of inhabitants and buildings, exposed to certain noise levels in the observed area [2]. The problem of environmental noise and the development of noise maps in the Federation of Bosnia and Herzegovina (FBiH) is not given due attention, since the only noise map was made for a part of the City of Sarajevo (by DvokutPro). When it comes to noise measurements, some companies within the framework of their environmental monitoring, according to the environmental permission, perform measurements. Without noise mapping, it is not possible to solve the negative impact of noise, nor to reduce the risk to the health of the population. Bearing in mind all the complexity and a scarce level of noise map modelling, the desire emerged to invest its own contribution to make a noise map of one of

developed business zones in FBIH, i.e., Bukva-Vila. Therefore, the priority goals of this paper are to develop industrial noise maps, using existing data from companies' noise monitoring, to develop conflict noise maps, i.e., maps showing values that exceed the legal permissible ones, and to propose noise protection measures for future action plans.

2. SPATIAL CHARACTERISTICS OF THE BUSINESS ZONE

Like many municipalities, the Municipality of Tešanj has organized its economic life through business zones. The business zone is a space for various business activities that emerged as a result of an organized and well-designed development concept, characterized by a common infrastructure and proximity to economic entities [3].

Three business zones have been established in the Municipality of Tešanj [3]. They are:

- Bukva - Vila,
- Ciglana-Glinište and
- Ekonomija.

Due to its economic importance, Bukva-Vila seems very important and interesting to study the noise levels in it and to make its noise map. Bukva-Vila is one of the three business zones in the Municipality of Tešanj and it consists of Bukva, Logobare and Novo Selo, along the local road Tešanj - Tešanjka, with the starting point at Toplana and the endpoint located in the Dubalj road, as shown in Figure 1. This business zone covers a total area of 59,5 ha. Considering the residential areas that make up this business zone, the total population in Bukva, Logobare and Novo Selo is approximately 2300. The construction of small and medium enterprises is planned in a comprehensive area, so the entire Plan would be homogenized. Although, according to the Plan, the Business Zone does not include residential areas of Bukva, Logobare and Novo Selo, households are in its immediate vicinity. The only inhabited area in this location is the refugees' settlement Vila, which is preparing to be removed to some other place [3]. In the area of Bukva-Vila, 38 business entities have been established, out of which 17 (45%) produce various types of goods. Given the impact of industry on noise levels, it is considered important to address it in the paper.

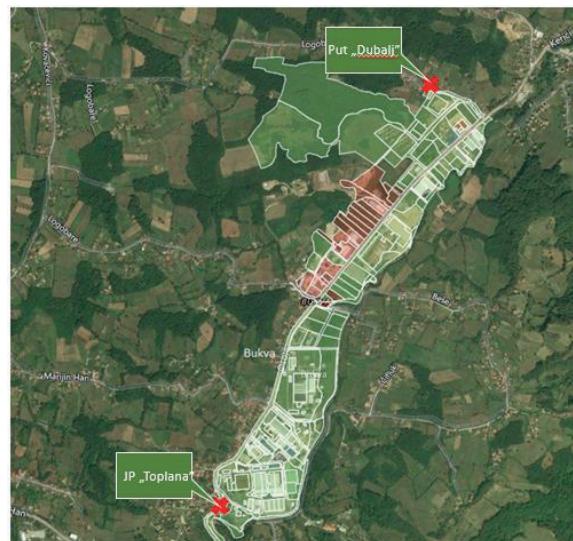


Figure 1. Location of the Bukva-Vila Business Zone [3]

3. NOISE MAPPING FRAMEWORK

3.1 Legislation

In the Federation of Bosnia and Herzegovina and Zenica-Doboj Canton (ZDC), to which the area of this Business Zone belongs, the issue of noise is regulated by the Law on Noise Protection (Official Gazette of the Federation of B&H No. 110/12) and the Law on Protection from Noise (Official Gazette of ZDC No. 1/14). Also, there is the Law on Environmental Protection that regulates the limit values of noise depending on the purpose of the location, surrounding area, time of day, noise protection measures, method of measuring and recording noise in order to protect human health, protection of working and living space and the environment in general [4].

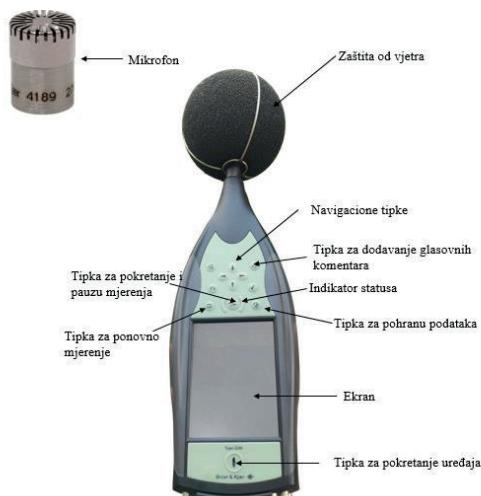
According to this Law, the day lasts from 06:00 a.m. to 10:00 p.m., and the night from 10:00 p.m. to 06:00 a.m. [4]. Table 1 shows the permissible noise levels of the parameters Leq and L_1 for the selected purpose of this area. Also, according to the Law, federal, cantonal, city and municipal bodies, responsible for spatial planning, are obliged to produce noise maps, and an initial noise map should have been made within 3 years from the entry into force of this Law, but it was not done.

Table 1 Allowed noise levels in the zone VI [4]

Area (zone)	AREA PURPOSE	Equivalent noise level (Leq)		Peak level
		day	night	
VI	Industrial, cargo, service and traffic area without residential area	70	70	85

3.2 Selection of measuring points and measuring noise

Noise measurement is an activity without which noise protection cannot be planned, as well as the formation of a base in relation to which noise will be judged. Also, the goal of the measurement is to collect data that will be used in making spatial planning. In order to see the impact of industrial noise on the total environmental noise, and to make a conflict map of noise, it was necessary to perform our own measurements. Noise measurement was performed in accordance with BAS ISO 17025:2005, using a Brüel & Kjaer type 2250 sound level meter, shown in Figure 2, with its basic components. A sound level meter is an instrument designed to measure noise levels in a standardized way [5]. Since the observed business zone is a large area, 28 measuring points were selected near industrial plants and on the border between the business zone and residential areas, and the measurement was performed for a period of day and night. Graphical representation of measuring points is shown in Figure 3 (MM1-MM14) and Figure 4 (MM15-MM28).

**Figure 2** Sound level meter Brüel & Kjaer**Figure 3** Locations of measuring points MM1 - MM14**Figure 4** Locations of measuring points MM15 - MM28

During the measurement, the frequency of traffic (number of passengers and cargo vehicles) in the measuring interval of 15 minutes was recorded to gain a better insight into the character and dynamics of some measurements, i.e., results.

3.3 Creating industrial noise maps using iNoise

Business entities in the area of Bukva-Vila, in

issued in environmental permits to perform noise monitoring as an integral part of environmental monitoring. For the need of this paper, data on previous monitoring were collected for five (5) industrial plants: JP¹ Toplana d.d.², JP Pobjeda d.d., Saracević d.o.o.³, MADI d.o.o. and Eko-servis d.o.o. Modeling of the industrial noise map was performed using the iNoise program. The iNoise software version V2021.1 Free is free software for acoustic modeling of industrial noise in the environment, according to the ISO 9614 method and the recommendations of the ISO 17534 quality standard [6]. The reason for choosing this software is the ability to create a map, if the sound power of the noise source is not known, but measured at a known distance from the source.

3.3.1 Georeferencing

In iNoise software, an image from Google Earth can easily be georeferenced to a model, using the option *View → Background Map → Calibrate*. To calibrate the map, as shown in Figure 5, the *Scale only* option was used, which requires knowing the distance between two selected points that have already been measured in Google Earth Pro.

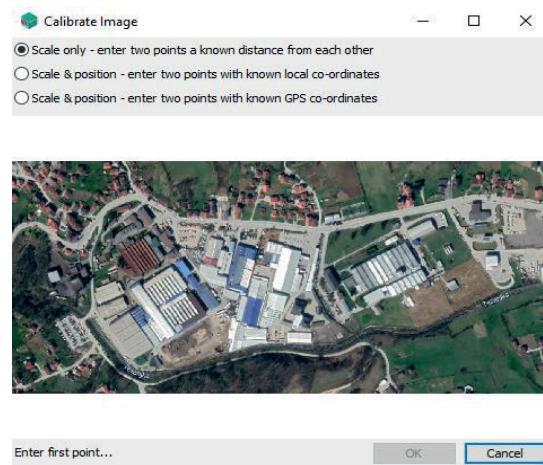


Figure 5 Georeferencing of map into model

3.3.2 Defining the network, buildings, vegetation and residential buildings

After georeferencing the map, it is necessary to set up a grid to calculate the model itself. The grid is drawn to cover the entire surface of the map with a distance between the grid points of 10 m along the x and y axes, as seen in Figure 6.

¹ JP stands for public enterprise (PE)

² d.d. stands for joint stock company (JSCo)

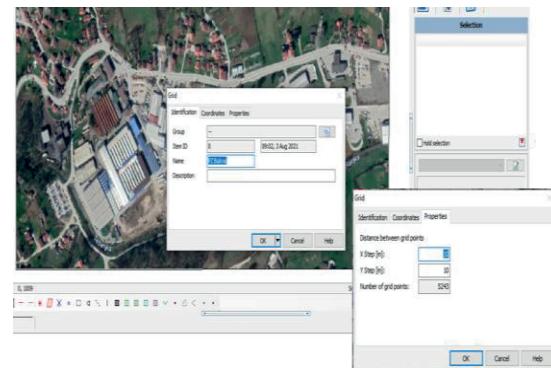


Figure 6 Setting up the model grid

In addition to the model network, it is necessary to set other layers of the model, such as buildings, vegetation layer and residential areas. Each of the layers in order to be complete and to be able to perform the calculation of the model needs to have a height and not to intersect with each other. The appearance of the map model after this step can be seen in Figure 7.



Figure 7 Map view with layers

3.3.3 Data entry of previous monitoring in industrial plants

Data from previous monitoring in industrial plants were entered using the *Source Explorer* option, which was a demo for the unlicensed free version of this software. Using this option, it is not necessary to know the data on the noise source, but the noise level with a known distance from the source. When entering data, the *Sound power calculation* option, using ISO 8297, was selected, because the number of noise sources within one plant is not known. According to this standard for determining the sound power, as can be seen in Figure 8, it is necessary to enter the basic parameters of noise level measurement such as temperature, wind speed, wind direction, relative humidity,

³ d.o.o. stands for limited liability company (LLC)

measurement height, noise source height, measuring area and distance from the source. Because most noise measurements, according to previous monitoring of business entities, are said to be measured near the noise source, it was adopted that the distance is 3 m, due to the rule that a measuring point must be 3 m away from reflective surfaces, the area of the nearby object must be considered, because it is assumed that noise is coming from that object, and also, it is assumed that all noise sources are point sources. To compare the results of modeling the map in iNoise and own measurements near the plant, receivers were put at the places where noise measurements were performed.

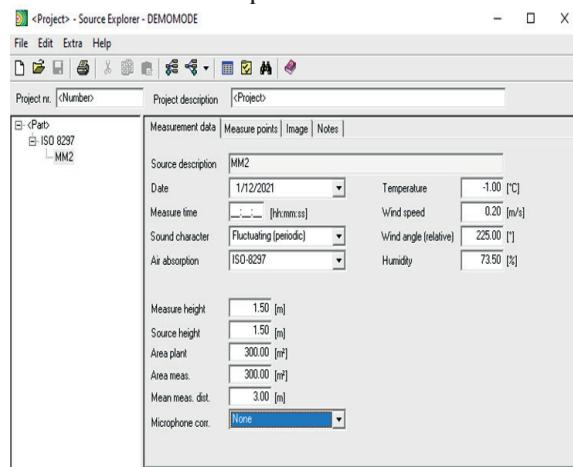


Figure 7 Display of measurement data entry for MM2 - JP Toplana in the Source Explorer option

4. RESULTS AND ANALYSIS OF RESULTS

4.1 Measurement results

Measurement of noise levels in the area of the business zone was performed in the period from July 26, 2021 to July 28, 2021. Table 2 shows the meteorological conditions read from the AccuWeather application and all the data provided are consistent with the values that make the measurement credible [7]. The differences between the measurement results of the obtained noise level values for the stated locations measured using the Brüel & Kjaer noise meter and the limit values are shown in Table 2 for day measurements and in Table 3 for night measurements. The tables show the equivalent noise values, maximum and minimum values, as well as the values of L₁, L₁₀ and L₉₀ noise. As can be seen from the Table 3 at five measuring points, namely

MM10, MM11, MM14, MM15 and MM27, the equivalent noise level (L_{eq}) exceeds the legally allowed values for the business zone of 70 dB in the interval of exceeding 0,7 dB up to 2,2 dB. The reason exceeding the allowed values for these places is the higher frequency of traffic, as well as the business activities of the companies located near the specified measuring points. Table 4 shows that only at one measuring point the measured value of L_{eq} exceeds the limit value, since most companies do not perform business activity during the night. The measured value of L_{eq} at measuring point MM27 exceeds the allowed value by 0,7 dB due to the speed of vehicles on this road, as well as the higher frequency of cargo vehicles. The value of parameter L₁ does not exceed the limit value for the selected area purpose.

Table 2 Meteorological conditions during noise measurements

Parameter	26.7.2021.		27.7.2021.		28.7.2021
	Day	Night	Day	Night	Night
Temperature °C	32	29	30	25	20
Wind direction	SSE	SSE	SSE	S	S
Wind speed, m/s	3	3	1	1	2
Precipitation	Ne	Ne	Ne	Ne	Ne
Relative humidity, %	52	71	38	65	71
Atmospheric pressure	1015	1015	1018	1016	1016

Table 3 Noise measurement results by sound level meter - day period

Label	Measurement interval	Traffic frequency		Measured values [dB]					
		Pass. veh.	Cargo veh.	LA _{eq}	L ₁	LA _{max}	LA _{min}	LA ₉₀	LA ₁₀
MM1	7:41-7:56	4	0	49,9	62,8	70,9	42,3	50,2	55,2
MM2	8:01-8:16	6	0	55,4	68,1	74,9	48,7	57,6	61,2
MM3	8:18-8:33	2	0	67,5	69,9	89,6	66,3	66,9	67,7
MM4	8:38-8:53	11	0	54,5	67,9	72,9	45,3	47,8	54,2
MM5	8:57-9:12	7	1	59,2	65,7	76,1	56,4	57,7	59,5
MM6	9:15-9:30	8	5	59,2	68,7	78,7	52,4	55,1	60,5
MM7	9:36-9:51	94	7	60,2	70,8	75,6	55,4	57,2	60,4
MM8	9:54-10:10	161	10	67,1	76,3	82,6	51,3	54,7	71,1
MM9	10:13-10:28	168	4	66,2	74,3	81,6	45,0	52,4	70,2
MM10	10:30-10:45	201	12	71,9	82,2	88,4	44,1	50,1	75,9
MM11	12:50-13:05	183	7	71,1	80,7	87,7	46,4	55,8	75,0
MM12	10:50-11:05	172	5	62,5	71,2	78,4	49,2	52,7	66,4
MM13	11:09-11:24	188	8	62,5	71,4	79,9	51,6	54,9	65,3
MM14	11:34-11:49	239	16	71,8	81,4	92,9	52,3	59,6	75,2
MM15	11:15-12:11	177	8	72,2	82,0	88,2	53,2	59,5	76,2
MM16	17:53-18:08	9	0	62,0	70,2	75,1	59,1	60,2	62,4
MM17	18:12-18:27	6	1	53,6	66,0	75,6	38,8	41,6	52,7
MM18	18:31-18:47	2	0	51,1	60,9	78,1	42,7	45,8	51,3
MM19	18:54-19:09	138	4	69,8	79,7	86,8	40,3	51,9	74,2
MM20	19:13-19:28	131	0	67,8	76,9	81	47,8	53,8	72,2
MM21	19:31-19:46	99	0	69,7	80,3	84,2	46,5	51,5	74,1
MM22	19:52-20:07	5	0	53,8	66,4	76,1	41,0	43,9	55,4
MM23	12:13-12:28	118	8	67,0	76,1	86,2	46,0	52,9	71,2
MM24	20:10-20:25	2	0	49,2	60,4	74,7	31,4	35,6	49,4
MM25	20:29-20:44	1	0	45,4	53,2	68,6	38,3	41,4	45,8
MM26	20:46-21:01	0	0	66,0	69,3	72,1	54,1	64,7	67,1
MM27	21:06-21:21	82	2	70,7	79,8	96,2	44,2	51,7	72,6
MM28	11:53-12:08	121	12	66,2	75,3	81,6	44,4	52,6	69,1

Table 4 Noise measurement results by sound level meter - night period

Label	Measurement interval	Traffic frequency		Measured values [dB]					
		Pass. veh.	Cargo veh.	LA _{eq}	L ₁	LA _{max}	LA _{min}	LA ₉₀	LA ₁₀
MM1	5:26-5:41	0	0	44,1	51,5	71,6	40,3	41,3	44,1
MM2	5:07-5:22	1	0	64,3	66,7	74,5	62,8	63,8	64,7
MM3	4:51-5:06	0	0	59,5	61,1	64,7	57,4	58,6	60,4
MM4	4:33-4:48	0	0	45,7	51,0	60,4	41,7	43,8	46,9
MM5	4:16-4:31	3	0	60,8	64,1	76,7	56,5	59,6	61,5
MM6	3:59-4:14	2	0	52,5	61,8	73,3	46,8	48,4	51,9
MM7	3:40-3:55	11	1	50,1	56,5	70,5	46	47,2	50,7
MM8	3:23-3:38	8	0	59,8	72,1	86,1	42,5	46,8	53,2
MM9	3:06-3:21	12	0	54,2	66,2	73,1	38,5	40,4	57,0
MM10	4:15-4:30	21	1	64,1	77,6	84,6	46,0	47,5	63,8
MM11	4:32-4:47	15	0	60,9	73,8	86,2	43,8	45,0	58,7
MM12	4:49-5:04	12	1	57,1	68,7	76,5	48,0	51,9	56,4
MM13	5:06-5:21	10	1	56,7	70,0	75,7	44,9	46,0	56,0
MM14	5:24-5:39	24	2	65,0	77,9	84,6	50,3	51,4	66,9
MM15	23:28-23:43	31	1	64,0	77,6	81,4	42,1	44,7	66,1
MM16	23:12-23:26	72	3	62,4	75,1	82,3	47,5	48,7	64,3
MM17	22:52-23:07	10	0	60,0	70,8	89,6	45,8	50,2	56,8
MM18	3:44-3:59	2	0	51,1	60,9	78,1	42,7	45,8	51,3
MM19	22:32-22:47	76	3	68,7	79,9	84,2	44,2	52,1	72,6
MM20	22:16-22:31	70	5	67,7	78,3	85,4	50,9	71,5	53,6
MM21	22:00-22:15	55	2	68,3	80,3	86,7	49,2	51,6	71,9
MM22	22:00-22:15	5	0	53,8	66,4	76,1	41,0	43,9	55,4
MM23	22:18-22:33	70	1	68,7	79,7	86,5	47,0	53,4	72,7
MM24	22:35-22:50	2	0	49,2	72,3	74,7	31,3	35,6	49,4
MM25	22:54-23:09	1	0	45,4	65,1	68,4	38,3	41,4	45,8
MM26	23:10-23:25	0	0	66,0	71,6	72,1	54,1	64,7	67,1
MM27	23:31-23:46	74	2	70,7	83,0	96,2	44,2	51,7	72,6
MM28	23:50-00:05	56	1	64,2	74,8	83,7	35,7	42,9	68,4

4.2. Results of industrial noise maps

As can be seen from the industrial noise maps of the Bukva-Vila Business Zone, shown in Figures 8 and 9, noise levels higher than the legal limit levels are near the noise source, i.e., the plant (marked in purple), while at the measurement sites of the previous monitoring data, the noise level does not exceed the limit values. Also, by comparing the results of own measurements, using a noise meter, and the results of noise levels, using the software at measuring points MM6, MM7, MM8, MM9, MM10, MM11, MM15, MM16, MM18, MM19, MM20, MM21, MM24 and MM28,

it can be seen that the average part of industrial noise in the total environmental noise is approximately 67,7 %. The smallest difference between the results of own measurements and model results is at MM6 and MM24, as seen in Figure 10, because these places have the lowest traffic frequency and no other significant noise sources. The biggest deviation is at measuring point MM15, due to the increase in traffic frequency and higher driving speed on this part of the road.

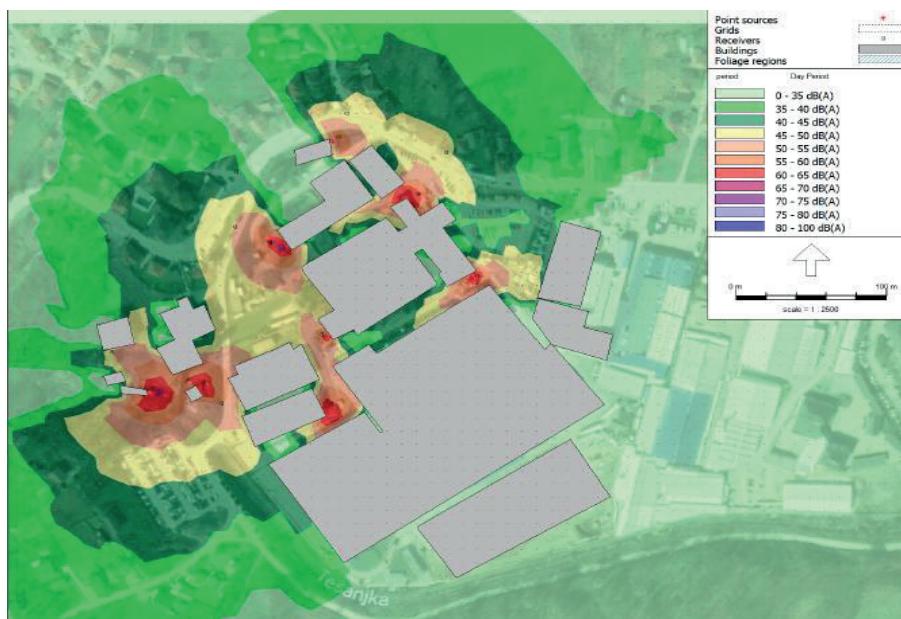


Figure 8 Industrial noise maps for PE Toplana and PE Pobeda, iNoise

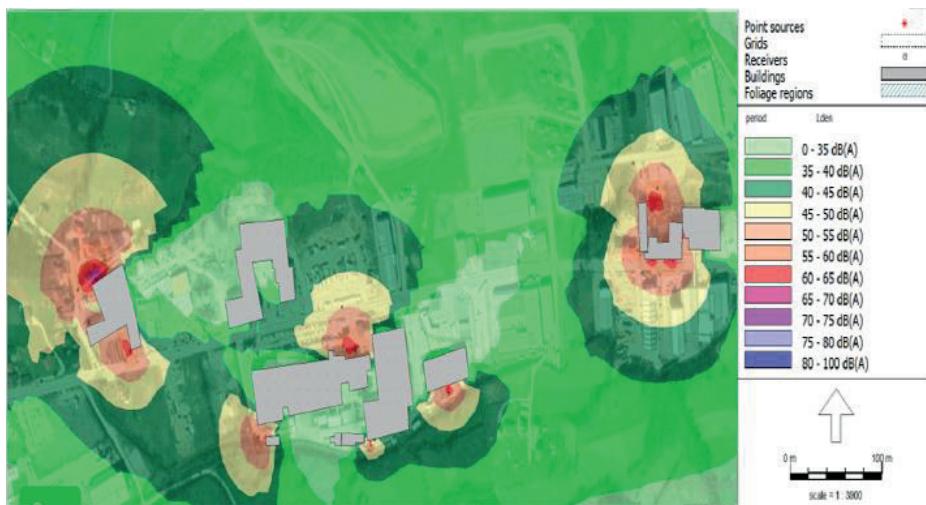


Figure 9 Industrial noise maps for Saracевич, MADI and Eko-servis, iNoise

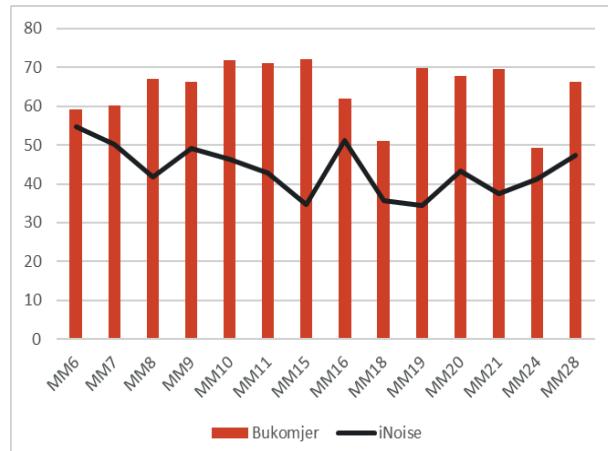


Figure 10 The difference between the results of the measurement by sound level meter and the results obtained by calculation in iNoise

5. CONFLICT NOISE MAPS

Although the area of the Bukva-Vila Business Zone is not intended for the existence of residential parts, it is in the immediate vicinity of populated areas, i.e., they are divided only by the road that passes through this Zone. If this statement were taken into consideration, then the area to which this Zone belongs, according to the Law on Noise Protection, is the combined industrial, storage, service and traffic area in a residential area with allowed value Leq during the day of 65 dB and during the night of 55 dB and the limit value L₁ of 80 dB [1]. For this reason, it was necessary to make conflict noise maps (shown in Figures 11 and 12) in relation to the allowed values of Leq for the purpose of the area. For the period of the day (6 a.m. - 10 p.m.), it can be noticed that the noise is at the highest, more precisely, 6 measuring points above the allowed noise level, in the interval up to 3 dB on certain sections of the road, and at locations SM3 branch located in Bukva-Vila, while at three measuring points it exceeds the limit value in the interval of 6 to 9 dB. Places where the noise level has exceeded the allowed noise level in the interval 6-9 dB are places near the road and companies Pobjeda, MANN + HUMMEL BA, ENKER and Saračević.

Observing the conflict map of noise for the night period, much larger exceedances of the allowed values of Leq can be noticed. During this period, there are exceedances of more than 15 dB marked on the border of the Business Zone, i.e., at the beginning of the road of Dubalj. Although the conflict noise maps were made according to the Leq parameter, it is important to mention the second legal parameter

L₁. The limit value of this parameter was exceeded during the day at few measuring points and the reason for exceeding the L₁ value was fast driving near the measuring points.

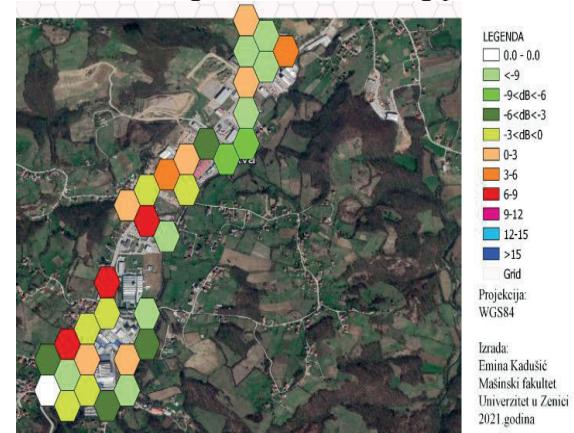


Figure 11 Conflict noise map for the Bukva-Vila Business Zone - day

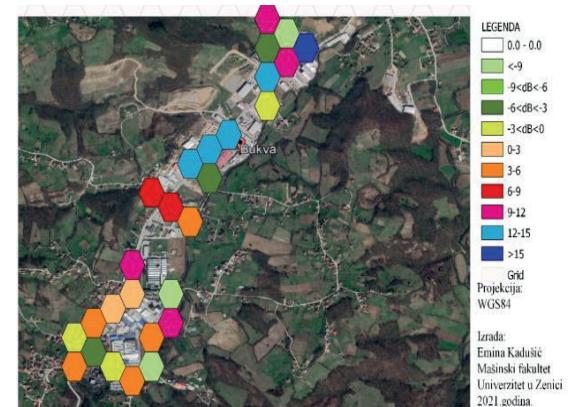


Figure 12 Conflict noise map for the Bukva-Vila Business Zone - night

During the day, the largest percentage of 51,6% of the population is exposed to the noise above the limit values, i.e., in the interval of 65 to 68 dB, while during the night, the largest number of the population of 30,6% is exposed to noise in the interval of 68 to 71 dB. Looking at the entire population in the settlements that make up the Zone, it can be concluded that 5% of the population is exposed to noise above 60 dB during the day, while at night 17% of the population is exposed to noise above 55 dB.

6. CONCLUSION

Business zones, as one of the important organizational and spatial segments of economic development, with their construction and expansion, mainly negatively impact all components of the environment. Certainly, one of such environmental impacts is noise, its emission, occurrence and accumulation in the zone itself and its immediate surroundings. In the specific case of this paper, Bukva-Vila and the impact of its noise sources on the Business Zone and the immediate environment were investigated through previous monitoring, own measurements and modeling of noise maps in real circumstances. Comparing the results of sound level meter measurements in the Business Zone with the allowed limit values for the Leq parameter, which for the purpose of this area is 70 dB and for the period of day and night, it can be seen that during the day (from 6 a.m. to 10 p.m.) at measuring points MM10, MM11, MM14, MM15, MM27 the statutory values are exceeded by an average of 1.5 dB. During the night, only at one measuring point the noise level exceeded the limit value, i.e., at MM27 by 0.7 dB. The noise values for parameter L₁ did not exceed the limit values at any measuring point, which are 85 dB for the purpose of this Zone.

Industrial noise maps created in the iNoise program show the spread of noise from industrial plants in this Zone and its impact on the overall noise in the environment. Comparing the results of own measurements, obtained by using noise meters, and the results of noise levels, obtained by using software, at the same measuring points, it was found that the average share of industrial noise in total environmental noise is approximately 67.7%, and that industrial noise had the greatest impact on MM6, MM7 and MM24, since no significant other noise sources were at these measuring points.

Based on the conflict noise maps, it was concluded that 5% of the population living in areas covered by the Business Zone is daily exposed to noise above 60 dB, while at night 13% of this population is exposed to noise above 55 dB.

The results of noise measurement and noise mapping in iNoise and QGIS can be an excellent starting point for developing a new or

reprogramming the existing spatial plan of this area of the Municipality of Tešanj and possibly further research, to more advanced software development of road models, distribution of population, meteorological conditions during the year, development of mandatory and unique noise maps of this and all other areas of importance, which is ultimately a legal obligation and what is expected from the responsible community in the near future.

7. BIBLIOGRAPHY

- [1] Directive 2002/49/EC, <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32002L0049> (accessed September 21)
- [2] Ahac M., Ahac S., Dragčević V., Lakušić S. (2008) - Prilog optimizaciji postupka izrade karata buke, Građevinar, Vol. 60 No. 09., 2008., <https://hrcak.srce.hr/28951> (accessed September 2021)
- [3] Poslovne zone – Općina Tešanj, <https://opcina-tesanj.ba/biznis/poslovne-zone/>
- [4] Zakon o zaštiti od buke (Službene novine Federacije BiH br. 110/12), [http://www.fuzip.gov.ba/bundles/websitenews/gallery/files/113/149692885353_Zakon_o_za%C5%A1titi_od_buke_\(%E2%80%9ESlu%C5%BEene_novine_Federacije_BiH%E2%80%9C_broj_110_12\).pdf](http://www.fuzip.gov.ba/bundles/websitenews/gallery/files/113/149692885353_Zakon_o_za%C5%A1titi_od_buke_(%E2%80%9ESlu%C5%BEene_novine_Federacije_BiH%E2%80%9C_broj_110_12).pdf) (accessed September 2021)
- [5] BRÜEL & KJÆR® Sound Level Meters, Hand-held Analyzer Types 2250 and 2270, <https://www.bksv.com/en> (accessed September 2021)
- [6] iNoise - Noise Prediction for Industry and Wind Turbines, <https://dgmrssoftware.com/products/inoise/> (accessed September 2021)
- [7] Turčinović N., Analiza i kontrola uticaja buke u saobraćaju na objekte koji se nalaze uz dionicu Glavne gradske magistrale Zenica, master rad, Politehnički fakultet Univerziteta u Zenici, 2018. godina, Zenica

Corresponding author:

Nusret Imamović
**Faculty of mechanical engineering,
University of Zenica,
Fakultetska 1, Zenica**
Email: nusret.imamovic@unze.ba
Phone: + 387 32 449 123

PRORAČUN I PRIMJENA TRAKASTOG TRANSPORTERA U RUDNIKU „KAKANJ“

CALCULATION AND APPLICATION OF BELT CONVEYOR IN THE KAKANJ MINE

Kasim Bajramović¹
Irhad Bajramović²

¹ Mašinski fakultet
Univerziteta u Zenici /
ZD RMU „Kakanj“ d.o.o.,
Kakanj

² Industry 4B d.o.o.,
Kakanj

Ključne riječi:
trakasti transporter,
proračun, traka transportera,
bubanj, valjak

Keywords:
belt conveyor, calculation,
rubber belt, pulley, roller

Paper received:
18.10.2021.

Paper accepted:
29.12.2021.

REZIME

Savremena tehnologija eksploatacije odredila je značaj i ulogu kontinuiranog transporta, a naročito transportnih traka kao glavnog predstavnika kontinuiranog transporta.

Transport trakama omogućuje primjenu kompleksne tehnologije pri eksploataciji, utovaru i istovaru svih vrsta čvrstih mineralnih sirovina i postizanje visoke produktivnosti i ekonomičnosti rada. Primjena traka omogućuje da se cijeli proizvodni proces organizira kontinuirano i potpuno automatizirano.

Proračun gumenih transportera koji se koriste u Rudniku „Kakanj“ tema su ovoga rada.

Stručni rad

SUMMARY

Modern exploitation technology has determined the importance and role of continuous transport, and especially conveyor belts as the main representative of continuous transport.

Transportation with belt conveyors enables the application of complex technology in exploitation, loading and unloading of all types of solid mineral raw materials and achieving high productivity and economy of work. The application of belt conveyors allows the entire production process to be organized continuously and fully automated.

The calculation of belt conveyors used in the Kakanj Mine is the topic of this paper.

Professional paper

1. INTRODUCTION

In the paper the calculation of the belt conveyor used in the Kakanj Mine with a total length of 135 m will be presented. In order to make the correct choice of the belt conveyor, only the one that works in the most difficult working conditions is checked. Other rubber belt conveyors are not calculated and checked, because they do not work in as much hard conditions [1]. A belt conveyor, type HKA 800/1300/150, was selected for the transport of workers and materials in the pit of "Begići-Bištrani" of the Coal Mine in Kakanj, L = 135 m, product of ERNST HESE, GmbH & Co from Germany. All important parameters of the conveyor will be calculated and checked [2-5]. In this paper, control calculations of tensile forces in the contour points of the conveyor, calculation of motor power, number of inserts in the rubber conveyor and the minimum required tightening are given.

1. UVOD
U okviru rada dat će se prikaz proračuna trakastog transportera sa gumenom trakom koji se primjenjuje u Rudniku „Kakanj“, ukupne dužine od 135 m.

Da bi se izvršio pravilan odabir gumenog trakastog transportera, vrši se provjera samo onog koji radi u najtežim uslovima rada. Ostali gumeni trakasti transporteri se računski ne provjeravaju, jer rade u lakšim uslovima [1].

Za prijevoz radnika i materijala u jami „Begići-Bištrani“ Rudnika mrkog uglja u Kaknju je odabran gumeni trakasti transporter tipa HKA 800/1300/150, L=135m, proizvod firme ERNST HESE, GmbH & Co iz Njemačke. Proračunom će se provjeriti bitni parametri transportera [2-5].

U ovom radu dati su kontrolni proračuni sila zatezanja u konturnim tačkama transportera, proračun snage motora, broj uložaka u gumenom transporteru i minimalno potrebno zatezanje.

2. PODACI ZA PRORAČUN

Osnovni tehnički podaci za proračun su dati kako slijedi:

- dužina transportera $L = 135 \text{ m}$
- brzina trake $v = 1,70 \text{ m/s}$
- kapacitet transporta uglja $Q = 300 \text{ t/h}$
- nasipna gustoća materijala $\rho = 1,56 \text{ t/m}^3$
- nagib transportera (prosječno) $\beta = 2,5^\circ$

3. PRORAČUN

3.1 Određivanje širine trake

$$b_1 = \sqrt{\frac{A \cdot 3600}{f}} \quad \dots(1)$$

gdje je:

- f – koeficijent oblika poprečnog presjeka materijala nasutog na traku (tabela 1.).
- A – površina poprečnog presjeka materijala nasutog na traku.

$$b_1 = \sqrt{\frac{0,0351 \cdot 3600}{465}} \Rightarrow b_1 = 0,52 \text{ m}$$

Tabela 1. Koeficijent oblika poprečnog presjeka materijala nasutog na traku
Table 1 Coefficient of cross-sectional shape of the material placed on the belt

Poprečni presjek transportera <i>Conveyor cross section</i>	Ravan <i>Flat</i>	Oblik V <i>V Shape</i>	Koritasti <i>Trough</i>	Koritasti <i>Trough</i>
Vrijednost faktora f <i>Factor value f</i>	240	450	465	550

Odabрано: užlijebljeni (koritasti) oblik s nagibom bočnih valjaka od 30° .

3.2 Presjek materijala nasutog na traku

$$A = \frac{1}{k_1 \cdot k_2} \cdot \frac{Q}{3600 \cdot \rho \cdot v} = \dots(3)$$

$$\frac{1}{0,90 \cdot 0,995} \cdot \frac{300}{3600 \cdot 1,56 \cdot 1,70} = 0,0351 \text{ m}^2$$

$\rho = 1,56 \text{ t/m}^3$ – nasipna gustoća materijala.

$k_1 = 0,80 \div 1,00$ – koeficijent smanjenja teoretskog kapaciteta zbog neravnomjernog nasipanja materijala na traku.

Usvojeno:

2. CALCULATION DATA

The basic technical data for the calculations are given as follows:

- Conveyor length $L = 135\text{m}$
- Belt speed $v = 1,70 \text{ m/s}$
- Coal transport capacity $Q = 300 \text{ t/h}$
- Bulk density of material $\rho = 1,56 \text{ t/m}^3$
- Conveyor inclination (average) $\beta = 2,5^\circ$

3. CALCULATION

3.1 Determining of the belt width

$$b_1 = \sqrt{\frac{A \cdot 3600}{f}} \quad \dots(1)$$

where are:

f – coefficient of cross-sectional shape of the material placed on the belt (Table 1).

A – cross-sectional area of the material placed on the belt.

$$b_1 = \sqrt{\frac{0,0351 \cdot 3600}{465}} \Rightarrow b_1 = 0,52 \text{ m}$$

Selected: grooved (trough) shape with side roller inclination of 30° .

3.2 Cross section of material loaded on the belt

$$A = \frac{1}{k_1 \cdot k_2} \cdot \frac{Q}{3600 \cdot \rho \cdot v} = \dots(3)$$

$$\frac{1}{0,90 \cdot 0,995} \cdot \frac{300}{3600 \cdot 1,56 \cdot 1,70} = 0,0351 \text{ m}^2$$

$\rho = 1,56 \text{ t / m}^3$ – bulk density of the material.

$k_1 = 0,80 \div 1,00$ – coefficient of reduction of theoretical capacity due to uneven placing of material on the strip.

$$k_1 = 0,90$$

$k_2 = 0,995$ – koeficijent smanjenja teoretskog kapaciteta zbog nagiba transportera od $2,5^\circ$.

Selected:

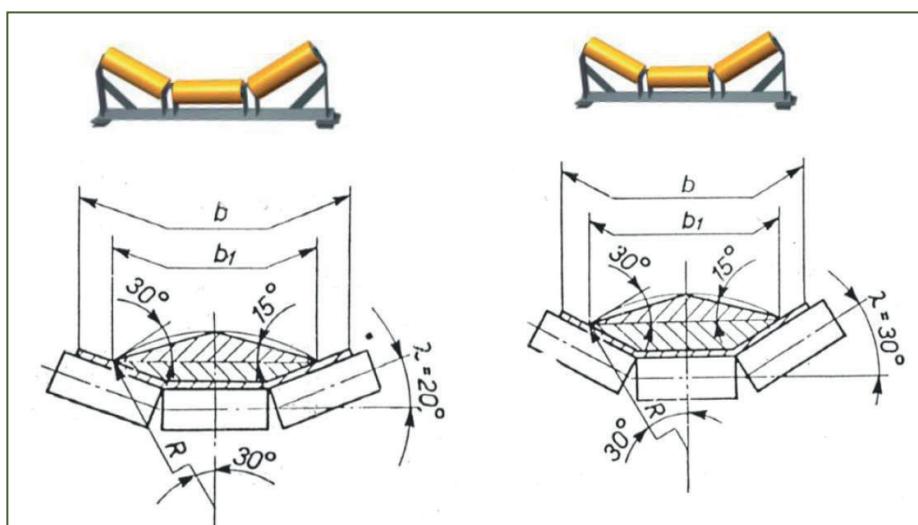
$$k_1 = 0,90$$

$k_2 = 0,995$ – coefficient of reduction of theoretical capacity due to the inclination of the conveyor of 2.5° .

Tabela 2. Koeficijent smanjenja teoretskog kapaciteta zbog nagiba transportera (k_2)

Table 2 Coefficient of reduction of theoretical capacity due to inclination of the conveyor (k_2)

Ugao nagiba β <i>Tilt angle β</i>	2°	4°	6°	8°	10°	12°	14°	16°	18°	20°	22°
Koeficijent k_2 <i>Coefficient k_2</i>	1,0	0,99	0,98	0,97	0,95	0,93	0,91	0,89	0,85	0,81	0,76



Slika 1. Presjek materijala nasutog na traku
Figure 1 Cross section of material loaded on belt

3.3 Stvarna širina trake

$$b = \frac{b_1 + 0,05}{0,9} = \frac{0,52 + 0,05}{0,9} \text{ m} \quad \dots(4)$$

$$b = 0,63 \text{ m}$$

Odabрано: $b = 1,00$, $m = 1000 \text{ mm}$
Najduži rub komada za ovu širinu trake je $400 \text{ mm} \Rightarrow$ tabela 3., za $b = 1000 \text{ mm}$.

3.3 Actual belt width

$$b = \frac{b_1 + 0,05}{0,9} = \frac{0,52 + 0,05}{0,9} \text{ m} \quad \dots(4)$$

$$b = 0,63 \text{ m}$$

Selected: $b = 1,00$, $m = 1000 \text{ mm}$
The longest edge of the piece for this belt width is $400 \text{ mm} \Rightarrow$ Table 3, for $b = 1000 \text{ mm}$.

Tabela 3. Najduži rub komada*Table 3 The longest edge of the piece*

Najduži rub komada (mm) <i>The longest edge of the piece (mm)</i>	Najmanja širina trake (mm) <i>Minimum belt width (mm)</i>	Najduži rub komada (mm) <i>The longest edge of the piece (mm)</i>	Najmanja širina trake (mm) <i>Minimum belt width (mm)</i>
100	400	400	1000
150	500	500	1200
200	650	600	1400
300	800		

3.4 Vrsta tkanine za transportnu traku

Izrađena je sa poliester-poliamidnim ulošcima, tipa EP 1250/4 ZK 4/2, DIN 22102, širine $b = 1000$ mm.

Odabрано: traka EP 1250/4 ZK 4/2, DIN 22102, širine $b = 1000$ mm s ulošcima iz poliester – poliamidnog prediva \Rightarrow tabela 4.

3.4 Type of fabric for conveyor belt

It is made with polyester-polyamide inserts, type EP 1250/4 ZK 4/2, DIN 22102, width $b = 1000$ mm.

Selected: tape EP 1250/4 ZK 4/2, DIN 22102, width $b = 1000$ mm with inserts made of polyester - polyamide yarn \Rightarrow Table 4.

Tabela 4. Tehničke karakteristike tkanine*Table 4 Technical characteristics of the fabric*

Tip platna <i>Canvas type</i>	Prekidna čvrstoća (N/m) <i>Breaking strength (N/m)</i>		Težina gumiranog platna (gr/m ²) <i>Weight of rubberized canvas (gr/m²)</i>	Debljina gumiranog platna (mm) <i>Rubberized canvas thickness (mm)</i>
B – 50	49305	24518	1300	1.65
B – 60B – 80	58842	31382	1500	1.95
	78456	44132	1730	2.20
PA – 120	117684	58842	930	1.00
PA – 160	156912	78456	1100	1.30
PA – 250	245175	98070	1350	1.65
PA – 315	308921	98070	1520	1.70
EP – 125	122588	49035	920	1.00
EP – 160	156912	63745	1050	1.30
EP – 250	245175	78456	1320	1.65
EP – 315	308921	78456	1470	1.80
RP – 125	122588	49035	1100	1.40
RP – 160	156912	63745	1300	1.70
RP – 250	245175	78456	1800	2.30
RP – 315	308921	78456	2100	2.50

Ukupna debljina uložaka (gumena traka s 4 uloška) određena je iz tabele 5. i iznosi 4 mm (za EP-125 i 4 uloška).

The total thickness of the layers (rubber band with 4 cartridges) was determined from Table 5 and it is 4 mm (for EP-125 and 4 layer).

Tabela 5. Ukupna debljina uložaka*Table 5 Total thickness of layers*

Tip platna <i>Canvas type</i>	Broj uložaka <i>Number of layers</i>						
	2	3	4	5	6	7	8
B – 50	3.30	4.95	6.60	8.25	9.90	11.55	13.20
B – 60	3.90	5.85	7.80	9.75	11.70	13.65	15.60
B – 80	4.40	6.60	8.80	11.00	13.20	15.40	17.60
PA – 120	2.00	3.00	4.00	5.00	6.00	7.00	8.00
PA – 160	2.60	3.90	5.20	6.50	7.80	9.10	10.40
PA – 250	3.30	4.95	6.60	8.25	9.90	11.45	13.20
PA – 315	3.40	5.10	6.80	8.50	10.20	11.90	13.60
EP – 125	2.00	3.00	4.00	5.00	6.00	7.00	8.00
EP – 160	2.60	3.90	5.20	6.50	7.80	9.10	10.40
EP – 250	3.20	4.80	6.40	8.00	9.60	11.20	12.80
EP – 315	3.60	5.40	7.20	9.00	10.80	12.60	14.40
RP – 125	2.80	4.20	5.60	7.00	8.40	9.80	11.20
RP – 160	3.40	5.10	6.80	8.50	10.20	11.90	13.60
RP – 250	4.60	6.90	6.20	11.50	13.80	16.10	18.40
RP – 315	5.00	7.50	10.10	12.50	15.00	17.50	20.00

Tabela 6. Ukupna masa uložaka (kg/m²)*Table 6 Total weight of layers (kg/m²)*

Tip platna <i>Canvas type</i>	Broj uložaka <i>Number of layers</i>						
	2	3	4	5	6	7	8
B – 50	2.60	3.90	5.20	6.50	7.80	9.10	10.40
B – 60	3.00	4.50	6.00	7.50	9.00	10.50	12.00
B – 80	3.46	5.19	6.92	89.65	10.38	12.10	13.84
PA – 120	1.86	2.79	3.72	4.65	5.58	6.50	7.44
PA – 160	2.20	3.30	4.40	5.50	6.60	7.70	8.80
PA – 250	2.70	4.05	5.40	6.75	8.10	9.45	10.80
PA – 315	3.04	4.56	6.08	7.60	9.12	10.64	12.16
EP – 125	1.84	2.76	3.68	4.60	5.52	6.44	7.36
EP – 160	2.10	3.15	4.20	5.25	6.30	7.35	10.56
EP – 250	2.64	3.96	5.28	6.60	7.92	9.24	10.56
EP – 315	2.94	4.41	5.88	7.35	8.82	10.29	11.76
RP – 125	2.20	3.30	4.40	5.50	6.60	7.70	8.80
RP – 160	2.60	3.90	5.20	6.50	7.80	9.10	10.40
RP – 250	3.60	5.40	7.20	9.00	10.80	12.60	14.40
RP – 315	4.20	6.30	8.40	10.50	12.60	14.70	16.80

3.5 Kvalitet obloge za transportnu traku

Odabрано: NZ 4/2

- debljina obloge gornjeg pokrovног sloja je 4,0 mm
- debljina donjeg pokrovног sloja je 2,0 mm ⇒ tabela 7.

$q_o = 7,74 \text{ kg/m}^2$ – masa gumenih obloga za odabranu traku ⇒ tabela 7.

3.5 Conveyor belt lining quality

Selected: NZ 4/2

- The thickness of the lining of the upper cover layer is 4.0 mm.
 - The thickness of the lower cover layer is 2.0 mm ⇒ Table 7.
- $q_o = 7,74 \text{ kg/m}^2$ – mass of rubber linings for the selected belt ⇒ Table 7.

Tabela 7. Masa gumenih obloga (kg/m^2)
Table 7 Mass of rubber linings (kg/m^2)

Debljina oblage (mm) <i>Lining width (mm)</i>	Kvalitet gumene obloge / Quality of rubber lining				
	M	N	VM	NZ	G
2/1 = 3	3,36	3,39	3,99	3,87	4,17
2/2 = 4	4,48	4,52	5,32	5,16	5,56
3/1 = 4	4,48	4,52	5,32	5,16	5,56
3/2 = 5	5,60	5,65	6,65	6,45	6,95
4/2 = 6	6,72	6,78	7,98	7,74	8,34
4/3 = 7	7,84	7,91	9,31	9,03	9,73
5/2 = 7	7,84	7,91	9,31	9,03	9,73
5/3 = 8	8,96	9,04	10,64	10,32	11,12
5/4 = 9	10,08	10,17	11,97	11,61	12,51
6/2 = 8	8,96	9,04	10,64	10,32	11,12
6/3 = 9	10,08	10,17	11,94	11,61	12,51
6/4 = 10	11,20	11,30	13,30	12,90	13,90
8/3 = 11	12,32	12,43	14,63	14,19	15,29
8/4 = 12	13,44	13,56	15,96	15,48	16,68

3.6 Promjer valjaka

Odabrano: $\varnothing = 108 \text{ mm}$ \Rightarrow tabela 8.

3.6 Roller diameter

Selected: $\varnothing = 108 \text{ mm}$ \Rightarrow Table 8.

Tabela 8. Referentne vrijednosti promjera nosećih valjaka u zavisnosti od širine i brzine trake

Table 8 Reference values of the diameter of the bearing rollers depending on the width and speed of the belt

v (m/s)	Širina trake B (mm) Belt width B (mm)									
	300	400	500	650	800	1000	1200	1400	1600	1800
1,05	51	51	51	90	90	90	108	108	108	133
1,31	51	51	65	90	90	108	108	108	108	133
1,68	51	65	90	108	108	100	108	108	133	133
2,09	51	65	90	108	108	100	108	108	133	133
2,62	65	65	108	108	108	108	133	133	133	159
3,35	65	65	108	108	108	108	133	133	133	159
4,19	65	90	108	133	133	133	133	133	133	159
5,24	90	90	108	133	133	133	133	133	133	159
6,70	90	90	108	133	133	133	133	133	159	159
8,38	90	90	133	133	133	133	159	159	159	159
10,5	90	90	133	133	133	133	159	159	159	159

3.7 Noseći valjci

$$g_v' = \frac{q_v \cdot n'}{L} \quad [\text{kg/m}] \quad \dots(5)$$

g_v' – masa rotirajućih dijelova nosećih valjaka po jednom metru dužnom transportera [kg/m'].

$q_v' = 18,0 \text{ kg}$ – masa rotirajućih dijelova nosećih trodijelnih valjaka u jednom slogu \Rightarrow tabela 9.

n' – broj nosećih slogova:

$$n' = \frac{L - l_v}{l'} + \frac{l_v}{l_1'} = \frac{135 - 3}{1,20} + \frac{3}{0,60} = \dots(6)$$

$= 115$ komada nosećih trodijelnih slogova.

$l_v = 3 \text{ m}$ – dužina utovarnog tijela transportera (dužina usmjerivača).

$l' = 1,20 \text{ m}$ – razmak slogova nosećih valjaka \Rightarrow tabela 10. (nasipna gustoća $1,56 \text{ t/m}^3$).

$l_1' = 0,5 \cdot l' = 0,5 \cdot 1,2 = 0,60 \text{ m}$ – razmak slogova na utovarnom mjestu. ... (7)

$$g_v' = \frac{q_v \cdot n'}{L} = \frac{18,0 \cdot 115}{135} = 15,333 \text{ kg/m}' \quad \dots(8)$$

3.7 Bearing rollers

$$g_v' = \frac{q_v \cdot n'}{L} \quad [\text{kg/m}] \quad \dots(5)$$

g_v' – mass of rotating parts of bearing rollers per one meter long of the conveyor [kg/m'].

$q_v' = 18,0 \text{ kg}$ – mass of rotating parts of bearing three - part rollers in one set \Rightarrow Table 9.

n' – number of supporting sets:

$$n' = \frac{L - l_v}{l'} + \frac{l_v}{l_1'} = \frac{135 - 3}{1,20} + \frac{3}{0,60} = \dots(6)$$

$= 115$ pieces of supporting three-part sets.

$l_v = 3 \text{ m}$ – length of the loading part of the conveyor (length of the router).

$l' = 1,20 \text{ m}$ – distance of bearing rollers \Rightarrow Table 10, (bulk density $1,56 \text{ t/m}^3$).

$l_1' = 0,5 \cdot l' = 0,5 \cdot 1,2 = 0,60 \text{ m}$ – distance of sets at the loading place. ... (7)

$$g_v' = \frac{q_v \cdot n'}{L} = \frac{18,0 \cdot 115}{135} = 15,333 \text{ kg/m}' \quad \dots(8)$$

Tabela 9. Približne mase nosećih i povratnih valjaka u kg**Table 9** Approximate masses of bearing and return rollers in kg

Promjer nosećih valjaka/ <i>Diameter of bearing rollers</i>	Tip nosećih valjaka/ <i>Type of bearing rollers</i>	Širina trake B (mm) <i>Belt width B (mm)</i>									
		300	400	500	650	800	1000	1200	1400	1600	2000
38	Vodoravan / horizontal	1,25	1,4	1,6	1,9	2,3					
	Dvodijelni / two-part	1,50	1,7	1,9	2,3	2,7					
	Trodijelni / three-part	1,80	2,0	2,2	2,6	3,1					
51	Vodoravan / horizontal	1,7	1,9	2,1	2,7	3,3					
	Dvodijelni / two-part	2,0	2,3	2,6	3,1	3,7					
	Trodijelni / three-part	2,5	2,7	3,1	3,5	4,1					
63	Vodoravan / horizontal	2,2	2,6	3,0	3,7	4,4	5,4				
	Dvodijelni / two-part	3,0	3,4	3,8	4,5	5,2	6,2				
	Trodijelni / three-part	3,8	4,6	4,6	5,9	6,0	7,0				
89	Vodoravan / horizontal		4,1	5,0	6,4	7,8	9,4	11,2	13,0		
	Dvodijelni / two-part		5,5	6,5	7,8	9,3	10,5	12,7	14,5		
	Trodijelni / three-part		7,0	7,9	9,3	10,7	12,5	14,1	15,9		
108	Vodoravan / horizontal			8,6	10,0	11,4	13,5	15,6	17,7	20,1	
	Dvodijelni / two-part			10,9	12,3	13,7	15,8	17,9	19,9	22,3	
	Trodijelni / three-part			13,1	14,5	15,9	18,0	20,1	22,2	24,6	
133	Vodoravan / horizontal				14,8	18,4	22,0	25,6	29,2		
	Dvodijelni / two-part				17,4	21,3	24,9	28,5	32,2		
	Trodijelni / three-part				20,0	24,2	27,8	31,4	35,0		
159	Vodoravan / horizontal						28,8	32,3	35,8	39,3	42,8
	Dvodijelni / two-part						33,4	36,9	40,4	43,9	47,4
	Trodijelni / three-part						38,0	41,5	45,0	48,5	52,0

Tabela 10. Razmak slogova nosećih valjaka**Table 10** Spacing in bearing rollers

Nasipna gustoća transportiranog materijala (t/m ³) <i>Bulk density of transported material (t/m³)</i>	Razmak između valjaka l' kod širine trake B (m) <i>Distance between rollers l' at belt width B (m)</i>						
	500 mm	650 mm	800 mm	1000 mm	1200 mm	1400 mm 1600 mm	1400 mm 1600 mm
do / up to 1,1	1,5	1,4	1,4	1,3	1,3	1,3	1,1
od / from 1,1 do / to 2,0	1,4	1,3	1,3	1,2	1,2	1,1	1,0
od / from 2,0 naviše / up	1,3	1,2	1,2	1,1	1,1	1,0	0,9

3.8 Povratni valjci

$$g_v'' = \frac{q_v''}{l''} = \frac{13,5}{3} = 4,5 \text{ kg/m'} \quad \dots(9)$$

g_v'' – masa rotirajućih dijelova povratnih valjaka po jednom dužnom metru transportera [kg/m'].

$q_v'' = 13,5 \text{ kg}$ – masa rotirajućih dijelova povratnih vodoravnih valjaka u jednom slogu
 \Rightarrow tabela 9.

$l'' = 3 \text{ m}$ – razmak slogova povratnih valjaka uzima se konstruktivno $(2 \div 3) \cdot l'$

$$G_t = 2 \cdot q_{tr} + g_v' + g_v'' + g_b = 2 \cdot 11,42 + 15,333 + 4,5 + 5,407 = 48,08 \text{ kg/m'} \quad \dots(10)$$

$$q_{tr} = b \cdot (q_u + q_o) = 1,0 \cdot (3,68 + 7,74) = 11,42 \text{ kg/m'} \text{ gdje su:}$$

$b = 1,0 \text{ m}$ – stvarna širina trake.

$q_u = 3,68$ – masa tekstilnog kostura (4 sintetička uloška kvaliteta EP-125) u kg/m².

$q_o = 7,74$ – masa gumene obloge (kvalitet NZ, debljine 4/2 = 6 mm) u kg/m².

$$q_b = 9,81 \cdot g_b = 9,81 \cdot 5,407 = 53,047 \text{ N/m'}$$

– linjska težina svih bubenjeva osim pogonskih.

$$g_b = \frac{\sum m_b}{L} = \frac{730}{135} = 5,407 \text{ kg/m} \quad \dots(11)$$

$$\sum m_b = n \cdot m_b = n_1 \cdot m_{b1} + n_2 \cdot m_{b2} = 2 \cdot 325 + 1 \cdot 80 = 730 \text{ kg} \quad \dots(12)$$

gdje su:

q_b – linjska težina svih bubenjeva osim pogonskih (N/m).

g_b – linjska masa svih bubenjeva osim pogonskih (kg/m).

$n_1 = 2$ – ukupan broj bubenjeva na transporteru bez pogonskih bubenjeva.

$n_2 = 1$ – ukupan broj otklonskih bubenjeva na transporteru.

$m_{b1} = 325 \text{ kg}$ – očitana masa bubenja prečnika Ø 400 mm i dužine 1150 (do 1200) mm iz tabele.

$m_{b2} = 80 \text{ kg}$ – očitana masa otklonskog bubenja do prečnika Ø250 mm i dužine 1150 mm iz tabele.

$L = 135 \text{ m}$ – dužina transporteru.

3.8 Return rollers

$$g_v'' = \frac{q_v''}{l''} = \frac{13,5}{3} = 4,5 \text{ kg/m'} \quad \dots(9)$$

g_v'' – mass of rotating parts of return rollers per one meter long conveyor [kg/m'].

$q_v'' = 13,5 \text{ kg}$ – mass of rotating parts of return horizontal rollers in one set \Rightarrow Table 9.

$l'' = 3 \text{ m}$ – the spacing of the return roller sets is taken constructively $(2 \div 3) \cdot l'$

$$G_t = 2 \cdot q_{tr} + g_v' + g_v'' + g_b = 2 \cdot 11,42 + 15,333 + 4,5 + 5,407 = 48,08 \text{ kg/m'} \quad \dots(10)$$

$$q_{tr} = b \cdot (q_u + q_o) = 1,0 \cdot (3,68 + 7,74) = 11,42 \text{ kg/m'}$$

where are:

$b = 1,0 \text{ m}$ – the actual width of the belt.

$q_u = 3,68$ – textile construction weight (4 synthetic inserts of EP-125 quality) in kg/m².

$q_o = 7,74$ – mass of rubber lining (quality NZ thickness 4/2 = 6 mm) u kg/m².

$q_b = 9,81 \cdot g_b = 9,81 \cdot 5,407 = 53,047 \text{ N/m'}$
– line weight of all drums except drive ones.

$$g_b = \frac{\sum m_b}{L} = \frac{730}{135} = 5,407 \text{ kg/m} \quad \dots(11)$$

$$\sum m_b = n \cdot m_b = n_1 \cdot m_{b1} + n_2 \cdot m_{b2} = 2 \cdot 325 + 1 \cdot 80 = 730 \text{ kg}$$

... (12)

where are:

q_b – line weight of all drums except drive ones (N/m).

g_b – line mass of all drums except drive ones (kg/m).

$n_1 = 2$ – total number of drums on the conveyor without drive drums.

$n_2 = 1$ – the total number of deflection drums on the conveyor.

$m_{b1} = 325 \text{ kg}$ – read mass of drum diameter Ø 400 mm and length 1150 (up to 1200) mm from the Table.

$m_{b2} = 80 \text{ kg}$ – the mass of the deflection drum up to a diameter of Ø250 mm and a length of 1150 mm from the Table.

$L = 135 \text{ m}$ – conveyor length.

$$\begin{aligned} G &= 3600 \cdot A \cdot v \cdot \rho = 3600 \cdot 0,0351 \cdot 1,70 \cdot \\ 1,56 &= 335,01 \quad [\text{t/h}]. \end{aligned} \quad \dots(13)$$

G – teoretska masa transportiranog materijala za jedan sat [t/h].

$$H = L \cdot \sin \beta = 135 \cdot \sin 2,5^\circ = 5,89 \quad \text{m} \quad \dots(14)$$

gdje su:

$\rho = 1,56 \text{ t/m}^3$ – nasipna gustoća materijala.
 H – visina dizanja ili spuštanja tereta, tj. visinska razlika krajnjih tačaka transporterja [m].

3.9 Dužinsko opterećenje transportovanog materijala

$$q_m = \frac{G}{3,6 \cdot v_t} = 54,74 \text{ kg/m}^1;$$

gdje je:

$G = 335,01 \text{ t/h}$ – časovni kapacitet.
... (15)

3.10 Dužinsko opterećenje od trake

$$q_t = B \cdot (z \cdot \delta_n + \delta_1 + \delta_2) \cdot \gamma_t \quad (\text{N/m}^1) \quad \dots(16)$$

$$q_t = 1 \cdot (4 \cdot 0,001 + 0,004 + 0,002) \cdot 9000$$

$$q_t = 90 \text{ N/m}^1$$

gdje su:

$B = 1,0 \text{ m}$ – širina trake.

$z = 4$ – broj uložaka.

$\delta_n = 0,001 \text{ m}$ – debljina jednog uložka.

$\delta_1 = 0,004 \text{ m}$ – debljina radne obloge.

$\delta_2 = 0,002 \text{ m}$ – debljina oslanjajuće obloge.

$\gamma_t \approx 9000 \text{ N/m}^3$ – zapreminska težina trake.

Broj uložaka (z) treba na kraju provjeriti i verifikovati sa maksimalnom silom (S_n).

3.11 Dužinsko opterećenje nosećih i povratnih valjaka

$$q_{vo} = \frac{G_{vo}}{l_{vo}} \text{ (N/m}^1\text{)} \rightarrow q_{vo} = \frac{360}{1,2} = 300,00 \text{ N/m}^1 \quad \dots(17)$$

$$q_{vp} = \frac{G_{vp}}{2 \cdot l_{vp}} \text{ (N/m}^1\text{)} \rightarrow q_{vp} = \frac{220}{2 \cdot 3} = 36,67 \text{ N/m}^1 \quad \dots(18)$$

gdje su:

$$\begin{aligned} G &= 3600 \cdot A \cdot v \cdot \rho = 3600 \cdot 0,0351 \cdot 1,70 \cdot \\ 1,56 &= 335,01 \quad [\text{t/h}]. \end{aligned} \quad \dots(13)$$

G – theoretical mass of transported material in one hour [t/h].

$$H = L \cdot \sin \beta = 135 \cdot \sin 2,5^\circ = 5,89 \quad \text{m}$$

... (14)

where are:

$\rho = 1,56 \text{ t/m}^3$ – bulk density of material.

H – height of lifting or lowering the load, i.e. height difference of the end points of the conveyor [m].

3.9 Length load of transported material

$$q_m = \frac{G}{3,6 \cdot v_t} = 54,74 \text{ kg/m}^1;$$

where is:

$G = 335,01 \text{ t/h}$ – time capacity.

... (15)

3.10 Belt length load

$$q_t = B \cdot (z \cdot \delta_n + \delta_1 + \delta_2) \cdot \gamma_t \quad (\text{N/m}^1) \quad \dots(16)$$

$$q_t = 1 \cdot (4 \cdot 0,001 + 0,004 + 0,002) \cdot 9000$$

$$q_t = 90 \text{ N/m}^1$$

where are:

$B = 1,0 \text{ m}$ – belt width.

$z = 4$ – number of layers.

$\delta_n = 0,001 \text{ m}$ – thickness of one insert.

$\delta_1 = 0,004 \text{ m}$ – working lining thickness.

$\delta_2 = 0,002 \text{ m}$ – the thickness of the supporting lining.

$\gamma_t \approx 9000 \text{ N/m}^3$ – bulk density of the belt.

The number of layers (z) should finally be checked and verified with maximum force (S_n).

3.11 Length load of bearing and return rollers

$$q_{vo} = \frac{G_{vo}}{l_{vo}} \text{ (N/m}^1\text{)} \rightarrow q_{vo} = \frac{360}{1,2} = 300,00 \text{ N/m}^1 \quad \dots(17)$$

$$q_{vp} = \frac{G_{vp}}{2 \cdot l_{vp}} \text{ (N/m}^1\text{)} \rightarrow q_{vp} = \frac{220}{2 \cdot 3} = 36,67 \text{ N/m}^1 \quad \dots(18)$$

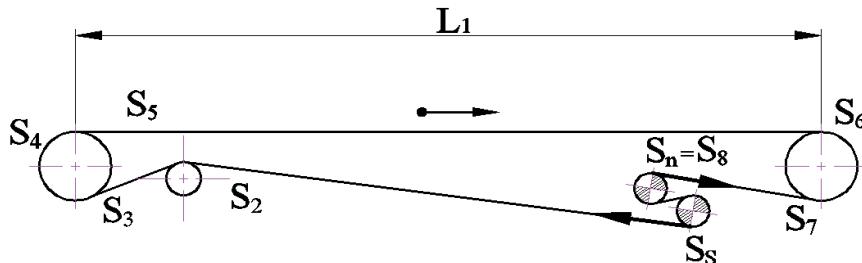
$G_{vp} = 80 + 140 \cdot B$...(20)	$G_{vo} = 130 + 230 \cdot B$...(19)
$l_{vo} = 1,925 - 0,625 \cdot B - 0,16 \cdot \rho \text{ (m)}$		$G_{vp} = 80 + 140 \cdot B$...(20)
$l_{vo} = 1,05 \text{ m} - \text{usvajam se } l_{vo} = 1,2 \text{ m} - \text{tabela 10.}$		$l_{vo} = 1,925 - 0,625 \cdot B - 0,16 \cdot \rho \text{ (m)}$	
$l_{vp} = (2 \div 3) \cdot l_{vo} - \text{usvaja se } l_{vp} = 3 \text{ m.}$		$l_{vo} = 1,05 \text{ m} - \text{selected } l_{vo} = 1,2 \text{ m} - \text{Table 10.}$	
$l_{vo} - \text{rastojanje između nosećih valjaka.}$		$l_{vp} = (2 \div 3) \cdot l_{vo} - \text{selected } l_{vp} = 3 \text{ m.}$	
$l_{vp} - \text{rastojanje između povratnih valjaka.}$		$l_{vo} - \text{the distance between the bearing rollers.}$	
$G_{vo} = 360 \text{ N} - \text{redukovana težina nosećih valjaka.}$		$l_{vp} - \text{the distance between the return rollers.}$	
$G_{vp} = 220 \text{ N} - \text{redukovana težina povratnih valjaka.}$		$G_{vo} = 360 \text{ N} - \text{reduced weight of bearing rollers.}$	
		$G_{vp} = 220 \text{ N} - \text{reduced weight of return rollers.}$	

4. KONTROLA I PRORAČUN SILA U TAČKAMA TRANSPORTERA METODOM OBILASKA PO KONTURI

Raspored konturnih sila na trasi trakastog transportera prikazan je na slici 2.

4. CONTROL AND CALCULATION OF FORCES AT CONVEYOR POINTS BY CONTOUR TRAVERSAL METHOD

The distribution of contour forces on the route of the belt conveyor is shown in Figure 2.



Slika 2. Shema transportera sa gumenom trakom za proračun zateznih sila na traci
Figure 2 Scheme of a conveyor with a rubber belt for the calculation of tensile forces on the belt

4.1 Otpori na punoj strani transportera

$$W_t = g \cdot [(q_m + q_{tr}) \cdot L \cdot c \cdot t \cdot \cos \beta + (g_v') \cdot L \cdot c \cdot t \pm (q_m + q_{tr}) \cdot L \cdot \sin \beta] \quad \dots(21)$$

$$W_t = 9,807 \cdot \left[(54,74 + 11,42) \cdot 135 \cdot 1,62 \cdot 0,022 \cdot \cos 2,5^\circ + (15,33) \cdot 135 \cdot 1,62 \cdot 0,022 \right. \\ \left. \pm (54,74 + 11,42) \cdot 135 \cdot \sin 2,5^\circ \right]$$

$$W_t = 7663,04 \text{ N} \quad \dots(22)$$

4.1 Resistances on the full side of the conveyor

4.2 Otpori na praznoj strani transportera

4.2 Resistances on the empty side of the conveyor

$$W_p = g \cdot [q_{tr} \cdot L \cdot c \cdot t \cdot \cos \beta + (g_v'') \cdot L \cdot c \cdot t \mp q_{tr} \cdot L \cdot \sin \beta] \quad \dots(23)$$

$$W_p = g \cdot [11,42 \cdot 135 \cdot 1,62 \cdot 0,022 \cdot \cos 2,5^\circ + (4,5) \cdot 135 \cdot 1,62 \cdot 0,022 \mp 11,42 \cdot 135 \cdot \sin 2,5^\circ]$$

$$W_p = 91,18 \text{ N}$$

...(24)

gdje je:

$t = 0,022$ – koeficijent trenja (ležišta bubnjeva i valjaka) za teške uslove rada (mogućnost prodiranja prašine u ležajeve, ljepljiv materijal itd.) – tabela 11.

$c = 1,62$ – faktor povećanja vučne sile koji uzima u obzir sporedne otpore ovisan o dužini transportera – tabela 12.

where is:

$t = 0,022$ – a coefficient of friction (bearings of drums and rollers) for difficult working conditions (possibility of penetration of dust into bearings, adhesive material, etc.) - Table 11.

$c = 1,62$ – a traction force increase factor that takes into account secondary resistances depending on the length of the conveyor - Table 12.

Tabela 11. Vrijednosti koeficijenta trenja "t"

Table 11 Friction coefficient values "t"

0,016 do / to 0,018	Za stabilna, dobro izrađena postrojenja sa kotrljajućim ležajevima, za transport, za transport materijala sa neznatnim unutarnjim trenjem. <i>For stable, well-made rolling bearing plants, for transport, for transport of materials with low internal friction.</i>
0,018 do / to 0,020	Za postrojenja s prosječnim uslovima rada. <i>For plants with average operating conditions.</i>
0,020 do / to 0,025	Za teške uslove rada (mogućnost prodiranja prašine u ležajeve, ljepljiv materijal). <i>For difficult working conditions (possibility of dust penetrating the bearings, adhesive material).</i>
0,05	Za postrojenja s kliznim ležajevima. <i>For plants with sliding bearings.</i>

Tabela 12. Vrijednosti faktora "c" u zavisnosti od transportne dužine

Table 12 Factor "c" values depending on the transport length

L (m)	c	L (m)	c	L (m)	c	L (m)	c	L (m)	c	L (m)	c	L (m)	c
<4	9	8	5,1	20	3,2	50	2,2	125	1,64	320	1,29	800	1,12
4	7,6	10	4,5	25	2,9	63	2	160	1,53	400	1,23	1000	1,1
5	6,6	12,5	4	32	2,6	80	1,85	200	1,45	500	1,19	1250	1,08
6	5,9	16	3,6	40	2,4	100	1,74	250	1,37	630	1,15		

$$S_s = S_1 \text{ (N)} \quad \dots(25)$$

$$S_s = S_1 \text{ (N)} \quad \dots(25)$$

$$S_8 \leq S_1 \cdot e^{(\mu_1 a_1 + \mu_2 a_2)}$$

$$S_8 \leq S_1 \cdot e^{(\mu_1 a_1 + \mu_2 a_2)} \quad \dots(26)$$

$$S_8 \leq S_1 \cdot e^{(\mu_1 a_1 + \mu_2 a_2)} \quad \dots(26)$$

Računajući da je:

$S_8 = 1,06 \cdot (S_1 + W_p) + W_t$ i iz uslova (25), dobije se:

$$\begin{aligned} S_1 &= \frac{W_t + 1,06 \cdot W_p}{e^{(\mu_1 \alpha_1 + \mu_2 \alpha_2)} - 1,06} = \\ &= \frac{7663,04 + 1,06 \cdot 91,18}{4,33 - 1,06} = 2363,89 \text{ N} \end{aligned} \quad \dots(27)$$

$\mu_1 = \mu_2 = 0,2$ – koeficijent klizanja između trake i bubnja.

$\alpha_1 = \alpha_2 = 210^\circ$ – obuhvatni ugao trake oko bubnjeva (tj. izražen u radijanima $\alpha_1 = \alpha_2 = 3,6652$).

$$e^{(\mu_1 \alpha_1 + \mu_2 \alpha_2)} = e^{1,46608} = 4,33 \quad \dots(28)$$

$$k_1 = 1,015, \quad k_2 = 1,025$$

$$S_1 = S_s \text{ (N)} \rightarrow S_1 = 2363,89 \text{ N} \quad \dots(30)$$

$$S_2 = S_1 + W_p \text{ (N)} \rightarrow S_2 = 2455,07 \text{ N} \quad \dots(31)$$

$$S_3 = k_1 \cdot S_2 \text{ (N)} \rightarrow S_3 = 2491,89 \text{ N} \quad \dots(32)$$

$$S_4 = k_2 \cdot S_3 \text{ (N)} \rightarrow S_4 = 2554,19 \text{ N} \quad \dots(33)$$

$$S_5 = S_4 + W_{ut} \text{ (N)} \rightarrow S_5 = 2625,02 \text{ N} \quad \dots(34)$$

$$W_{ut} = \frac{Q_u \cdot v_t^2}{2 \cdot 3,6 \cdot v_t} = \frac{300 \cdot 1,7^2}{2 \cdot 3,6 \cdot 1,7} \text{ N} \rightarrow W_{ut} = 70,83 \text{ N} \quad \dots(35)$$

$$S_6 = S_5 + W_t \text{ (N)} \rightarrow S_6 = 10288,06 \text{ N} \quad \dots(36)$$

$$S_7 = S_6 \text{ (N)} \rightarrow S_7 = 10288,06 \text{ N} \quad \dots(37)$$

$$S_8 = 1,06 \cdot (S_1 + W_p) + W_t \rightarrow S_8 = 10240,86 \text{ N} \quad \dots(38)$$

$$S_8 \leq S_1 \cdot e^{(\mu_1 \alpha_1 + \mu_2 \alpha_2)} \quad \dots(39)$$

$$10240,86 \leq 2363,89 \cdot e^{1,46608} = 10240,86 \quad \dots(40)$$

Obodna sila:

$$W = S_{max} - S_{min} \text{ (N)}$$

...(41)

$$W = 10288,06 - 2363,89 = 7924,17 \text{ N}$$

...(42)

4.3 Provjera potrebnog broja uložaka

Broj uložaka od umjetnih vlakana računa se po obrascu:

$$z = \frac{k_t \cdot S_{max}}{B \cdot \sigma_t} + 1 = \frac{9,8 \cdot 10288,06}{1 \cdot 122588} + 1 =$$

$$1,82 \rightarrow z = 4 \Rightarrow \text{usvojeno} \quad \dots(43)$$

Calculating that:

$S_8 = 1,06 \cdot (S_1 + W_p) + W_t$ and from condition (25), the following is obtained:

$$\begin{aligned} S_1 &= \frac{W_t + 1,06 \cdot W_p}{e^{(\mu_1 \alpha_1 + \mu_2 \alpha_2)} - 1,06} = \\ &= \frac{7663,04 + 1,06 \cdot 91,18}{4,33 - 1,06} = 2363,89 \text{ N} \end{aligned} \quad \dots(27)$$

$\mu_1 = \mu_2 = 0,2$ – the slip coefficient between the belt and the drum.

$\alpha_1 = \alpha_2 = 210^\circ$ – the coverage angle of the strip around the drums (i.e., expressed in radians $\alpha_1 = \alpha_2 = 3,6652$).

$$e^{(\mu_1 \alpha_1 + \mu_2 \alpha_2)} = e^{1,46608} = 4,33 \quad \dots(28)$$

$$\dots(29) \quad \dots(30)$$

$$\dots(31)$$

$$\dots(32)$$

$$\dots(33)$$

$$\dots(34)$$

$$\dots(35)$$

$$\dots(36)$$

$$\dots(37)$$

$$\dots(38)$$

$$\dots(39)$$

$$\dots(40)$$

Circumferential force:

$$W = S_{max} - S_{min} \text{ (N)}$$

...(41)

$$W = 10288,06 - 2363,89 = 7924,17 \text{ N}$$

...(42)

4.3 Check the required number of layers

The number of artificial fiber layers is calculated according to this:

$$z = \frac{k_t \cdot S_{max}}{B \cdot \sigma_t} + 1 = \frac{9,8 \cdot 10288,06}{1 \cdot 122588} + 1 = 1,82$$

$$\rightarrow z = 4 \Rightarrow \text{adopted}$$

...(43)

gdje su:

B – širina trake (m).

S_{max} – najveća sila na trasi trakastog transportera (N).

k_t – koeficijent sigurnosti ($k_t = 9,8$).

σ_t – prekidna čvrstoća trake ($\sigma_t = 122588 \text{ N/m}$).

where are:

B – belt width (m).

S_{max} – maximum force on the belt conveyor route (N).

k_t – safety factor ($k_t = 9,8$).

σ_t – breaking strength of the belt ($\sigma_t = 122588 \text{ N/m}$).

4.4 Provjera minimalne sile zatezanja iz uslova dozvoljenog ugiba trake

$$\begin{aligned} S_{min} &= 9,807 \cdot \frac{(q_m + q_{tr}) \cdot l'^2}{8 \cdot f_{doz}} = \\ &= 9,807 \cdot \frac{(54,74 + 11,42) \cdot 1,2^2}{8 \cdot 0,024} \end{aligned}$$

...(45)

$$S_{min} = 4866,23 \text{ N}$$

...(46)

gdje su:

S_{min} - minimalna sila napinjanja trake potrebna da bi progib ostao u dozvoljenim granicama.

f_{doz} - dozvoljeni progib trake između dva noseća sloga.

$$f_{doz} = 0,02 \cdot l' = 0,02 \cdot 1,2 = 0,024 \text{ m}$$

...(44)

4.5 Snaga potrebna za pogon opterećenog transportera bez dodatnih otpora

$$\begin{aligned} P_{bo} &= F_{bo} \cdot v = 8012,85 \cdot 1,70 = \\ &= 13621,84 \text{ W} = 13,62 \text{ kW} \end{aligned}$$

...(47)

$$F_{bo} = g \cdot \left[c \cdot t \cdot L \cdot \left(G_t + \frac{G}{3,6 \cdot v} \right) \pm \frac{G \cdot H}{3,6 \cdot v} \right]$$

...(48)

4.4 Checking the minimum tensile force from the conditions of the allowed deflection of the belt

$$\begin{aligned} S_{min} &= 9,807 \cdot \frac{(q_m + q_{tr}) \cdot l'^2}{8 \cdot f_{doz}} = \\ &= 9,807 \cdot \frac{(54,74 + 11,42) \cdot 1,2^2}{8 \cdot 0,024} \end{aligned}$$

...(45)

$$S_{min} = 4866,23 \text{ N}$$

...(46)

where are:

S_{min} - the minimum tensioning force of the belt required to keep the deflection within the permitted limits.

f_{doz} - permissible deflection of the belt between two supporting sets.

$$f_{doz} = 0,02 \cdot l' = 0,02 \cdot 1,2 = 0,024 \text{ m}$$

...(44)

4.5 Power required to drive a loaded conveyor without additional resistance

$$\begin{aligned} P_{bo} &= F_{bo} \cdot v = 8012,85 \cdot 1,70 = \\ &= 13621,84 \text{ W} = 13,62 \text{ kW} \end{aligned}$$

...(47)

$$F_{bo} = g \cdot \left[c \cdot t \cdot L \cdot \left(G_t + \frac{G}{3,6 \cdot v} \right) \pm \frac{G \cdot H}{3,6 \cdot v} \right]$$

...(48)

$$F_{bo} = 9,807 \cdot \left[1,62 \cdot 0,022 \cdot 135 \cdot \left(48,08 + \frac{335,01}{3,6 \cdot 1,70} \right) + \frac{335,01 \cdot 5,89}{3,6 \cdot 1,70} \right] \quad \dots(49)$$

$$F_{bo} = 8012,85 \text{ N} \quad \dots(50)$$

gdje je:

F_{bo} – vučna sila na obodu pogonskog bubenja (N).

where is:

F_{bo} – traction force on the circumference of the drive drum (N).

4.6 Dodatna snaga zbog dopunskih otpora uslijed skidača materijala i čistača

$$P_d = 1,6 \cdot v \cdot b \cdot n = 1,6 \cdot 1,70 \cdot 1,00 \cdot 3,0 = \\ = 8,16 \text{ kW} \quad \dots(51)$$

$n = 3$ – broj čistača.

4.7 Dodatna snaga zbog otpora uslijed bočnih vodilica

$$P_v = 0,08 \cdot l_I = 0,08 \cdot 3 = 0,24 \text{ kW} \quad \dots(52)$$

$l_I = 3 \text{ m}$ – dužina vodilica (usmjerivača).

4.8 Snaga motora za pogon transporterja

$$P_m = \frac{P_{ef}}{\eta} = \frac{22,02}{0,80} = 25,91 \text{ kW} \quad \dots(53)$$

$$P_{ef} = P_{bo} + P_d + P_v = 13,62 + 8,16 + 0,24 \quad \dots(54)$$

$P_{ef} = 22,02 \text{ kW}$ – efektivna snaga motora za pogon transporterja.

$\eta = 0,80 \div 0,85$ – koeficijent korisnog učinka mehaničkog prijenosa između elektromotora i bubenja.

Shodno gore navedenom, na spomenuti transporter bit će ugrađena pogonska jedinica instalirane snage elektromotora 45 kW.

4.9 Vučna sila u traci na bubenju

$$F_b = \frac{P_{ef}}{v} = \frac{22,02}{1,70} = 12954,02 \text{ N} \quad \dots(55)$$

4.10 Ukupna vučna sila u traci na punoj strani

$$F_t = F_{b1} + F_{b2} \quad \dots(56)$$

$$F_{b1} = F_b \frac{1}{e^{\mu a_r} + 1} = 12954,02 \cdot \frac{1}{2,08 + 1} = 4205,85 \text{ N} \quad \dots(57)$$

$$F_{b2} = F_b - F_{b1} = 12954,02 - 4205,85 = 8748,17 \text{ N} \quad \dots(58)$$

4.6 Extra power due to additional resistances due to material removers and cleaners

$$P_d = 1,6 \cdot v \cdot b \cdot n = 1,6 \cdot 1,70 \cdot 1,00 \cdot 3,0 = \\ = 8,16 \text{ kW} \quad \dots(51)$$

$n = 3$ – number of cleaners.

4.7 Extra power due to resistance due to side guides

$$P_v = 0,08 \cdot l_I = 0,08 \cdot 3 = 0,24 \text{ kW} \quad \dots(52)$$

$l_I = 3 \text{ m}$ – length of guides (routers).

4.8 Engine power to drive the conveyor

$$P_m = \frac{P_{ef}}{\eta} = \frac{22,02}{0,80} = 25,91 \text{ kW} \quad \dots(53)$$

$$P_{ef} = P_{bo} + P_d + P_v = 13,62 + 8,16 + 0,24 \quad \dots(54)$$

$P_{ef} = 22,02 \text{ kW}$ – effective motor power to drive the conveyor.

$\eta = 0,80 \div 0,85$ – the efficiency of the mechanical transmission between the electric motor and the drum.

Given the above, a drive unit with electric motor power of 45 kW will be installed on the mentioned conveyor.

4.9 Traction force in the belt on the drum

$$F_b = \frac{P_{ef}}{v} = \frac{22,02}{1,70} = 12954,02 \text{ N} \quad \dots(55)$$

4.10 Total traction force in the belt on the full side

$$F_t = F_b \cdot \left(1 + \frac{1}{e^{\mu\alpha_r} - 1} \right) = 12954,02 \cdot (1 + 0,93) = 25001,26 \text{ N} \quad \dots(59)$$

$$e^{\mu\alpha_r} = 2,08 \text{ za } \mu=0,20 \text{ i } \alpha=210^\circ \quad \dots(60)$$

$\mu = 0,20$ – koeficijent trenja između bubenja i trake \Rightarrow tabela 13.

$\mu = 0,20$ – coefficient of friction between the drum and the belt \Rightarrow Table 13.

Tabela 13. Koeficijent trenja između bubenja i trake za bubanj
Table 13 Coefficient of friction between the drum and the belt

μ	Vrijednost izraza $e^{\mu\alpha_r}$ za α											
	The value of the expression $e^{\mu\alpha_r}$ for α											
	180°	210°	240°	270°	300°	330°	360°	380°	400°	420°	450°	480°
0,1	1,37	1,44	1,52	1,60	1,69	1,78	1,87	1,94	2,01	2,08	2,19	2,31
0,15	1,60	1,87	1,87	2,03	2,19	2,37	2,57	2,71	2,85	3,00	3,25	3,51
0,2	1,87	2,31	2,31	2,57	2,85	3,16	2,51	3,77	4,04	4,33	4,84	5,34
0,3	2,56	3,51	3,51	4,11	4,81	5,63	6,69	7,31	8,14	9,00	10,50	12,35
0,35	3,00	4,33	4,33	5,20	6,27	7,51	9,02	10,19	11,50	13,00	15,60	19,22
0,4	3,51	5,34	5,34	6,59	8,12	10,01	12,33	14,35	16,30	18,50	23,00	28,51

4.11 Prijelazna dužina trake

Odabрано: za $b = 1,00 \text{ m}$ i nagib valjaka $\lambda = 20^\circ \Rightarrow L_p = 0,85 \text{ m}$

L_p – prijelazna dužina trake od zadnjeg nosećeg sloga do pogonskog bubenja [m] \Rightarrow tabela 14.

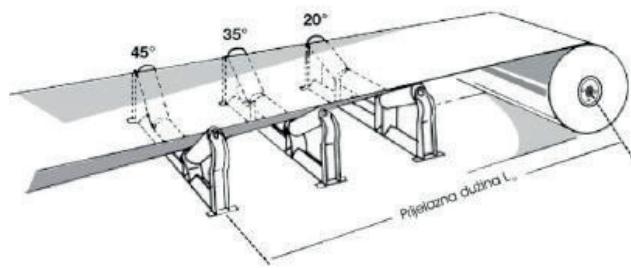
4.11 Transition strip length

Selected: for $b = 1,00 \text{ m}$ and roller inclination $\lambda = 20^\circ \Rightarrow L_p = 0,85 \text{ m}$

L_p – transition length of the strip from the

Tabela 14. Prijelazne dužine transportnih traka
Table 14 Transition lengths of conveyor belts

Širina trake B (mm) <i>Belt width B (mm)</i>	$\lambda = 20^\circ$	$\lambda = 30^\circ$
300	0,25	0,35
400	0,35	0,50
500	0,40	0,60
650	0,55	0,85
800	0,65	1,00
1000	0,85	1,25
1200	1,00	1,50
1400	1,20	1,80
1600	1,40	2,10
1800	1,60	2,40
2000	1,75	2,60
2200	1,95	2,90



*Slika 3. Prijelazne dužine
Figure 3 Transition lengths*

5. ZAKLJUČAK

U ovom radu dati su: kontrolni proračuni sila zatezanja u konturnim tačkama transportera, koji se koristi u jami „Begići-Bištrani“ Rudnika Kakanj, proračun snage motora, broj uložaka u gumenom transporteru i minimalno potrebno zatezanje. Brzina trake bira se na temelju vrste materijala koji se transportira, dužine puta i namjene transportera. Najčešće upotrebljavani oblici poprečnog presjeka transporteru s gumenom trakom su transporteri s ravnom trakom, transporteri s trakom u obliku slova V, transporteri s koritastom trakom sa bočnim valjcima pod nagibom 20° i transporteri s koritastom trakom sa bočnim valjcima pod nagibom 30° . Zavisno od uslova rada, transportne trake se izrađuju u različitim konstrukcijama. Debljina trake zavisi od konstrukcije trake i računa se debljina obloga i broj umetaka.

Gumene transportne trake spadaju u transportna sredstva kontinuiranog načina djelovanja i rade na principu trenja između gumene trake, koja je noseći elemenat, i pogonskih bubenjeva.

5. CONCLUSION

This paper presents: control calculations of tensile forces in the contour points of the conveyor, which is used in the pit "Begići-Bištrani" of the Kakanj Mine, calculation of engine power, number of inserts in the rubber conveyor and the minimum required tension. The speed of the belt is chosen based on the type of material being transported, the length and the purpose of the conveyor. The most commonly used cross-sectional forms of rubber belt conveyors are flat belt conveyors, V-belt conveyors, 20° side roller conveyors with side rollers and 30° side roller conveyors with side belt trough. Depending on the working conditions, conveyor belts have different constructions. The thickness of the belt depends on the construction of the belt, and when calculated, the thickness of the lining and the number of inserts are taken into account. Rubber conveyor belts are the means of transport for continuous mode of operation and they work on the principle of friction between the rubber belt, as the supporting element, and the drive drums.

6. LITERATURA – REFERENCES

- [1] Pravilnik o tehničkim normativima za prijevoz transporterima sa trakom u rudarstvu ("Službeni list SFRJ", br. 5/73, 12/74, 4/86 i 4/89)
- [2] DRP otvaranja i pripremanja OP Kk-III („A“ ploče) krovnog ugljenog sloja jame „Begići-Bištrani“ pogona „HALJINIĆI“, RMU „KAKANJ“ d.o.o. Kakanj, (rudarsko, mašinski i elektro dio)
- [3] Zakon o rudarstvu Federacije Bosne i Hercegovine (Službene novine 26/10 – 05. 05. 2010. godine)
- [4] Pravilnik o tehničkim normativima za podzemnu eksploraciju ugljena ("Službeni list SFRJ", br. 4/89, 45/89, 3/90 i 54/90)
- [5] https://rudar.rgn.hr/~tkorman/nids_tkor/man/Transport/Vjezbe/TabliceIIProgram.pdf; pristupljeno 08. 10. 2021. godine

Corresponding author:

Kasim Bajramović

Faculty of mechanical engineering of the University of Zenica / RMU „Kakanj“ d.o.o. Kakanj

**Email: kasimbajramovic@gmail.com
kasim.bajramovic@mf.unze.ba**

Phone: +387 (0)61 136 095

UPRAVLJANJE PROCESIMA RIZIKA U PROJEKTIMA PREMA SMJERNICAMA ISO 10006:2017

RISK MANAGEMENT FOR PROJECTS ACCORDING TO ISO 10006:2017

Emir Babić¹

Sabahudin Jašarević²

¹Krivaja Metali d.o.o.

²Univerzitet u Zenici,
Politehnički fakultet

Ključne riječi:

upravljanje rizicima,
ISO 10006:2017, procedure

Keywords:

risk management,
ISO 10006:2017, procedures

Paper received:

29.10.2021.

Paper accepted:

29.12.2021.

REZIME

Upravljanje projektima predstavlja složen proces prilikom kojega je potrebno adekvatno upravljati aktivnostima i procesima, koje projekat sadrži, kako bi se ostvarili pozitivni poslovni rezultati. Svaki projekat sadrži procese koje je neophodno izvršiti kako bi se ostvario projektni proizvod. U ovom radu analiziran je proces upravljanja rizicima definiran prema smjernicama standarda ISO 10006:2017. Upravljanje kvalitetom procesa rizika, analizirano u radu, može se primjenjivati za različite projekte, bez obzira na njihovu prirodu i veličinu. Na osnovu definiranih i analiziranih aktivnosti unutar procesa rizika moguće je projektovati procedure za upravljanje kvalitetom procesa rizika u projektima. Shema koja je izvedena iz smjernica datih prema standardu ISO 10006:2017 omogućava jasan uvid u kompletan proces upravljanja rizicima, od planiranja do završne faze projekta.

SUMMARY

Project management is a complex process in which it is necessary to adequately manage the activities and processes contained in the project, in order to achieve positive business results. Each project encompasses processes that are necessary to make, in order to achieve the project product. This paper analyzes the risk management process defined according to the guidelines of the ISO 10006:2017 standard. The quality management of the risk process analyzed in the paper can be applied to different projects, regardless of their nature and size. Based on the defined and analyzed activities within the risk process, it is possible to design procedures for managing the quality of risk process in projects. The scheme, derived from the guidelines given according to the ISO 10006:2017 standard, provides a clear overview of the complete risk management process, from planning to the final phase of the project.

1. UVOD

Izvođenje projekata sa sobom povlači veliki broj rizika koji se mogu desiti. Rizicima je potrebno upravljati kako bi se izbjegli nepoželjni efekti, koji mogu negativno utjecati na rezultate projekta, npr. poput nepredviđenih rasipanja sredstava. Upravljanje procesima rizika predstavlja skup aktivnosti kojima je zajednički cilj prepoznavanje svih potencijalnih rizika te njihovo tretiranje do završetka projekta i zaključivanja radova. S druge strane, ako se u fazi planiranja prepoznaju svi rizici, moguće je donijeti odluke koje će ih ublažiti ili izbjegći te čak pretvoriti u poslovne prilike.

1. INTRODUCTION

Execution of projects entails a large number of risks that may occur. Risks need to be managed to avoid undesirable effects that could negatively impact the project results, e.g. in the form of unforeseen waste of capital. The management of risk processes represents a set of activities with the common goal of identifying all potential risks and treating them until the end of the project and the conclusion of the works. On the other hand, if all risks are recognized in the planning phase, it is possible to make decisions that will mitigate or avoid them and even turn them into business opportunities.

Rizike i njihove učinke trebalo bi promatrati na svim ključnim mjestima odlučivanja u projektu i putem svih sudionika uključenih u proces donošenja odluka [1]. Odgovorni za donošenje odluka treba da identificiraju, analiziraju i procijene rizike u čitavom životnom ciklusu projekta te da koriste organizacijsku strukturu i administrativne prakse kako bi se djelovalo na rizike u korist projekta [2]. Da bi se osigurao kvalitet upravljanja procesima rizika, neophodno je osigurati sve potrebne informacije i iskorisiti ih za donošenje odluka. Najbolji način za to je da se prilikom izvođenja projekata evidentiraju i arhiviraju sve značajne informacije do kojih se došlo. Složenost projekta i zrelost organizacija promatraju se kao važni faktori koji mogu utjecati na uspjeh projekta [3]. Zbog toga je potrebno evidentirati sva stečena znanja, arhivirati ih i na osnovu njih donositi odluke koje će donijeti koristi u budućnosti. Procedurama se definiraju ključne faze u kojima se evidentiraju svi značajni podaci i informacije, a koje služe za upravljanje kvalitetom procesa rizika.

2. UPRAVLJANJE PROJEKTIMA

Projekat je jednokratan i cjelovit proces, poseban i jedinstven (zbog različitih ciljeva, obima, rokova, troškova, potrebnih kadrova i dr.), ciljno usmjeren, s određenim početkom i zahtjeva organizaciju izvođenja za vrijeme svog trajanja, sve dok se ne postigne konačni, zadani cilj [4].

To je jedinstven proces, koji se sastoji od skupa koordiniranih i kontroliranih aktivnosti s datumom početka i završetka, koje se poduzimaju radi postizanja cilja koji je u skladu sa specifičnim zahtjevima, uključujući ograničenja vremena, troškova i mogućnosti [5].

Svaki projekat ima određene posebnosti, a one zavise od niza parametara, kao što su oblast radova, vrijeme trajanja, složenost, broj učesnika i slični parametri. Pogotovo je kod složenih projekata teško predvidjeti sve probleme i neusklađenosti koji se mogu pojaviti prilikom izvođenja. Moguće je, međutim, stalno usavršavati znanja izvođenja projekata, iskustvena i naučna, kako bi se neželjeni efekti sveli na minimum, odnosno kako bi se adekvatno upravljalo projektnim ciljem. Zbog svoje složenosti najbolje je projekte podijeliti u faze izvođenja i tako

Risks and Risk process management is a set of activities with their effects should be observed in all key decision-making positions in the project and through all participants involved in the decision-making process [1]. Responsible persons for decision making should identify, analyze and assess risks throughout the project life cycle and use their organizational structure and administrative practices to address the risks in favor of the project [2]. In order to ensure the quality of risk process management, it is necessary to provide all the necessary information and use it for decision making. The best way to do this is to record and archive all significant information that has occurred during the execution of the project. Project complexity and organizational tradition are viewed as important factors that can influence project success [3]. Therefore, it is necessary to record all acquired knowledge, archive it and make decisions based on it, which will bring benefits in the future. The procedures define the key stages when to record all relevant data and information, for the reason of using it for managing the quality of risk process.

2. PROJECT MANAGEMENT

The project is a one-time and complete process, special and unique (due to different goals, scope, deadlines, costs, required staff, etc.), targeted, with a specific beginning and it requires the organizational execution during its duration, until the final target is achieved [4].

It is a single process, consisting of a set of coordinated and controlled activities with a start and end date, undertaken to achieve a final goal that is in line with specific requirements, including time, costs and opportunities constraints [5].

Each project has certain features and they depend on a number of parameters, such as the scope of work, duration, complexity, number of participants and other similar parameters. Especially with complex projects, it is difficult to predict all the problems and inconsistencies that may arise common goal to identify all potential risks and treat them until the end of the project. On the other hand, if all risks are identified in the planning phase, it is possible to make decisions

pojednostaviti upravljanje, tj. imati nekoliko kontrolnih tačaka uspješnosti.

Prema [6], faze životnog ciklusa kroz koje prolazi svaki projekat su:

- pokretanje projekta,
- organiziranje i priprema,
- izvođenje projektnog zadatka i
- zatvaranje projekta.

Svaka od faza okarakterizirana je određenim specifičnostima i kao takva predstavlja bitan segment upravljanja projektima. S obzirom da ovaj rad analizira procese rizika, bitno je naglasiti da su prema [6] oni najveći u početnoj fazi projekta, jer se na osnovu donesenih odluka i prepoznatih rizika planiraju ostale faze projekta.

2.1. Dokumentovanje odluka i stečenih znanja

Za pravilno upravljanje projektima neophodno je usvojiti procedure za provođenje projekta u svim fazama. Procedure definiraju skup uputstava za upotrebu osobi ili osobama, koje izvršavaju određeni zadatak, o tome šta treba učiniti, kako to učiniti, kada i kako to arhivirati [7].

Procedure treba da održe kontinuitet i kvalitet poslovanja, jer se zasnivaju na dobroj poslovnoj praksi i stručnim znanjima [8].

Za pisanje procedura potrebno je mnogo iskustvenog i naučnog znanja, na temelju kojeg će se definirati koraci za upravljanje projektima. Pomoću definiranih koraka u procedurama ostvaruje se jasnije, brže i pouzdanije donošenje odluka na aktuelnim projektima, a donesene odluke je potrebno evidentirati i iskoristiti kod donošenja novih u novim projektima. To znači da definirani koraci upravljanja projektima moraju da budu jasni, konkretni i jednostavnii za upotrebu kako bi se pomoću njih ostvarila bolja efikasnost upravljanja.

during project execution. But, it is possible to constantly improve the knowledge of project implementation, experiential and scientific, in order to reduce negative effects to a minimum, i.e., to adequately manage the project goal. Due to their complexity, it is best to divide projects into implementation phases and, in that way, simplify their management, i.e., introduce several control points of success.

According to [6], the life cycle phases that each project goes through are:

- launching the project,
- organization and preparation,
- execution of the project task and
- project closure.

Each of these phases is characterized by certain specific features and as such represents an important segment of project management. Considering that this paper analyzes the risk processes, it is important to emphasize that according to [6], the greatest challenge is the initial phase of the project, because remaining phases will be planned according to the decisions made and risks identified in this phase.

2.1. Documenting decisions and acquired knowledge

For proper project management, it is necessary to adopt procedures for project implementation at all stages. Procedures define a set of instructions for a person or persons who are performing a specific task, informing them on what to do, how to do it, when and how to archive it [7].

Procedures should maintain business continuity and quality as they are based on good business practice and expertise [8].

Writing procedures requires a lot of experiential and scientific knowledge, on the basis of which the project management steps will be defined. According to the defined steps in the procedures, clearer, faster and more reliable decision-making on current projects is achieved, and the decisions made need to be recorded and used when making new ones in new projects. This means that the defined project management steps must be clear, specific and easy for use, in order to help achieve better management efficiency.

Svaka oblast projekta treba da ima definirane procedure za upravljanje, odnosno dokumentaciju na osnovu koje se vrši praćenje i upravljanje. Prema [5] da bi se neki projekat izveo potrebno je izvršiti navedenih sedam grupa procesa:

- međuzavisni procesi,
- procesi obima,
- vremenski procesi,
- troškovni procesi,
- komunikacijski procesi,
- procesi rizika i
- procesi nabavke.

Nisu svi procesi, definirani prema standardu ISO 10006:2017, neophodni za određeni projekat, dok su u nekim projektima možda potrebni i dodatni procesi [5]. Stoga, svaki projekat je potrebno analizirati prije njegovog provođenja, a preduzeće mora definirati procedure za upravljanje, kako bi osiguralo i bolje upravljanje kvalitetom.

Pošto su ovim radom obuhvaćeni procesi rizika, u nastavku rada bit će detaljno analizirani, a smjernice se mogu upotrebljavati za upravljanje procesima rizika u projektima, na način da ih preduzeća mogu prilagoditi svojim potrebama i mogućnostima.

3. UPRAVLJANJE PROCESIMA RIZIKA PREMA SMJERNICAMA ISO 10006:2017

Upravljanje rizicima je proces identifikacije i obrade rizika, uzimajući u obzir kontekst i ciljeve organizacije, zahtjeve zainteresovanih strana, kao i druga pitanja i zahtjeve sistema upravljanja kvalitetom, te definiranje kontrolnih aktivnosti kao preventivne mјere, čiji je cilj izbjegavanje neželjenih događaja, i praćenje njihove realizacije [9]. U cilju osiguranja prepoznavanja i upravljanja rizicima organizacija prije svega mora da ima razvijene alate za upravljanje rizicima i metode za njihovu identifikaciju. Procedure su ključne za upravljanje rizicima, jer se na osnovu definiranih koraka na kritičnim mjestima donose važne odluke koje će utjecati na izvođenje projekta u svim njegovim fazama. Rizici se često smatraju

Each area of the project should have defined management procedures, i.e., documentation on the basis of which monitoring and management are performed. According to [5], in order to carry out a project, it is necessary to perform the following seven groups of processes:

- interdependent processes,
- scope-related processes,
- time-related processes,
- cost-related processes,
- communication-related processes,
- risk-related processes, and
- procurement processes.

Not all processes, defined according to ISO 10006:2017, are necessary for a particular project, while some projects may require even additional processes [5]. Therefore, each project needs to be analyzed before it is implemented, and the company must define project management procedures in order to manage quality better. As this paper covers the risk processes, they will be analyzed in detail in the following, and the guidelines can be used to manage risk processes in projects, in a way that companies can adapt them to their needs and capabilities.

3. RISK PROCESS MANAGEMENT ACCORDING TO ISO 10006:2017 GUIDELINES

Risk management is the process of identifying and processing risk, considering the context and goals of the organization, stakeholder requirements, as well as other issues and requirements of the quality management system, defining control activities as measures aimed at avoiding negative effects and monitoring their implementation [9]. In order to ensure the identification and management of risks, the organization must first of all have developed tools for risk management and methods for their identification. Procedures are crucial for risk management, because - based on defined steps - important decisions are made in critical points that will affect the execution of the project in all its phases. Risks are often considered as a

negativnom pojavom, međutim ako se na vrijeme prepoznaju, moguće je njima upravljati ili ih tretirati na neki drugi način. Iskustvena znanja i tradicija firme omogućavaju da se prepoznaju svi rizici i da se njima upravlja.

Procesi rizika prema smjernicama standarda ISO 10006:2017 dijele se na [5]:

- prepoznavanje rizika,
- procjenu rizika,
- upravljanje rizikom i
- kontrolu rizika.

Definirani procesi prema standardu ISO 10006:2017 daju smjernice za tretiranje rizika od faze prepoznavanja do njihove kontrole. Svaka od faza je bitna za uspješnost projekta, a prema [10] rizik i neizvjesnost su najveći u početnoj fazi pokretanja projekta.

U nastavku je prikazana shema upravljanja kvalitetom procesâ rizika, koja je prilagođena smjernicama standarda ISO 10006:2017. Na ovaj je način olakšano razumijevanje procesâ rizika, koji su slikovito prikazani, te je na osnovu sheme moguće organizirati poslovanje i kreirati procedure za poslovanje i kroz njih poboljšati sistem upravljanja kvalitetom procesâ rizika te na taj način izbjegći neželjene posljedice. Razumijevanje procesâ rizika u velikoj mjeri smanjuje broj nepredviđenih situacija, pa je poželjno da se što više vremena posveti upravo ovim procesima na projektu.

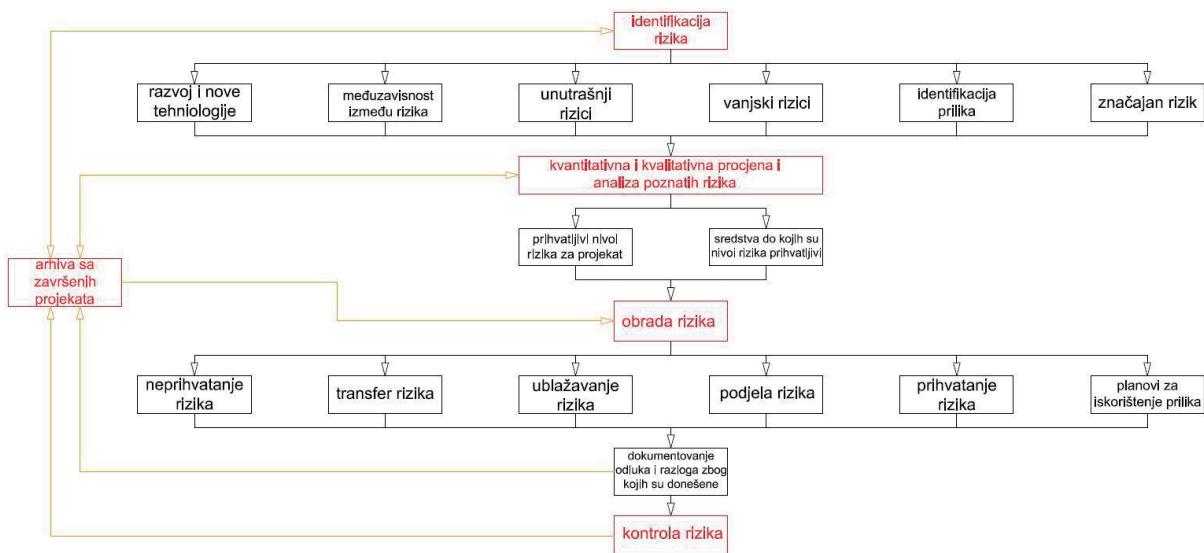
negative phenomenon, but if they are recognized in due time, it is possible to manage them or treat them in some other way. The company's experiential knowledge and tradition enable the identification of all risks and the manner of their management.

Risk processes according to the guidelines of ISO 10006:2017 standard are divided into [5]:

- risk identification,
- risk assessment,
- risk management, and
- risk control.

Defined processes according to the ISO 10006:2017 standard provide guidelines for treating risks from the recognition phase to their control. Each of the phases is important for the success of the project and according to [10] the risk and uncertainty are the biggest in the initial phase of project launch.

The risk management process quality scheme, adjusted according to the guidelines of the ISO 10006:2017 standard, is presented below. In this way, it is easier to understand the risk processes that are illustrated, and based on the scheme, it is possible to organize business operating and create business operating procedures and through them improve the quality management system of the risk processes and thus avoid unwanted consequences. Understanding the risk processes highly reduces the number of unforeseen situations, so it is desirable to devote as much time as possible to these processes in the project.



Slika 1. Shema upravljanja kvalitetom procesa rizika (prilagođeno prema [5])
Figure 1 Risk process quality management scheme (adapted according to [5])

Prepoznavanje ili identifikacija rizika – faza je u kojoj treba prepoznati sve rizike, koji mogu biti prijetnja prilikom izvođenja radova na projektu. U ovoj fazi iskustvena znanja i arhiva su najbolji temelj za donošenje odluka. Rizici mogu biti mnogobrojni i teško ih je prepoznati bez detaljne analize stručnih osoba i ponašanja rizika na istim ili sličnim situacijama. U ovoj fazi potrebno je prepoznati rizike, unutrašnje i vanjske, te njihovu međuzavisnost kako bi se na vrijeme mogle predvidjeti moguće nepoželjne pojave prilikom izvođenja radova na projektu. Pored rizika izraženih u vremenu i novcu, rizik treba da obuhvata i šire oblasti, kao što su zdravlje i sigurnost zaposlenih, zagađenje okoliša, kvalitet proizvoda i sl. [5]. Prepoznati sve rizike ujedno znači i prepoznati sve prilike koje se mogu iskoristiti na projektu. Posebnu pažnju treba posvetiti fazama u kojima se uvode nove tehnologije, jer je to nepoznato područje i postoji neizvjesnost prilikom implementacije. Nakon što su odluke i zaključci doneseni, sve ih je neophodno arhivirati kako bi se mogli koristiti kod donošenja odluka na narednim projektima i u slučaju da je potrebno provjeriti validnost donesene odluke na trenutnom projektu.

Procjena rizika – svi prepoznati rizici se moraju procijeniti kako bi se u nastavku projekta mogli

Recognition or identification of risks – this is the stage when should be identified all risks that may be a threat when performing work on the project. At this stage, experiential knowledge and archives are the best solution for decision making. Risks can be numerous and difficult to identify without a detailed analysis by professionals and risk behavior in the same or similar situations. At this stage, it is necessary to identify risks, internal and external, and their interdependence in order to be able to predict possible adverse events during the execution of works on the project. In addition to the risks expressed in time and money, the risk should include wider areas such as health and safety of employees, environmental pollution, product quality, etc. [5]. Recognizing all the risks also means recognizing all the opportunities that can be used within the project. A special attention should be paid to the phases in which new technologies are introduced, because they represent an unknown area and there is uncertainty during implementation. After all the decisions and conclusions are made, it is necessary to archive them, so they can be used for decisions making in the course of future projects, and as well, in case it is necessary to check the validity of the made decision regarding the current project.

Risk assessment - all identified risks must be assessed in order to be adequately treated

tretirati na odgovarajući način. Prilikom procjene prepoznatih rizika moguće je koristiti razne metode za ocjenu, kao i kvantitativne i kvalitativne metode. Cilj je procijeniti mogućnost pojave prepoznatog rizika i njegov utjecaj na projekat. Kod ovog procesa treba koristiti arhivu završenih projekata, jer sadrži korisne informacije i znanja, što se može upotrijebiti za procjenu i donošenje ispravne odluke. Kod prepoznatih rizika, koji mogu imati veliki utjecaj na rezultate projekta, potrebno je dodijeliti odgovorne osobe koje će biti zadužene za njegovo praćenje i upravljanje [5]. Nakon toga, sve donesene odluke potrebno je arhivirati kako bi se mogle kontrolirati prilikom izvođenja projekta, a i da bi poslužile kao iskustveno znanje kod budućih projekata.

Upravljanje rizicima – nakon prepoznavanja svih rizika i njihove ocjene, potrebno je donijeti odluku o njihovom tretiranju, odnosno kako njima upravljati. Postoje mnoge vrste rizika, a oni mogu biti: neprihvatljivi, nepoželjni, prihvatljivi i zanemarivi. Svaka podjela sadrži karakteristike rizika te na osnovu njegovog utjecaja na projekat donosi se odluka o njegovom tretiranju. Neke rizike je moguće prihvati, a neke ne. Neke je moguće ublažiti, a neki se rizici mogu prebaciti na poslovne partnere. Zbog toga je jako bitno prepoznati ih i tretirati na pravi način, kako bi se osigurala efikasnost projekta. Prilikom donošenja odluka i u ovoj je fazi preporučeno koristiti arhivu završenih projekata, jer sadrži korisne informacije i iskustvena znanja, a donesenu odluku je, također, potrebno arhivirati, radi praćenja u fazi provođenja projekta te da bi poslužila kao osnov za donošenje odluka prilikom budućih projekata.

Kontrola rizika – sve prisutne rizike na projektu treba kontrolirati radi osiguravanja da ne izađu izvan predviđenih okvira. Zaposleni uvijek moraju pratiti prepoznate rizike i biti spremni ako se pojavi nepoželjni efekat. Također, ako dođe do novih rizika, koji nisu prepoznati, potrebno ih je tretirati i nakon toga arhivirati, kako bi bili prepoznati kod narednih projekata.

in the continuation of the project. When assessing the identified risks, it is possible to use various assessment methods, quantitative and qualitative ones. Their goal is to assess the possibility of the identified risk occurring and its impact on the project. In this process, the archive of completed projects should be used, because it contains useful information and knowledge that can be used in order to make the right decision and assessment. In case of identified risks that can have a significant impact on the results of the project, it is necessary to assign responsible persons who will be in charge of its monitoring and management [5]. After that, all decisions made need to be archived, so they can be controlled during the project and used as experiential knowledge in future projects.

Risk management - after identifying all risks and their assessment, it is necessary to make a decision on their treatment or management. There are many types of risks, and they can be: unacceptable, undesirable, acceptable and negligible. Each type contains the characteristics of the risk and based on its impact on the project, a decision is made regarding its treatment. Some risks can be accepted and others cannot, some can be mitigated and some risks can be transferred to business partners. Therefore, it is very important to recognize them and treat them in the right way to ensure the efficiency of the project. When making decisions in this phase, it is recommended to use the archive from completed projects, because it contains useful information and experience, and also the reached decision must be archived, so it can be monitored in the implementation phase of the project and can be used as a basis for decision-making in the course of future projects.

Risk control - all risks, present in the project, should be controlled in order to ensure that they do not go beyond the intended limits. Employees must always monitor the identified risks and be prepared if an adverse effect occurs. Also, if there are new risks that are not recognized, they need to be treated and then archived, so they can be identified in future projects.

4. ZAKLJUČAK

Procesi rizika su ključni za uspješnost projekta, jer sprječavaju nastanak nepredviđenih situacija ili ih smanjuju na prihvatljiv nivo za organizaciju. Utjecaj rizika može imati dvojako djelovanje na uspješnost projekta, jer ako se prepoznaju na vrijeme i posljedice će biti manje, ili zanemarive, a u nekim situacijama se čak mogu pretvoriti i u prednosti, dok - s druge strane - ako se ne prepoznaju na vrijeme, mogu imati jako nepovoljne efekte na krajnje rezultate projekta.

U vezi s tim potrebno je angažirati kvalifikovano radno osoblje za upravljanje kvalitetom procesa rizika, kako bi se ostvarila bolja efikasnost krajnjeg rezultata projekta.

Pored toga, potrebno je koristiti iskustvena znanja stečena tokom prethodnih projekata, jer sadrže dosta korisnih informacija o ponašanjima rizika prilikom njihovog pojavljivanja, a u istu svrhu je sve donesene odluke na novom projektu neophodno arhivirati.

5. LITERATURA

- [1] A. Ceric and T. Marić, "Određivanje prvenstva pri upravljanju rizicima građevinskih projekata", *GRAĐEVINAR*, vol. 63, no. 3, pp. 265-271, 2011.
- [2] C. R. Rodrigues-da-Silva and J. António, "The project risk management process, a preliminary study", *Procedia Technology*, vol. 16, pp. 943-949, 2014.
- [3] H. Sanchez, B. Robert and R. Pellerin, "A Project Portfolio Risk-Opportunity Identification Framework", *Project Management Journal*, vol. 39, no. 3, pp. 97-109, 2008.
- [4] R. Avlijaš and G. Avlijaš, Upravljanje projektom, 4. izmenjeno i dopunjeno izdanje, Beograd: Univerzitet Singidunum, 2018.
- [5] ISO - International Organization for Standardization, ISO 10006:2017 Quality management systems - Guidelines for quality management in projects, Geneva: ISO, 2017.
- [6] Project Management Institute, A guide to the project management body of knowledge, Newtown Square, Pennsylvania: PMI, Inc., 2017.
- [7] J. Gorgh and M. Hamrell, "Standard Operating Procedures (SOPs): Why Companies Must Have Them, and Why They Need Them", *Drug Information Journal*, vol. 43, no. 1, pp. 69-74, 2009.
- [8] J. Gorgh and M. Hamrell, "Standard Operating Procedures (SOPs): How Companies Can Determine Which Documents They Must Put in Place", *DNg Information Journal*, vol. 44, pp. 49-54., vol. 44, no. 1, pp. 49-54, 2010.
- [9] S. Pobrić and E. Bajramović, "Upravljanje rizicima kao preventivni alat za unapređenje sistema upravljanja kvalitetom", *12th International Scientific Conference on Production Engineering*, Bihać, 2019.
- [10] Project Management Institute, A guide to the project management body of knowledge (PMBOOK Guide), Fifth edition, Pennsylvania: PMI, Inc., 2013.

4. CONCLUSION

Risk processes are key to project success, because they prevent unforeseen situations from occurring or reduce them to an acceptable level for the organization. The impact of risk can have a double effect on the success of the project, because if it is recognized in time, its consequences will be lessened or negligible, and in some situations may even turn into advantages, while on the other hand, if not recognized in time, risks can have very adverse effects on project results.

In regard to this, it is necessary to hire qualified staff to manage the quality of the risk processes in order to achieve better efficiency of the final result of the project.

In addition, it is necessary to use experiential knowledge acquired from previously finished projects, because it contains many useful pieces of information about risks' behaviors when they appear, and also all decisions made regarding a new project must be archived for the same purpose.

Corresponding author:
Sabahudin Jašarević
University of Zenica
Faculty of Polytechnics
Email: sabahudin.jasarevic@unze.ba

STVARANJE KVALITETNE MREŽNE INFRASTRUKTURE U CILJU USPJEŠNOG POSLOVANJA

CREATING A QUALITY NETWORK INFRASTRUCTURE FOR THE PURPOSE OF SUCCESSFUL BUSINESS

Muharem Redžibašić

Politehnički fakultet
Univerziteta u Zenici,
Fakultetska 3, Zenica

Ključne riječi:
mrežna infrastruktura,
informacijska sigurnost,
mrežna oprema, kolizijska
domena, sigurnosni rizici

Keywords:
network infrastructure,
information security,
network equipment,
collision domain, security
risk

Paper received:

02. 12. 2021.

Paper accepted:

31. 12. 2021.

Stručni članak

REZIME

Brzim razvojem tehnologije mnogi poslovni procesi preneseni su na elektroničku obradu podataka, što je podrazumijevalo i razvoj lokalnih mreža u mnogim firmama i organizacijama. Većina mrežnih infrastrukturna razvijala se inkrementalno, proširivala se prema potrebama i u većini slučajeva to je bio ad-hoc pristup, bez puno planiranja i brige o sigurnosti. Mrežni implementatori uglavnom nisu bili stručnjaci, tako da su česti problemi na mreži i sigurnosni rizici. Mnoge današnje mrežne infrastrukture imaju zastarjelu mrežnu opremu koja je konfigurirana na protokole koji su postali još nesigurniji, a fizička implementacija mreže je često jedna velika kolizijska domena. Ovaj rad će predstaviti pristup, tj. kako se može kreirati kvalitetna mrežna infrastruktura i koji su ključni koraci u identificiranju slabih tačaka mrežne infrastrukture.

Professional paper

SUMMARY

The rapid development of technology caused many business processes to start using electronic processing of data, what implied development of local networks in many companies and organizations. Most network infrastructures have been developed incrementally, and expanded according to the needs, and mostly an ad-hoc approach was applied, without a lot of planning and taking care of security. Network implementers, in general, were no professionals, so the network issues and security risks happen often. Many pieces of today's network infrastructure have obsolete network equipment, with configured protocols that have become insecure, and physical implementation of the network is often a big collision domain. This paper will present approach, i.e., how a quality network infrastructure can be created and what are the key steps in identifying the weak points of the network infrastructure.

1. NETWORK INFRASTRUCTURE

A computer network can be viewed as a communication system, where information generated on the one side is delivered to the other. This paper mainly deals with local area networks (LANs) that the most users use in their homes, companies, or institutions.

The definition that will be singled out according to the Croatian Academic and Research Network (CARNET) says: "A computer network consists of a group of interconnected computers. Networks can be classified according to size, connectivity, functional connection, and architecture." [1].

LANs are used to connect computers and other network devices to share resources (such as printers) and exchange information over a network [9].

The implementation of each network must go through certain stages, which are most often: *network design phase, network implementation phase, network documentation, etc.* Each network is a system that consists of certain parts and that develops over time. The question is when it can be said that the network implementation process is complete. The answer is never. The network goes through constant modifications and expansions in its lifetime, and every change needs to be monitored through these phases, so it is very important to follow new trends in technology and networks to be able to identify shortcomings and improve the network. It is very important if it can be managed to prevent some things in due time, before setting everything up again.

1.1 Design phase

When designing LANs for medium and large companies, it is best to use a three-layer hierarchical model. The hierarchical model involves dividing the network into discrete layers. Each layer provides specific functions that define its role in the entire network. This achieves a modular design that ultimately results in better performance and greater network scalability. The three layers that make the hierarchical network model are:

1. Access layer,
2. Distribution layer, and
3. Core layer.

Applying this model brings many advantages, such as, first, **network scalability**, which refers to the possibility of simple system scalability.

According to Figure 1, it is enough to add a switch device, connect it to the distribution layer and our network is simply expandable - scalable.

Redundancy - this feature is important, especially when there is a network that provides services for the so-called ‘mission critical’ applications, where connectivity is imperative. Redundant links provide alternative links to the destination, making the network resistant to sudden falls of parts of the network.

Security - a three-tier hierarchical model allows users to create specific security policies on each of these layers. Security can be implemented at the level of ports, virtual LANs, access lists, etc.

Manageability - such networks are easier to manage. The necessary interventions can be done and focused on individual parts or at the level of a particular layer, without affecting the rest of the system.

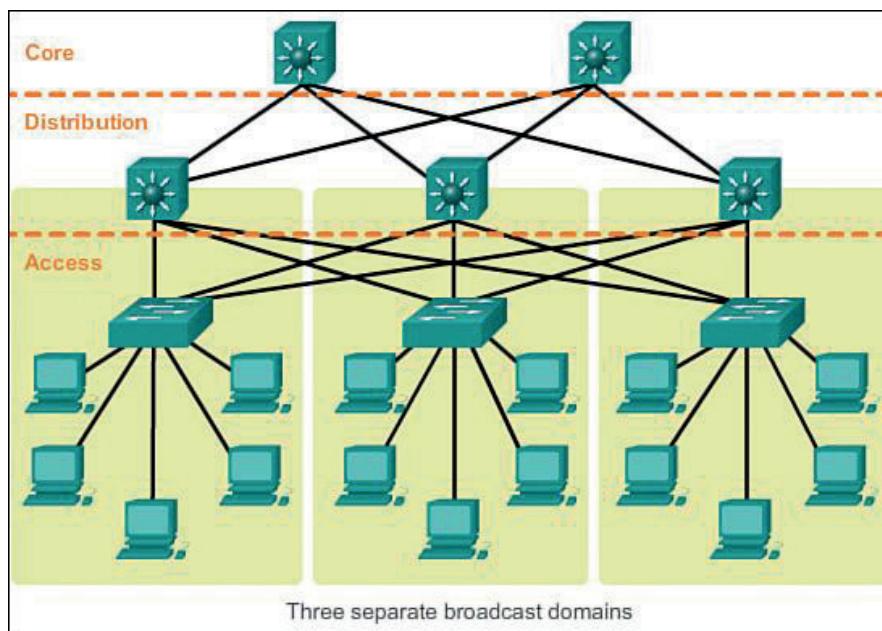


Figure 1 Hierarchical network model [3]

If the computer network is designed as a new one, then definitely this model is important. However, in the case of reconstructing the existing network, it is needed to make as many changes as possible to bring the existing situation closer to this hierarchical model, solely for the advantages mentioned above.

It is very important to mention that the network documentation is a document that is created at the time of network design, supplemented by

elements related to implementation¹, containing information about a particular class of administration, and other pieces of information related to network functionality. Depending on the size of the network, paper can be used or some programs with automatic support for tables, and if the network is more complex, there are even specialized software solutions. Therefore, any data related to operating and functioning of the network should be part of the

¹ Implementation is the phase when works are performed in order to implement the network defined in the project. It includes laying cables, mounting connectors and connecting to patch panels,

marking cables and sockets, implementing cable guides and channels, grounding, etc.

network documentation. Documentation is a document that is developed and maintained over the life of the network. If the documentation is not up to date, it can represent a bigger problem than if it's not present at all, because it can lead a user to wrong conclusions.

1.2 Structural cabling

The emergence of a large number of different network equipment manufacturers has led to the need to define standards that would cover general aspects of networking. The set of standards related to networking is called structural cabling. Structural (generic) cabling includes all possible types of cabling.

The purpose of structured cabling is to introduce rules for planning and implementation of computer networks. As an example, structured cabling will be mentioned, which includes saturated cabling, that envisages the installation of two connections on every 2-3 m² of working space. This approach is used for networking in facilities where the exact layout of computers and other IT infrastructure is not known.

Structured cabling involves cross connections (distribution facilities) and patch panels (switchboards), all with the aim of ease restructuring the computer network.

The standards related to structured cabling are:

- ISO / IEC IS11801 - International standards
- EN 50173 - European standards
- EIA / TIA 568 - American standards

It is very important to note that when cabling adhere to one of the standards and respect all the elements of structured cabling, where special attention have to be payed to backbone cabling where this type of cabling is used to connect main distribution facilities (MDF) with intermedia distribution facilities (IDF). Backbone cabling should be performed using network media with as much bandwidth as possible (e.g., optical cables).

In order to improve the existing network infrastructure, an analysis of the state of the network is needed and, if there are resources, the bandwidth in relevant part of the network should be improved.

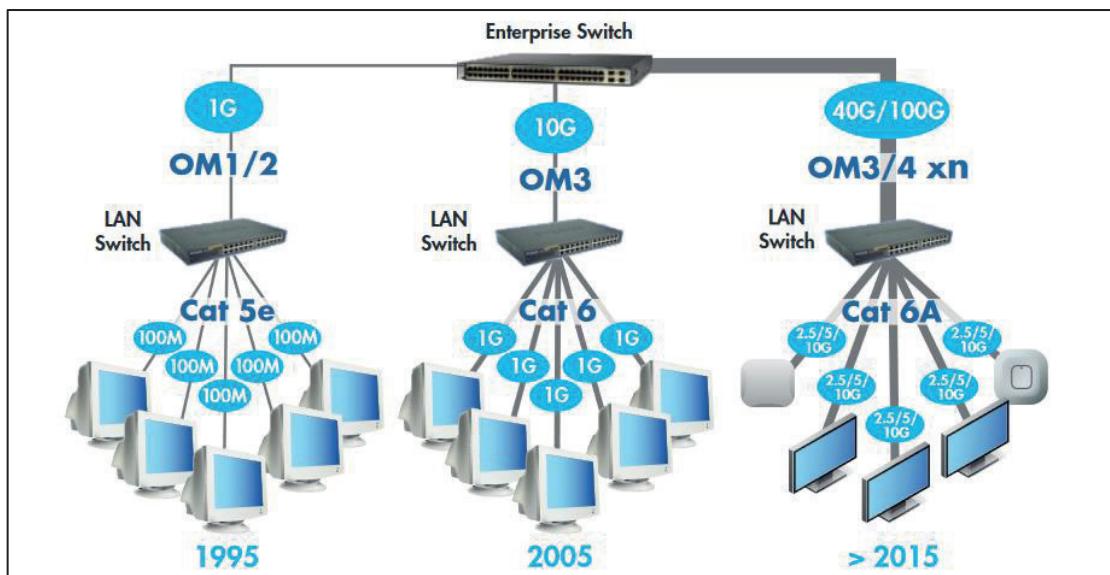


Figure 2 LAN cabling [4]

2. STEPS TO IMPROVE NETWORK INFRASTRUCTURE

This chapter will cover some of the key things to look out for when considering a network infrastructure, whether building a new one or reconstructing an existing one. The things covered in this chapter will actually be the key things to look out for in order to improve or identify vulnerabilities in a particular network infrastructure.

2.1. Collision domain

A collision domain is a shared network segment where a collision can occur, that is an area of the network that would be affected by a collision. Regarding the devices of the first layer (OSI reference model), due to the mode of action,

signal amplification and its transmission, such devices increase the collision domain.

Second level of devices do segmentation (division) of the collision domain. The switch, on the other hand, does micro segmentation, where each port on the switch, and each device connected to the switch, represent a separate collision domain, and if it is a full duplex communication, then it is a collision-free environment, an environment without the possibility of collision. It is because the switch has almost eliminated the use of hubs in computer networks.

In practice, this would mean that wherever is a hub device, it is not a big investment to replace it, but in terms of the performance of our network, it will be very important.

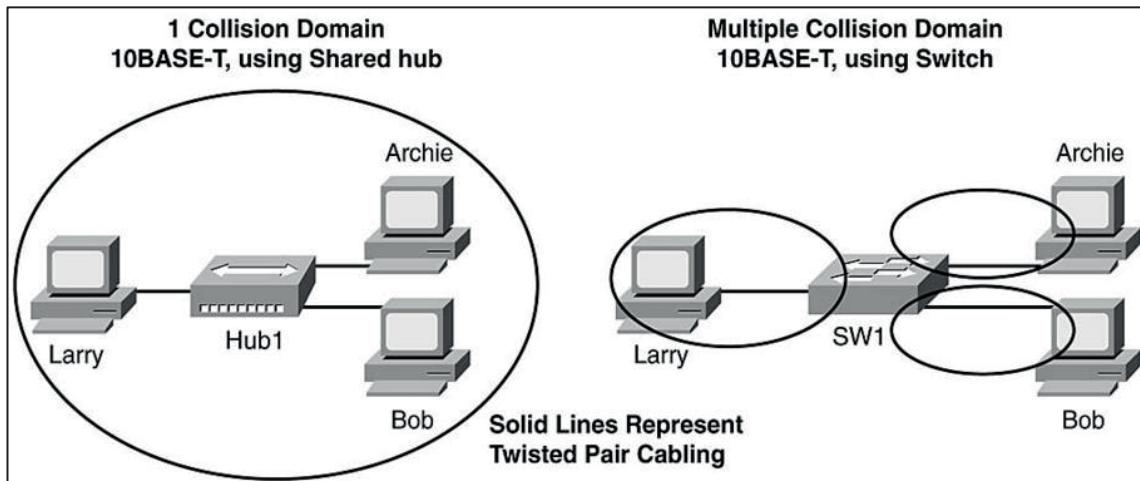


Figure 3 Collision domains [2]

2.2. IP addressing and subnets

An IP address allows to uniquely identify a host on a network. Without a proper addressing scheme, communication between computers would not be possible. To make address management easier, all addresses are divided into specific IP address classes. In the original Internet routing scheme developed in 1980, IPv4 addresses were divided into 5 classes. These are Class A, Class B, Class C, Class D and Class E. The last two classes are special purpose classes, and are less commonly used.

Mostly, many institutions and organizations did the addressing poorly, with unnecessary loss of IP addresses. To avoid it, it is necessary to use subnets (subnetting).

When talking about subnetting, it means that one whole class (A, B, C) is divided into several small ones, thus minimizing the loss of IP addresses. The recognition of subnetting is by the fact that certain hosts are assigned to the network part. It can be best established whether a network is subnetted by the subnet mask. If the value of the subnet mask is different from the default one, then it can be said it is a subnetted network.

Subnetting allows an administrator to divide a particular network into several small ones to fulfil the task of addressing devices on the network.

If the network is divided into subnets, there are many benefits, such as:

- reducing network traffic,
- optimizing network performance,
- making it easier to spot and solve network problems, and
- increasing network security.

2.3. Updating firmware

Firmware is a program that is permanently installed on hardware devices such as routers. It is programmed to provide constant instructions for communicating with other devices and perform functions such as basic input / output tasks. The firmware is usually stored in the flash ROM (read-only memory) of the hardware device. It can be deleted and overwritten [5].

The firmware was originally designed for high-level software, and it can be replaced by a new device without replacing the hardware. The firmware, also, retains basic instructions for the hardware devices that make them operational. Without the firmware, the hardware device would be non-functional [7]. Flashing firmware update involves overwriting existing firmware or data, contained in EEPROM or flash memory modules present in the electronic device, with the new data. Some firmware cannot be overwritten, while others are upgradeable, meaning it is possible to upgrade the firmware of the device by connecting to a computer in a specific configuration and then run the software of the manufacturer.

This process is called ‘flashing firmware’ or simply ‘flashing’. This becomes necessary when a device becomes incompatible with new operating systems, or simply when there is a need to improve device performance [8].

For example, for network devices such as routers and modems, it is very important to check on the official website of the manufacturer the latest version of the firmware available and compare it with the current version on the device. If a new version is available, there is a need to upgrade existing one. Before upgrading, it is always recommended to back up the existing firmware and device configuration, so if a problem occurs, it can be restored to its original state. Firmware upgrades are mainly performed to improve performance, but if it is a network device, then it is very important to do so for the sake of security. Often some devices with older firmware versions become vulnerable to certain malicious code types and to protect and prevent something unexpected from happening with big consequences on the network, a firmware update to the latest available secure version has to be done.

3. EXAMPLE

In this section, a typical network diagram, where the computer network was created incrementally, will be presented, and after that a reconstructed network diagram with suggestions for improvement will be presented, too.

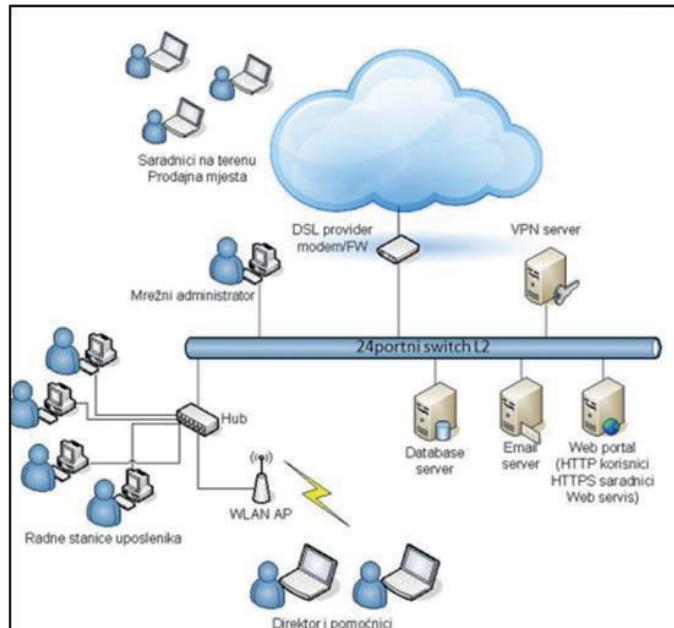


Figure 4 Example of weak network infrastructure (Source: authors)

A closer look at the previous picture shows many shortcomings. First, there is a hub device that expands the collision domain, and it is very slow. So, in order to reduce the potential number of collisions, there is a need to replace the hub device with a switch device, which will increase the number of collision domains, and reduce the number of potential collisions in the network and thus gain speed. Second, it should be noted that a DSL modem is used from a provider that is also a router. For a more professional approach, it is necessary to keep the device from the provider, but to use only the modem function, and for other services and settings to use other, more sophisticated, devices with more features and higher memory, such as a separate router. In this way, it can be achieved, in addition to security, a gain in performance, and as well, the scalability property prescribed by the hierarchical network model, described in the first chapter of this paper.

It is also clear that servers, employees, administrators and everyone else are on the same subnet. From the aspect of security, this is not satisfactory, and the suggestion is to set up a security network device (firewall) and to separate subnets according to the type of equipment and relevant users.

Also, regarding wireless access, there is only one wireless access point, what represents vulnerability, because they are all connected via the same access point. Since we need to separate different types of users into different subnets, a good move would be to install another wireless access point to serve only visitors / guests. This access will be separated from the internal network. Also, VLANs should be implemented for logical segmentation.

After all the above, an improved network infrastructure diagram can be presented.

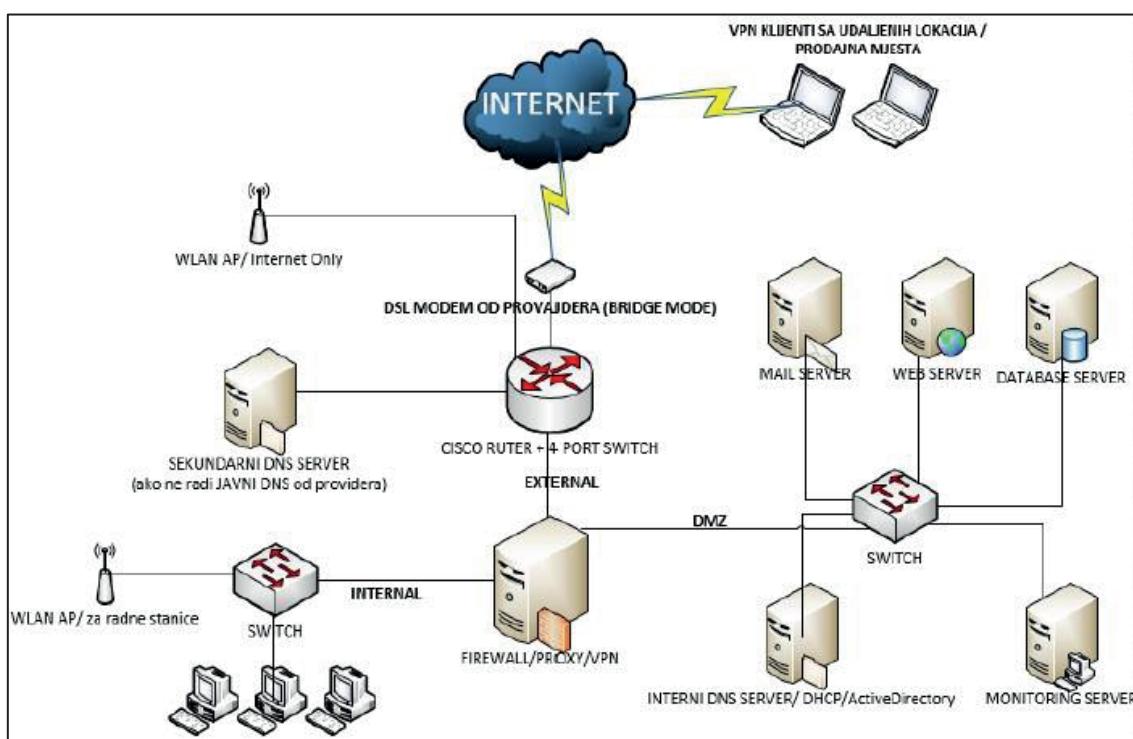


Figure 5 Example of improved network infrastructure (Source: authors)

4. CONCLUSION

Given that many of today's network infrastructures have outdated network equipment with physical network implementations that are quite poor, and they very often represent one major collision domain. From the very phase of network design, clearly a three-layer hierarchical model of network

infrastructure should be adhered to. If it is possible to reconstruct the existing network infrastructure, there should be done things that will resort to the greatest degree to the hierarchical model of network infrastructure. Also, a great importance is put on the structured cabling, where is very important to do everything in accordance with the predefined

standards, and to make quality network documentation, in a way that any piece of information related to the operation and functioning of the network is a part of the network documentation.

For the smooth functioning of the computer network, it is very important to reduce the area of the network that could be affected by the collision. This can be achieved by increasing the number of collision domains, by replacing network devices and, thereby, reducing the area of the network that could be affected by the collision. Also, to optimize network performance and increase security, there is a need to do quality IP addressing in the network. One way to achieve these goals is to introduce subnets. The security can be increased by having adequate monitoring firmware versions on network devices and by updating them.

Malicious users and malicious types of program code can cause not only a financial damage, from which most entities recover, but can also cause life-threatening damage. *Killware* is a new term in cyber security that refers to the malicious use of information technology that can result in the loss of human lives. An example of such an attack was in Florida, USA, where a malicious user tried to contaminate water in a plant from which water is delivered to the population. Furthermore, failures in healthcare, where people depend on medical devices that are connected and controlled through a computer network and software, are inadmissible. The same case is with the car industry and the advent of autonomous vehicles where applying malicious code to such systems could greatly compromise human safety and lives.

Therefore, planning, designing, implementing and maintaining a computer network infrastructure is not a negligible process and a quality approach to it can be a prevention of many potential security risks, especially in an age when each device is more or less connected to some type of computer network [6].

This paper identified the key things related to creating a quality network infrastructure and it suggested steps that should be primary if the goal is to improve the existing network infrastructure and maintain a successful business.

6. LITERATURE

- [1] CARNet - Croatian Academic and Research Network, (2009.), „Sigurnosni model mreže računala“, p. 6.
- [2] CCIE Study Blog, „Ethernet: Collision Domains and Switch Buffering“, <https://bethepacketsite.wordpress.com/2016/02/10/ethernet-collision-domains-and-switch-buffering> (accessed 20.10.2021.)
- [3] Cisco Networking Academy Connecting Networks Companion Guide: Hierarchical Network Design, <http://www.ciscopress.com/articles/article.asp?p=2202410&seqNum=4>, (accessed 19.10.2021.)
- [4] COMMSCOPE White Paper, „Fiber Backbone Cabling in Buildings“ <https://www.commscope.com/globalassets/digizuite/2506-fiber-backbone-in-buildings-wp-109423-en.pdf?r=1>, p. 3., (accessed 21.10.2021)
- [5] Halonja A., Milica M., (2009.) „Računalni nazivi sa elementom – WARE u engleskome i hrvatskome jeziku“, Rasprave Instituta za hrvatski jezik i jezikoslovje, p. 116.
- [6] Official PANDA Security Website, <https://www.pandasecurity.com/en/mediacentre/security/what-is-killware/> (accessed 15.11.2021.)
- [7] Official TACHOPEDIA Website, <https://www.techopedia.com/definition/2137/firmware>, (accessed 25.10.2021.)
- [8] Official TECH-FAQ Website, „Flashing Firmware“, <http://www.tech-faq.com/flashing-firmware.html>, (accessed 25.10.2021.)
- [9] Tanenbaum A., Wetherall D., (2013.) „Computer Networks“, Fifth edition, University of Washington , p. 19.

Corresponding author:

Muharem Redžibašić
Politehnički fakultet Univerziteta u Zenici,
Fakultetska 3, Zenica
Email: r.muharem@gmail.com
Phone: + 387 61 629 136

FABLABOV SPEKTROMETAR SA PRIPADAJUĆOM OPREMOM

FABLAB SPECTROMETER WITH ASSOCIATED EQUIPMENT

Emir Karamehmedović
FabLab Team

*FabLab BiH,
Digital Fabrication
Laboratory,
Zmaja od Bosne 8,
Sarajevo, BiH*

Ključne riječi:
laser, optika,
spektrometar,
3D štampanje

Keywords:
laser, optics,
spectrometer,
3D printing

Paper received:
25.12.2021.
Paper accepted:
31.12.2021.

REZIME

Ovaj rad opisuje dizajn 3D štampanog spektrometra za vidljivo i blisko infracrveno područje elektromagnetskog spektra svjetla. Uredaj ima rezoluciju od oko 2 nm i čini samo jedan dio cjeline koja se još sastoji od odgovarajućeg izvora svjetla, posude za uzorku odnosno kivete i pratećih optičkih kablova. Spektar svjetlosti se prikazuje na računaru u aplikaciji koja je posebno razvijena kako bi se demonstrirao rad ovog instrumenta. Implementacija ovog instrumenta je jeftina, pa bi se spektrometar mogao koristiti kao odlično sredstvo za pokazne eksperimente u školama, ali i za realizaciju jednostavnijih projekata u kojima je potrebno na brz i jednostavan način dobiti informaciju o spektru svjetlosti.

ABSTRACT

This paper describes the design of a 3D printed spectrometer for the visible and near-infrared region of the electromagnetic spectrum of light. The device has a resolution of about 2 nm and forms only one part of the whole, which still consists of a suitable light source, sample container or cuvette, and accompanying optical cables. The spectrum of light is displayed on a computer in an application developed specifically to demonstrate the work of this instrument. The spectrometer is low-budget, and it is adequate as a teaching aid in schools or for simpler projects, aimed at obtaining information about the spectrum of light in a fast and simple way.

Stručni rad

Professional paper

1. UVOD

Spektrometar je optički instrument koji razlaže upadajuću svjetlost na komponente odnosno boje, i registruje jačinu svake boje posebno. Ovaj, u suštini vrlo jednostavan instrument, je jako koristan u nizu disciplina, naročito u hemiji, biologiji i fizici. Svaka tvar ili rastvor ima specifičan i unikatan spektar apsorpcije svjetla, tako da se npr. apsorpcionom spektrometrijom može utvrditi prisustvo određenog jedinjenja u uzorku. Spektrometrom je moguće pratiti i dinamiku neke hemijske ili biološke reakcije, praćenjem izmjene spektra, bilo apsorpcionog ili emisionog. Od posebnog aplikativnog značaja je spektrometrija u infracrvenom i dubokom infracrvenom području, ali svjetlost, u kontekstu spektrometrije, je praktično svako elektromagnetno zračenje, od ultraljubičastog do dubokog infracrvenog. Spektrometar može da mjeri i karakteristike svjetlosnih izvora ili da analizira refleksiju svjetla o različite površine, i time pomogne u procesu karakterizacije materijala ili čak objekata koji su eventualno van dometa laboratorija.

1. INTRODUCTION

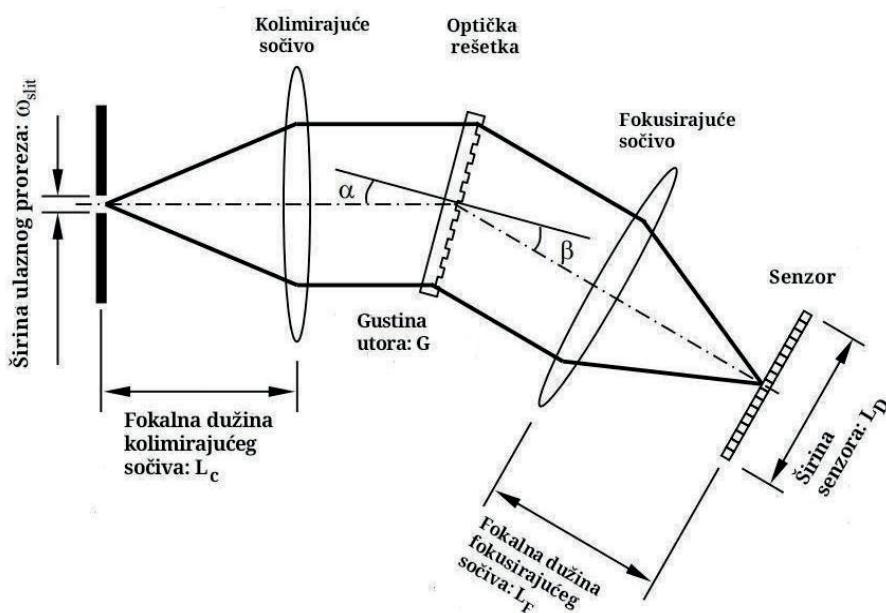
A spectrometer is an optical device that separates the source light into its components (colors) and registers the intensity of each color separately. This, essentially a very simple device, is useful in several science disciplines, especially in chemistry, biology, and physics. Each substance or solution has a specific, unique spectrum, by which absorption spectrometry is able to determine the presence of a particular compound in a given sample. In the same way it is possible to monitor the dynamics of a chemical or biological reaction by monitoring changes of the spectrum (absorption or emission). Particularly important is the application of spectrometry in the infra-red and deep infra-red range, but the light (in the context of spectrometry) is any electromagnetic radiation from ultraviolet to deep infra-red. In addition, with the spectrometer we can measure the characteristics of light sources or analyze the reflection of light on different surfaces, thus the spectrometer can help characterizing materials or even objects that are out of the laboratory's range.

2. NAČIN RADA SPEKTROMETRA

Fablab Sarajevo je razvio spektrometar koji radi u vidljivom i blisko infracrvenom području svjetlosti i pogodan je za nastavne i demonstrativne svrhe, ali može poslužiti i u određenim razvojnim projektima. Šematska skica rada spektrometra, baziranog na transmisionoj rešetki, data je na slici 1.

2. MAIN PART

Fablab Sarajevo has developed a spectrometer that works in the visible and near-infrared areas of the light, and it is suitable for teaching and demonstration purposes, as well as for certain development projects. The basic principle the device is based on is shown in Figure 1.



Slika 1. Šematski prikaz spektrometra
Figure 1 Basic principle of the spectrometer

Kao što se može primijetiti na slici, upadno svjetlo dolazi iz standardnog multimodnog optičkog vlakna promjera jezgra $50\mu\text{m}$, kroz jedan od zidova kućišta spektrometra, što djeluje kao prorez. Svjetlo se kolimira sočivom fokalne dužine 75 mm, a rešetka sa 1000 rebara po milimetru razlaže svjetlo na komponente. Konačno, drugo sočivo prethodno razloženu svjetlost fokusira na CCD senzor.

Detektor primljeno zračenje pretvara u električni naboј koji se očituje kao napon i pojačava, tako da mikrokontroler registruje niz napona kao spektar i šalje ga aplikaciji na računaru putem serijske komunikacije.

Ideja iza dizajna i izrade prvog spektrometra u FabLabu BiH, demo centar Sarajevo, bila je da se dizajnira cijenom pristupačan spektrometar, ali sa performansama komercijalnog proizvoda, te da se može proizvesti u bilo kojem lokalnom FabLabu, kao i drugim sličnim mjestima, koristeći lako dostupne materijale. FabLab posjeduje uslove za aditivnu proizvodnju, što je

As Figure 1 shows, the source light comes from a standard, multimode optical fiber with a core diameter of $50\mu\text{m}$, through housing, acting as a slot. The light is collimated by a lens with a focal length of 75 mm, and the grid, with 1000 ribs per mm, decomposes the light. Finally, the second lens focuses the previously decomposed light on the CCD sensor.

The detector converts the received radiation into an electric charge, which is manifested as a voltage, that is being amplified, while the microcontroller registers a series of voltages as commercial unit, spectrum and sends it to the computer via serial communication.

The idea behind the design and development of the first spectrometer at FabLab BiH (Sarajevo Demo Center) was to develop an affordable spectrometer, but with the performance of a which can be produced in any other FabLab, or similar place, by using easily accessible materials.

omogućilo dizajn i izradu ovog niskobudžetnog proizvoda. Kućište spektrometra je napravljeno od materijala za 3D štampanje, povezano je preko mikrokontrolera *Teensy USB* serijskom komunikacijom sa računarom koji ima instaliran softver za spektralnu analizu u realnom vremenu. Jednostavno povezivanje uređaja sa računarom čini ga korisnim za učenje i analiziranje u učionicama i laboratorijima. FabLabov spektrometar je dizajniran za analizu u vidljivom i bliskom infracrvenom području svjetlosti odnosno za talasne dužine od 400 nm do 800 nm sa ciljanom rezolucijom od oko 1 nm.

Optičke karakteristike proizvoda:

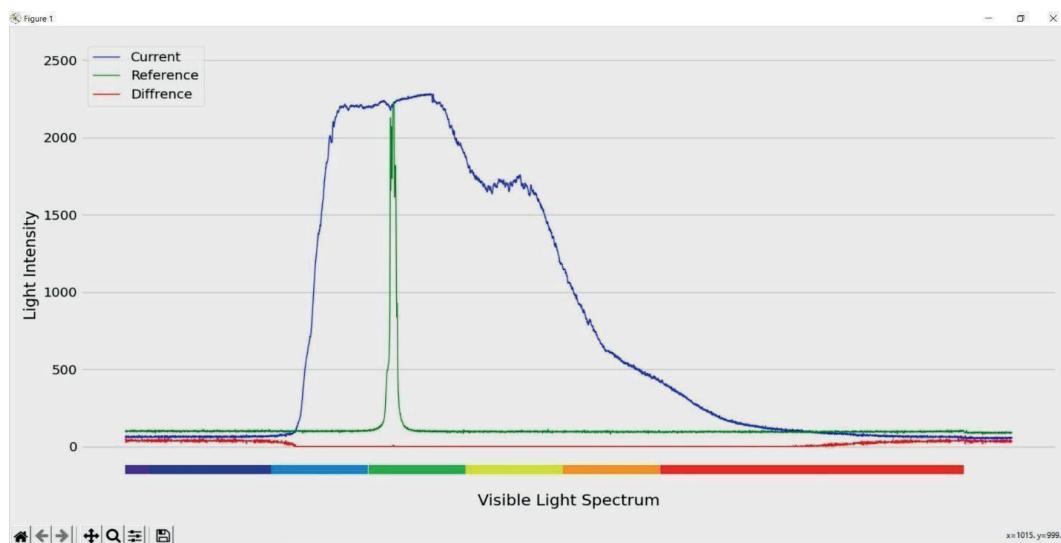
Minimalna talasna dužina: $\lambda_1 = 400 \text{ nm}$
Maksimalna talasna dužina: $\lambda_2 = 800 \text{ nm}$
Opseg talasne dužine: $\lambda_2 - \lambda_1 = (800 \text{ nm} - 400 \text{ nm}) = 400 \text{ nm}$
Centralna talasna dužina: $\lambda_c = (\lambda_1 + \lambda_2) / 2 = 600 \text{ nm}$
Gustina optičke rešetke: $G = 1000 \text{ g/m}$ [1]

The spectrometer was made of material for 3D printing and connected via a Teensy USB microcontroller cable to a computer with a real-time spectrum analysis program, thus making it useful for education and practice in classrooms and laboratories.

The FabLab spectrometer was designed for analysis of the visible and near-infrared range of light, i.e., for 400 nm to 800 nm wavelengths with a targeted resolution of about 1 nm.

Optical characteristics of the product:

Minimum wavelength: $\lambda_1 = 400 \text{ nm}$
Maximum wavelength: $\lambda_2 = 800 \text{ nm}$
Wavelength range: $\lambda_2 - \lambda_1 = (800 \text{ nm} - 400 \text{ nm}) = 400 \text{ nm}$
Central wavelength: $\lambda_c = (\lambda_1 + \lambda_2) / 2 = 600 \text{ nm}$
Optical grating density: $G = 1000 \text{ g/m}$ [1]



Slika 2. Prikaz spektara lasera i bijelog svjetla Ce:YAG lampe u okruženju aplikacije
Figure 2 Display of laser and white light spectrum Ce: YAG lamps in the application environment

Upadni i difrakcioni uglovi α i β se računaju preko jednačina:

$$\alpha = \sin^{-1} \left(\frac{\lambda_c G}{2 \cos(\frac{\phi}{2})} \right) - \frac{\phi}{2} = 17,5^\circ \quad \dots(1)$$

$$\beta = \phi - \alpha = 17,5^\circ \quad \dots(2)$$

Rezultirajuća rezolucija:

$$\Delta\lambda = \frac{w_{slit} \cos(\alpha)}{GL_c} = 0,64 \text{ nm} \quad \dots(3)$$

The incident and diffraction angles α and β were calculated using the following equations: $\alpha = \sin^{-1} \left(\frac{\lambda_c G}{2 \cos(\frac{\phi}{2})} \right) - \frac{\phi}{2} = 17,5^\circ \quad \dots(1)$

$$\beta = \phi - \alpha = 17,5^\circ \quad \dots(2)$$

Resulting resolution:

$$\Delta\lambda = \frac{w_{slit} \cos(\alpha)}{GL_c} = 0,64 \text{ nm} \quad \dots(3)$$

Realna rezolucija instrumenta je oko 2 nm, dok je izračunata rezolucija oko 0.64 nm. Spektri Ce:YAG lampe (širokopojasni) i zelenog lasera (uski spektar) prikazani su na slici 2. Program za obradu podataka je u stalnom razvoju, pa je u planu da uključi napredne analize, kao što su metode za eliminaciju buke, automatsko prepoznavanje maksimuma ili minimuma itd. Na slikama 3.1., 3.2., kao i 4.1. i 4.2., prikazani su svi prateći detalji dizajna i komponenti spektrometra, gdje se kroz *render* prikaz vidi način sastavljanja svih postojećih elemenata. Izuzev sočiva i elektroničkih komponenti vezanih za senzor detekcije svjetla, svi ostali elementi napravljeni su metodom 3D štampanja. Konačan proizvod je prikazan na slikama 4.1 i 4.2.



Slika 3.1. *Render* prikaz spektrometra
Figure 3.1 *Render* view of spectrometer

Spektrometar kao nezavisan uređaj nije upotrebljiv bez adekvatne dodatne opreme. FabLab Sarajevo je razvio i konstantan izvor svjetlosti, kao i držač kivete u kojem bi se nalazio analizirani uzorak. Kompletan sistem je i dalje jeftin za implementaciju, a uključuje i tutorijal za izvođenje i analizu osnovnih eksperimenata, kao i dodatnu opremu poput optičkih i elektroničkih kablova. Cijeli dizajn je *open-source*, a sam uređaj je u fazi daljeg unapređivanja.

The real resolution of the instrument is ca. 2 nm, while the calculated resolution is ca. 0.64 nm. The spectra of Ce: YAG laser (broadband) and green laser (narrow spectrum) are shown in Figure 2. The program for real-time data processing is constantly evolving, and it is planned to include advanced analysis methods like noise elimination and automatic detection of maximum/minimum values, etc.

In Figures 3.1, 3.2, 4.1 and 4.2 all the relevant details of the design and components of the spectrometer are shown, where the rendering shows the fit of all parts in the image. Except for the lenses and the electronic components, all spectrometer parts were 3D printed, which can be seen in Figures 4.1 and 4.2.



Slika 3.2. *Render* svih komponenti u sklopu
Figure 3.2 *Render* of all components in the assembly

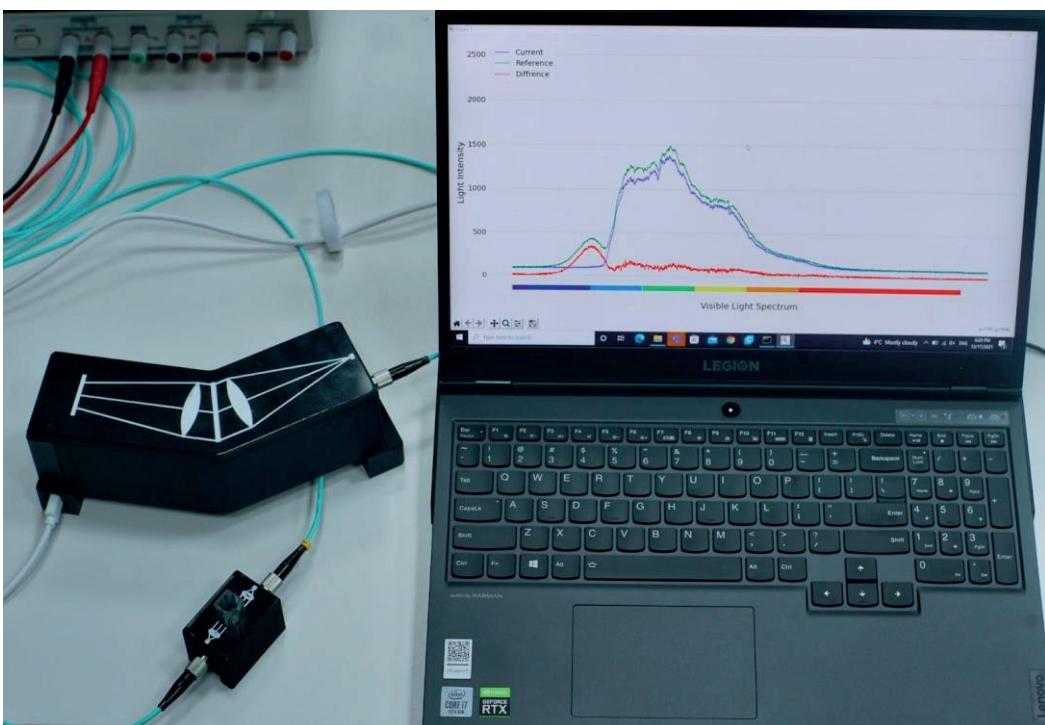
Without adequate equipment, the spectrometer is not usable for a more serious experiment. In addition to the spectrometer development, FabLab Sarajevo has developed an intensive light source as well as a cuvette holder where the sample is being analyzed. The set of this equipment is still very cheap, and includes a tutorial for basic experiments with explanations, and has all the necessary cables (optical and electrical). The design is open-source and ready for upgrade.



Slika 4.1 3D printani sklop spektrometra
Figure 4.1 3D printed spectrometer assembly



Slika 4.2 Unutrašnjost spektrometra
Figure 4.2 Inside of the spectrometer



Slika 5. Spektrometar povezan sa kompjuterom, nosač kivete sa kolimatorima i fiberima
Figure 5 Spectrometer connected to a computer, cuvette holder with collimators and fibers

3. ZAKLJUČAK

U ovom radu razvijen je i testiran spektrometar za vidljivo područje sa pripadajućom opremom i zabilježeni su spektri raznih svjetlosnih izvora, kao i apsorpcioni spektri nekih uzoraka. Ponovljivost rezultata je zadovoljavajuća, ali je potrebna rekalibracija prilikom svakog novog mjerjenja. Teoretska rezolucija je oko 0,64 nm, ali je u praksi rezolucija oko 2 nm, što pripisujemo nepravilnostima u izvedbi i korištenju kućista i sočiva, tačnije tolerancijama u 3D štampanju i hromatskim i sferičnim aberacijama sočiva.

3. CONCLUSION

The developed spectrometer for the visible area, with the associated equipment, was being tested successfully, with the spectra of various light sources as well as the absorption spectra of samples being recorded. The reproducibility of the results is satisfactory, but recalibration is required with each measurement. The theoretical resolution is ca. 0.64 nm, with the real resolution being higher, ca. 2 nm, which we attribute to the imperfections in the performance, i.e., 3D printing tolerances, chromatic and spherical aberrations of the lens.

Ovo znači da se i multimodni fiberi sa dosta većom jezgrom, npr. 100 μm, mogu koristiti i povećati osjetljivost odnosno manje intenzivni izvori svjetlosti mogu da se koriste. CeYAG izvor, koji je ovdje korišten, ima relativno uzak spektar za spektroskopiju (od oko 100 nm), ali pokazao se kao dobar u mnogim aplikacijama gdje je potrebno vršiti demonstraciju sa vidljivom svjetlošću.

This implies that multimode fibers with a much larger core, e.g., 100 μm, can be used to increase sensitivity, meaning that less intense light sources can be used as well. The Ce:YAG source, which was used, has a relatively narrow spectrum for spectroscopy (ca. 100 nm), but has proven to be satisfactory in many applications where demonstration with visible light is required.

4. REFERENCE

- [1] "Ibsen photonics. Spectrometer design guide"
<https://ibsen.com/resources/spectrometer-resources/spectrometer-design-guide/>,
- [2] Neumann, Wilfried. (2014). Fundamentals of Dispersive Optical Spectroscopy Systems. SPIE.
- [3] Nikolai V. Tkachenko. (2006). Optical Spectroscopy Methods and Instrumentations.
- [4] J. F. James, R. S. Sternberg. (1969). The design of optical spectrometers.

Corresponding author:

Emir Karamehmedović
FabLab BiH
Email: emir@fablab.ba
Phone: +387 61 605 746

INSTRUKCIJE ZA AUTORE (Style: Times New Roman, 14pt, Bold)**INSTRUCTIONS FOR AUTHORS** (Style: Times New Roman, 14pt, Bold)

Name Surname 1,
Name Surname 2,
Name Surname X
*(Author's name,
Co-author's name -
Style: Times New
Roman, 11pt, Bold)*

Authors' Institutions
(Style: Times New Roman,
11pt)

Ključne riječi:
abecedni popis ključnih
rijeci na bosanskom,
hrvatskom ili srpskom
jeziku (Style: Times New
Roman, 10pt)

Keywords:
Alphabetic list of
keywords in English
(Style: Times New Roman,
10pt)

Paper received:

xx. xx. xxxx.

Paper accepted:

xx. xx. xxxx.

Kategorizacija članka (Style: Times New Roman, 10pt, Bold, Italic)

REZIME (Style: Times New Roman, 10pt, Bold)

Naslov rada (do 15 riječi). Puna imena i prezimena autora (bez navođenja zvanja i akademskih titula). Rezime rada (do 150 riječi). Rezime treba što vjernije odražavati sadržaj rada. U njemu se navode upotrijebljene metode i ističu ostvareni rezultati kao i doprinos rada. Naslov, rezime rada i ključne riječi autori s prostora bivše Jugoslavije pišu na bosanskom, hrvatskom ili srpskom jeziku. Ključne riječi u pravilu su iz naslova rada, a samo eventualno iz sažetka rada. Nakon recenzentskog postupka može se dati uputa autorima da naprave određene popravke ili dopune svoj rad. (Style: Times New Roman, 10pt, Italic)

Categorization of paper (Style: Times New Roman, 10pt, Bold, Italic)

SUMMARY (Style: Times New Roman, 10pt, Bold)

Title of the paper (up to 15 words). The full list of authors (without specifying their ranks and academic titles). Summary (up to 150 words). Summary should reflect as faithfully as possible the content of the paper. It outlines the methods used and highlight the results achieved as well as the contribution of the paper. Authors from the former Yugoslavia may write the title, summary of paper and keywords in the Bosnian, Croatian or Serbian language. Keywords are generally taken from the title of paper, but there is a possibility also to be taken from the summary. After the review process, authors may be instructed to make certain changes or additions to their paper. (Style: Times New Roman, 10pt, Italic)

1. INTRODUCTION

(Style: Times New Roman, 11pt, Bold)

Upon its acceptance, the article is categorized as follows: original scientific paper, preliminary notes, subject review, professional paper and conference paper.

Original scientific papers should report on original theoretical or practical research results. The given data must be sufficient in order to enable the experiment to be repeated with all effects described by the author, measurement results or theoretical calculations.

Preliminary notes present one or more new scientific results but without details that allow the reported data to be checked. The papers of this category inform about experimental research, small research projects or progress reports that are of interest.

Subject reviews cover the state of art and tendencies in the development of the specific theory, technology and application with given remarks by the author. Such a paper ends with a list of reference literature (bibliography) with all the necessary items in the related field.

Professional papers report on the original design of an instrument, device or equipment not necessarily resulting from the original research. The paper contributes to the application of well-known scientific results and to their adaptation for practical use.

Papers presented at scientific conferences can also be published in the journal upon the agreement of the conference organizer and the author. (Style: Times New Roman, 11pt, Normal)

Papers to be published in the journal "Mašinstvo" should be written in English. The

metrology and terminology used in the paper have to meet legal regulations, standards and International System of Units (SI)

1.1. Subtitle 1 (Writing Instructions)

(Style: Times New Roman, 11pt, Bold)

The text of the paper is arranged in sections and when necessary into subsections. Sections are marked with one Arabic numeral and subsections with two Arabic numerals, e.g. 1.1., 1.2., 1.3., etc. When a subsection is arranged into smaller parts, all are marked with three Arabic numerals, e.g. 1.1.1., 1.1.2., etc. Further divisions are not allowed.

The text has to be organized in the following order:

Title of the paper (up to 15 words). Paper should have a concise but informative title that clearly reflects the subject of the paper.

Authors' full names (stated without ranks and academic titles).

Summary - Abstract (up to 150 words) should present a brief and factual account of content and conclusions of the paper, and an indication of the relevance of the new material presented.

Title and abstract in Bosnian/Croatian/Serbian (B/C/S) only for authors from the former Yugoslavia. An alphabetic list of keywords in English and in (B/C/S) is needed. Keywords normally originate from the title and from the abstract.

Introduction should state the reason for the work, with brief reference to previous work on the subject. It informs about the applied method and its advantages.

Central part of the paper may be arranged in sections. Complete mathematical procedures for formula derivations should be avoided. The necessary mathematical descriptions may be given in an appendix. Authors are advised to use examples to illustrate the experimental procedure, applications or algorithms. In general, all the theoretical statements have to be experimentally verified.

In **Conclusions** all the results are stated, and all the advantages of the used method are pointed out. The limitations of the method should be clearly described as well as the application areas. **Bibliography** should be given at the end of the article and numbered in square brackets in order of appearance of references in the text.

Corresponding authors' full names should be followed by the name and address of the institution in which the work was carried out.

A **List of used symbols** and theirs SI units is optional after the bibliography.

1.1.1. Subtitle 2 (Preparation of Manuscript)

(Style: Times New Roman, 11pt, Bold)

The paper should be written using Latin characters. Greek letters may be used for symbols. The volume of the article is limited to 10 pages (A4 format). That includes blanks and equivalent number of characters covered by figures and tables. Number of pages must be even.

The text should be sent to the Editorial Board using email. For the text preparing should be used only MS Word for Windows respectively *.doc, *.docx (Word Document) or *.rtf (Rich Text Format) format of records. The text has to be prepared in accordance with this template.

The Editorial Board may exceptionally request the CD-ROM with recorded articles and figures and tables. In that case the figures (drawings, diagrams and photographs) should be submitted stored on the CD-ROM in JPG/JPEG, PNG, TIF (TIFF Bitmap) or BMP (Windows Bitmap) format, min. resolution of 300 dpi. Each figure should be labelled in the same way in both the paper and recorded format (e.g. fig-1.JPG). If figures are inserted into the text, their resolution must be of min. 300 dpi.

Latin or Greek characters in italics are used for physical symbols and normal characters for measuring units and numerical values. Text in figures is also written with normal letters. Character size is to be chosen on the basis of the following criterion: after expected figure size reduction, a capital Latin character should be about 2 mm high (no less than 6pt).

All figures in the Journal will be printed in black and white technique.

Coloured figures will be seen only in the PDF format on the website <http://www.mf.unze.ba> Tables are created with the word processing program. Each table is positioned in the desired place in the text. In the case of decimal numbers, use commas (e.g. 0,253) and use a small gap to separate the thousands (e.g. 25 000, but not in the case of 1500).

The texts under figures and table titles are in English language and in B/C/S for authors from the former Yugoslavia.

Section titles and titles of subsections are typed in small letters only in English language. Equations are numbered with Arabic numerals in parenthesis at the right margin of the text. In the text an equation is referenced by its number in parenthesis like "... from Eq. (3) follows ...".

Create equations with MS Word Equation Editor (some examples are given below).

$$O_i^4 = \overline{w}_i f_i = \overline{w}_i (p_i x_1 + q_i x_2 + r_i) \quad (1)$$

$$E_i = \frac{(o^i - y^i)^2}{2} \quad (2)$$

$$G(s) = \frac{\omega_n^2}{s^2 + 2\zeta\omega_n s + \omega_n^2} \quad (3)$$

(Notice: If you convert and save your document as a MS Word 2010 file and then add equations to it, you will not be able to use previous versions of MS Word to change any of the new equations.).

Figures and tables are numbered with Arabic numerals (1 ÷ n). In the text, a figure or table is referenced by its number (e.g. in Fig. 1, in Tab. 1, etc.).

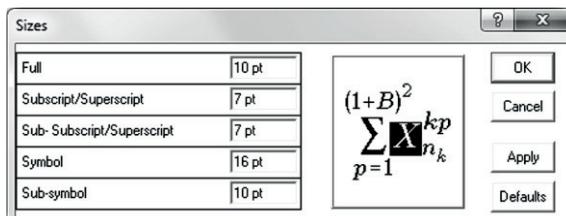


Figure 1 The texts within formulas (only for authors from the former Yugoslavia)
(Style: Times New Roman, 11pt, Italic)

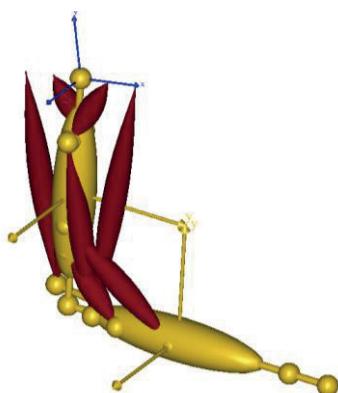


Figure 2 Simplified musculoskeletal model
of an arm
(Style: Times New Roman, 11pt, Italic)

When reference to literature is made, the publication number from the bibliography in square brackets is used like "... in [7] the authors showed ...". In the bibliography, literature is cited in accordance with examples given in the section titled Style Citation Guide.

2. COPYRIGHT TRANSFER AGREEMENT

Copyright assignment. The author hereby assigns to the journal "Mašinstvo" the copyright in the above article, throughout the world, in any form, in any language, for the full

term of copyright, effective upon acceptance for publication.

Author's warranties. The author warrants that the article is original, written by stated author/s, has not been published before and it will not be submitted anywhere else for publication prior to acceptance or rejection by "Mašinstvo", contains no unlawful statements, does not infringe the rights of others, and that any necessary written permissions to quote from other sources have been obtained by the author/s.

Rights of authors. Authors retain the following rights:

- All proprietary rights relating to the article, other than copyright, such as patent rights,
- The right to use the substance of the article in future own works, including lectures and books, and
- The right to reproduce this article for own purposes, provided the copies are not offered for sale.

Co-authorship. If the article was prepared jointly with other authors, the signatory of this form warrants that he/she has been authorized by all co-authors to sign this agreement on their behalf, and agrees to inform his/her co-authors of the terms of this agreement.

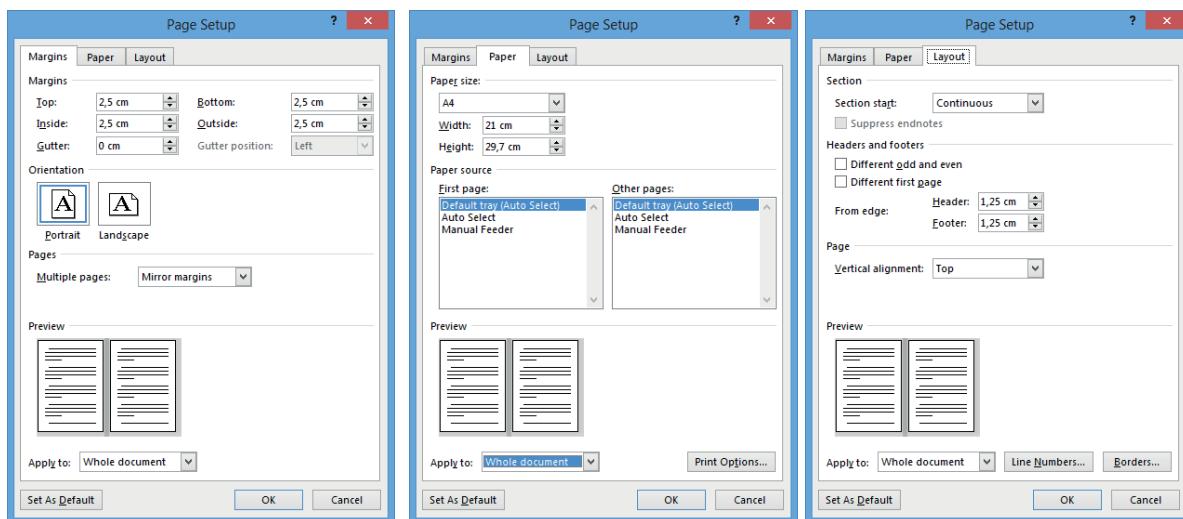


Figure 3 Page setup
(Style: Times New Roman, 11pt, Italic)



Figure X Photography resolution of 300 dpi (min.)
(Style: Times New Roman, 11pt, Italic)

3. PUBLICATION ETHICS AND PUBLICATION MALPRACTICE STATEMENT

The publication of an article in a peer reviewed journal is an essential model for our journal "**Mašinstvo**".

It is necessary to agree upon standards of expected ethical behaviour for all parties involved in the act of publishing: the author, the journal editor, the peer reviewer and the publisher.

Publication decisions. The editor of the "**Mašinstvo**" is responsible for deciding which of the articles submitted to the Journal should be published.

The editor may be guided by the policies of the Journal's Editorial Board and constrained by such legal requirements as shall then be in force

regarding libel, copyright infringement and plagiarism. The editor may confer with other editors or reviewers in making this decision.

Fair play. An editor at any time evaluate manuscripts for their intellectual content without regard to race, gender, sexual orientation, religious belief, ethnic origin, citizenship, or political philosophy of the authors.

Confidentiality. The editor and any editorial staff must not disclose any information about a submitted manuscript to anyone other than the corresponding author, reviewers, potential reviewers, other editorial advisers, and the publisher, as appropriate.

Disclosure and conflicts of interest. Unpublished materials disclosed in a submitted manuscript must not be used in an editor's own research without the written consent of the author.

Contribution to editorial decisions. Peer review assists the editor in making editorial decisions and through the editorial communications with the author may also assist the author in improving the paper.

Acknowledgement of sources. Reviewers should identify relevant published work that has not been cited by the authors. Any statement that an observation, derivation, or argument had been previously reported should be accompanied by the relevant citation. A reviewer should also call to the editor's attention any substantial similarity or overlap between the manuscript under consideration and any other published paper of which they have personal knowledge.

Table 1 Table titles
(Style: Times New Roman, 11pt, Normal)

Engineering stress σ_e / MPa	Engineering plastic strain $\varepsilon_{e,pl}$ / %	True stress σ_t / MPa	True plastic strain $\varepsilon_{t,pl}$ / %
250,0	0,00	250,8	0,00
250,0	0,21	250,8	0,21
285,7	1,35	290,0	1,34
322,7	2,13	330,1	2,10
358,4	3,06	370,0	3,00
393,1	4,35	411,0	4,24
423,6	6,05	450,1	5,85
449,7	8,76	490,1	8,36
457,0	15,79	530,1	14,59
467,9	21,58	570,0	19,45
475,0	29,77	617,5	25,94

(Style in table: Times New Roman, 11pt, Normal)

4. CONCLUSION

Paper manuscripts, prepared in accordance with the Instructions for Authors, are to be submitted to the Editorial Board of the "Mašinstvo" journal. Manuscripts and the CD-ROM are not returned to authors. When prepared for printing, the text may undergo small alternations by the Editorial Board. Papers not prepared in accordance with the Instructions shall be returned to the first author. When there are several authors, the first author will be contacted. The Editorial Board shall accept the statements made by the first author.

5. STYLE CITATION GUIDE

Bibliography

(Style: Times New Roman, 11pt, Normal)

The following recommendations are from The Chicago Manual of Style, University of Chicago Press, 15th ed., 2003. For further information and examples of additional types of sources, please visit <http://www.chicagomanualofstyle.org>

In the bibliography, please state your sources in accordance with the examples given below. Also, indent the second and subsequent lines.

Online sources that are analogous to print sources (such as articles published in online journals, magazines, or newspapers) should be cited similarly to their print counterparts but with the addition of a URL. Some publishers or disciplines may also require an access date. For online or other electronic sources that do not have a direct print counterpart (such as an institutional website or a weblog), give as much information as you can in addition to the URL.

Books

One author

[1] Doniger, Wendy. *Splitting the Difference*. Chicago: University of Chicago Press, 1999.

Two authors

[2] Cowlishaw, Guy, and Robin Dunbar. *Primate Conservation Biology*. Chicago: University of Chicago Press, 2000.

Four or more authors

[3] Laumann, Edward O., John H. Gagnon, Robert T. Michael, and Stuart Michaels. *The Social Organization of Sexuality: Sexual Practices in the United States*. Chicago: University of Chicago Press, 1994.

Editor, translator, or compiler instead of author

[4] Lattimore, Richmond, trans. *The Iliad of Homer*. Chicago: University of Chicago Press, 1951.

Chapter, essay or other part of a book

[5] Wiese, Andrew. "The House I Live In": Race, Class, and African American Suburban Dreams in the Postwar United States." In *The*

New Suburban History, edited by Kevin M. Kruse and Thomas J. Sugrue, 99–119. Chicago: University of Chicago Press, 2006.

Books published electronically

If a book is available in more than one format, you should cite the version you consulted, but you may also list the other formats, as given below.

[6] Kurland, Philip B., and Ralph Lerner, eds. *The founders' Constitution*. Chicago: University of Chicago Press, 1987. <http://press-pubs.uchicago.edu/founders/>. Also available in print form and as a CD-ROM.

Journals

Scholarly journal (show volume & date)

[7] Smith, John Maynard. "The Origin of Altruism." *Nature* 393 (1998): 639–40.

Popular magazine article (show date alone)

[8] Martin, Steve. "Sports-Interview Shocker." *New Yorker*, May 6, 2002.

Article in an online journal, magazine or newspaper

Add the article's URL to the basic citation. However, for articles accessed through a third-party database (e.g., JSTOR), list the URL of the "main entrance" page of the database instead of the individual article, e.g. <http://www.jstor.org/> or <http://muse.jhu.edu/> If an access date is required by your discipline, include it parenthetically at the end of the citation.

[9] Hlatky, Mark A., Derek Boothroyd, Eric Vittinghoff, Penny Sharp, and Mary A. Whooley. "Quality-of-Life and Depressive Symptoms in Postmenopausal Women after Receiving Hormone Therapy: Results from the Heart and Estrogen/Progestin Replacement Study (HERS) Trial." *Journal of the American Medical Association* 287, no. 5 (February 6, 2002), <http://jama.ama-assn.org/issues/v287n5/rfull/joc10108.html#aainfo>.

Websites

Websites may be cited in running text ("On its website, the Evanston Public Library Board of Trustees states . . .") instead of in an in-text citation, and they are commonly omitted from a bibliography or reference list as well. The

following examples show the more formal versions of the citations. If an access date is required by your discipline, include it parenthetically at the end of the citation, as in the example below.

[10] Evanston Public Library Board of Trustees. "Evanston Public Library Strategic Plan, 2000–2010: A Decade of Outreach." Evanston Public Library. <http://www.epl.org/library/strategic-plan-00.html> (accessed June 1, 2005).

Corresponding author:

Name and surname

Institution

Email: xxxxxx@xx.xxxx.xx

Phone: + xxx xx xxxxxx

(Style: Times New Roman, 11pt, Bold)



FabLab Sarajevo

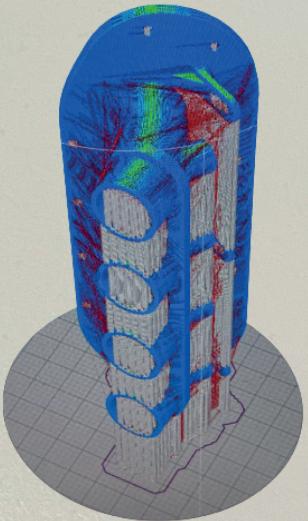
www.fablab.ba

PROFESIONALNO PRINTANJE
MALE PROIZVODNE SERIJE
RAPID PROTOTYPING
3D SKENIRANJE
PODRŠKA KOD PATENTIRANJA
EDUKACIJE ZA FIRME



LABORATORIJE

3D PRINTING
ELEKTRONIČKA
AR/VR
DRONE
AI & ML



FabLab BiH je formiran u januaru 2020. godine i centralno je tijelo za buduće FabLab-ove u BiH.
Zvanično je priznat od strane FabLab fondacije i FabLab zajednice. FabLab Sarajevo je jedini oficijelni FabLab u BiH.

FabLab-ov tim uključuje 3 zastupnika za zaštitu industrijskog vlasništva.

Zmaja od Bosne 8, Kampus Univerziteta u Sarajevu, zgrada Centra za Interdisciplinarnе studije, Sarajevo