ISSN 2228-9860 eISSN 1906-9642 CODEN: ITJEA8

International Transaction Journal of Engineering, Management, & Applied Sciences & Technologies

http://TuEngr.com

FMECA Analysis of Random Mechanical Failures of a Coal System in a Surface Mine

Safet Rika[1*], Elizabeta Hristovska[1], Zlatko Sovreski[1], Sevde Stavreva[1]

[1] *Faculty of Technical Sciences, University St. Kliment Ohridski –Bitola, R. N. MACEDONIA.*
**Corresponding Author (Tel: +389-70223196, safetrika@ yahoo.com).*

Paper ID: 15A1B

Volume 15 Issue 1

Received 08 January 2024
Received in revised form 19 February 2024
Accepted 26 February 2024
Available online 01 March 2024

Keywords:
Failure analysis; Rotor excavator; FMECA; Risk priority number (RPN); Belt covoeyor; SH400.

Abstract

This paper analyzes the random mechanical failures that occurred with SH 400 rotary excavators in the open (surface) coal mine in Oslomej, Kichevo, North Macedonia, for the period January 2019-2021, especially in the transport system of the excavator, referring to the data recorded by the dispatching services of the power plant. The paper deals with the failure hours and frequency of failures occurring in some subsystems of SH 400 rotary excavators and coal crushers, especially the conveyor rubber belt – their carrier structure, conveyor rubber belt, rollers, and drums. The contribution of this paper is to present the methodology for identifying potential failures before they occur, by applying FMECA as a qualitative and quantitative analysis for the coal system and calculation of the risk priority number (RPN).

Disciplinary: Industrial Engineering and Management, Reliability.

Cite This Article:

Rika S., Hristovska E., Sovreski Z., Stavreva S. (2024). FMECA Analysis of Random Mechanical Failures of a Coal System in a Surface Mine. *International Transaction Journal of Engineering, Management, & Applied Sciences & Technologies, 15*(1), 15A1B, 1-12. http://TUENGR.COM/V15/15A1B.pdf DOI: 10.14456/ITJEMAST.2024.2

1 Introduction

The current range of the coal system in general, at the surface mine Oslomej West - Kicevo, with the components listed below, is a relatively complex system composed of a sequence with a sequential relationship between the subsystems, as shown in Figure 1.

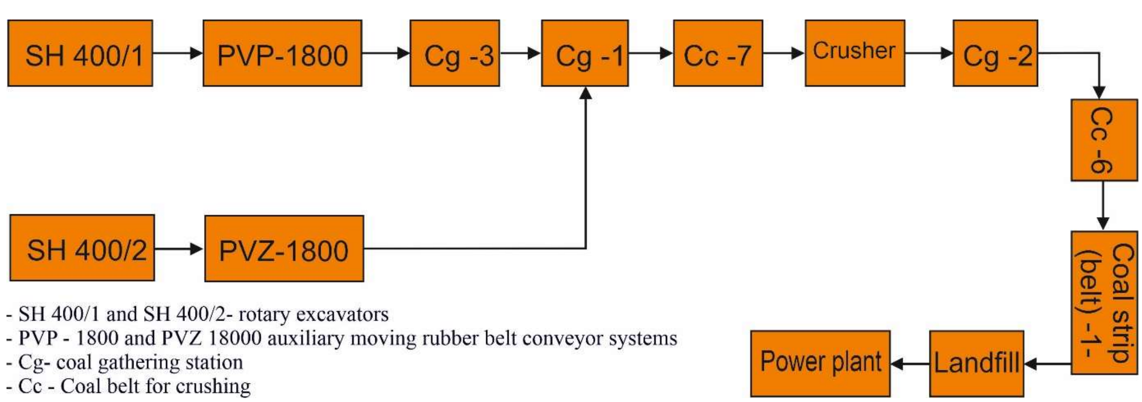


Figure 1: The subsystems of the coal system in the surface mine Oslomej West – Kichevo.

1. Two rotary excavators of the SH 400 type that do not work at the same time, but with the possibility, and if necessary to work parallelly.
2. Rubber belt conveyor,
3. Other additional transporters,
4. Procrastinators,
5. Crusher

The coal system, seen as a technical system, can be in a state of operation when all subsystems will satisfactorily perform the assigned functions during a specified time interval and in a state of failure when at least one of the subsystems is non-working. Due to the failure of one of the subsystems, it can cause a stoppage or lead to the failure of the entire system.

2 Failures of the SH 400 Rotary Excavator

2.1 The Characteristic Parts and Systems

Rotary excavators [3], [4] are continuous self-propelled machines that excavate the coal or tailings with buckets attached to the periphery - the casing of the rotating wheel, and then transfer the same material to the belt conveyor placed on the rotary excavator itself, and further the material with the help of the dumper machine from the excavator it is discharged onto a stationary with belt conveyor and that's how it ends up at the crusher and landfill. Seen from a technical point of view, this represents a serial connection of subsystems, which requires high reliability for the system to work without failures, and this is achieved by regular maintenance and service control of all subsystems.

The compact rotary (hydraulic) excavator SH 400 is a very complex and important machine system, made up of a large number of subsystems, from which the productivity of the excavator mainly depends on its reliability, actually from the reliability (hopefulness) of its subsystems.

Figure 2. a), shows the rotary compact excavator with buckets SH 400/1, and Figure 2. b), shows the rotary compact excavator with buckets SH 400/2, installed in the surface coal mine in West Oslomej – The Municipality of Kichevo.

The rotary excavators SH 400/1 and SH 400/2 do not work at the same time, but if possible and necessary, they can work in parallel work.

a) b)

Figure 2:
a) Rotary excavator with SH 400 buckets (internally named as SH 400 /1),
b) Rotary excavator with SH 400 buckets (internally named as SH 400 /2)

The main subsystems of the SH 400 rotary excavator are:

1. The steel structure of the excavator,
2. The excavation subsystem (Rotor with buckets),
3. Excavator movement subsystem (mechanism of transport and tracks),
4. Conveyor rubber belt intake subsystem,

5. Transportation subsystem for disposal with rubber belt,
6. 6. Subsystem for rotating the upper structure,
7. The hydraulic subsystem
8. The drive station

Several technical characteristics of the SH 400 rotary excavator [9] are briefly given in Table 1.

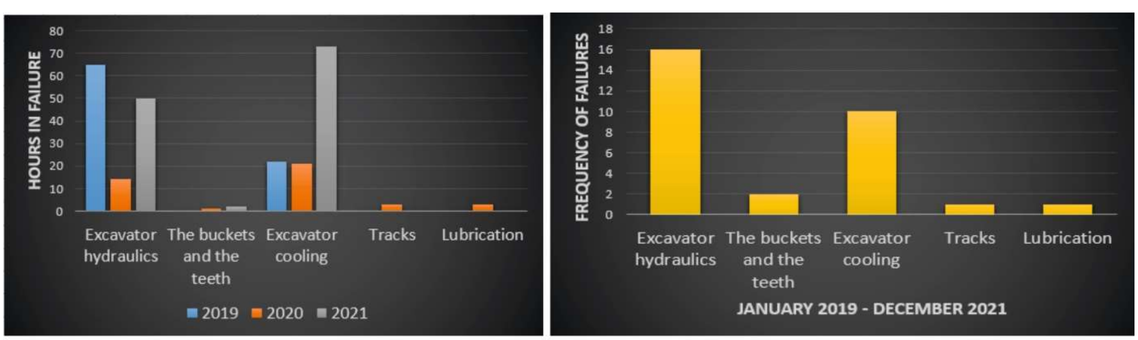
Table 1: Basic technical characteristics of SH 400 rotary compact excavators

Data	Data
Year of production	1974
Machine number of SH 400 /1	L 1337
Machine number of SH 400 /2	L 1338
Intended	For surface mines
Intended for mining material	Lignite (Coal)
Capacity	Medium
Theoretical capacity	1570 m^3/h
Number of buckets	10
Number of teeth on each bucket	6
Type of transport	With a tracked transport device
Length of telescopic boom (receiver part)	12 m
Deferred section	22 m
Type of conveyor rubber belt	4 EP x 1200 mm

Table 2 shows the number of failures and the frequency of failures in three years (2019, 2020, and 2021) [11], of certain characteristic parts/systems of the excavator, caused by failures of the subsystems of the rotary excavators, which are also given in the Figures 3. a) and Figures 3. b).

Table 2: Hours in failure and frequency of failures (number of failures) in the two SH 400 rotary excavators

Type of failures	2019	2020	2021	Frequency (n)
Excavator hydraulics	65	14	50	16
The bucket and the teeth	0	1	2	2
Excavator cooling	22	21	73	10
Track	0	3	0	1
Lubrication	0	3	6	3



a) b)

Figure 3: a) Hours in failure of the two SH 400 rotary excavators
b) The frequency of failures (the number of failures) for the two rotary excavators SH 400

2.2 Conveyor Rubber Belt

A rubber belt conveyor generally can be described as a conveyor device that uses an endless conveyor belt between two points and is an elastic part of the conveyor consisting of a core and rubber sheath [12], [13]. It is practically a bearing/working part of the conveyor which is the most expensive, the most sensitive, and the most short-lived part of the conveyor, Figure 4.

The most common forms of conveyor rubber belt damage are [14]:

- From damaged rollers and drums,
- Attrited from abrasive surfaces,
- Attrited due to fatigue of the material,
- And attrited due to rolling of materials/loads, as basic forms of attrition,
- The rupture and delimitation at the edges of the tape,
- The rupture of the parts that connect the ends of the tape, etc.
- Distance between rollers, (angle of inclination, length, initial tension of the tape, type of load, etc.) and several non-rotating rollers, etc.;
- Improper cleaning of the conveyor rubber belt from the material that is transported leads to the insertion of the material between the conveyor belt and the return belt of the drum, which causes serious damage to the conveyor rubber belt and damage to the rubber layers.
- Improper gluing of the ends of the movable conveyor rubber belt causes irregular movement on the tape, and premature damage occurs to the ends of the conveyor rubber belt.
- Uncoordinated movement and friction of the conveyor rubber belt with the construction parts quickly lead to damage to the ends of the conveyor rubber belt.
- The asymmetry of the drums and rollers can cause a complete tear of the conveyor rubber belt.
- The rupture of the bottom layer of the moving conveyor rubber belt is mainly caused by friction with the surface of the drums and rollers.
- Improper choice of material for the skeleton of the belt, which can lead to premature fatigue, tearing of textile, etc.
- Excessive belt tension causes premature fatigue on the traction side of the belt.

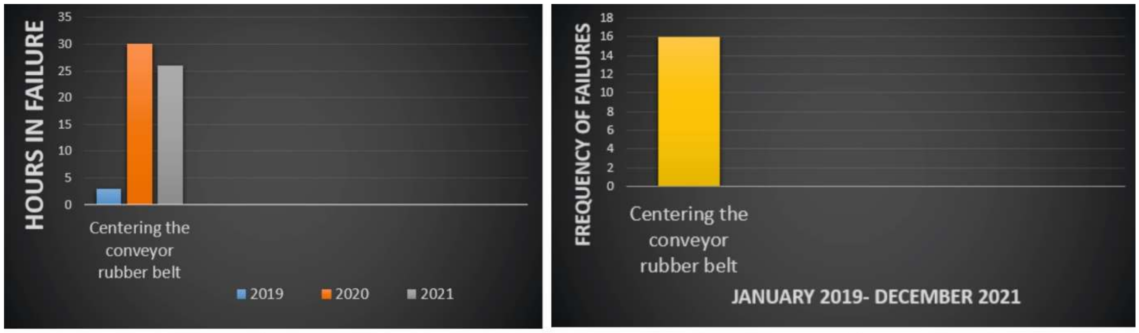
Figure 4: Damaged conveyor rubber belt

After changing the conveyor rubber belt or the drums, or replacing several rollers in the transport system, it is necessary to center the conveyor rubber belt.

The houres in failure and the frequency of failures for the conveyor rubber belt, in the period from 2019 to 2021, are given in Table 3 [11] and graphically through Figure 5 a) and Figure 5. b) [11].

Table 3: Hours in failure and frequency of failures (number of failures) due to centering conveyor rubber belt

Type of failures	2019	2020	2021	Frequency (n)
Centering the conveyor rubber belt	5	30	26	17



a) b)

Figure 5: a) Hours in failure due to the centering conveyor rubber belt
b) Frequency of dismissals (the number of dismissals) due to the centering conveyor rubber belt

2.2.1 The Load-bearing Construction

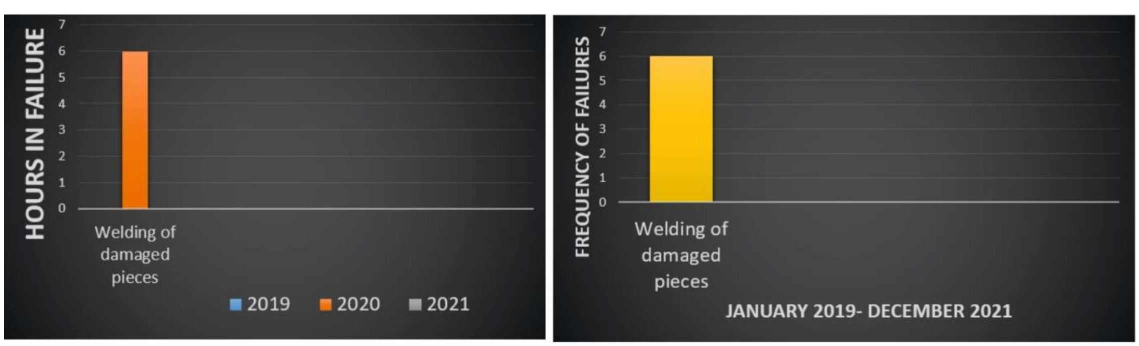
The load-bearing steel construction is an important system that connects all the elements of the conveyor into one altogether [12], [13]. The frequent failures that occur in the load-bearing construction are deformations and fractures of the steel parts from oscillations and improperly welded joints, torn bolts, displacement of the load-bearing construction due to overloading and subsidence of the ground from underground water, possible fires from the electrical installation, or from the strong friction of the conveyor rubber belt with the steel rollers or the rubber drums, Figures 6.

Figure 6: Parts of the load-bearing steel construction in an improper condition due to cracks and fractures from mechanical impacts, installed in the surface mine Oslomej West – Municipality of Kichevo

In Table 4, [11] and Figures 7a) and 7b), are given the hours in failure and the frequency of failures (the number of failures) caused by welding of damaged parts and pieces of the entire load-bearing metal construction of conveyors belt from 2019 until 2021.

Table 4: Hours in failure and frequency of failures (number of failures) the stoppage due to welding of the steel construction

Type of failures	2019	2020	2021	Frequency (n)
Welding of damaged pieces	0	6	0	6



a) b)

Figure 7: a) Hours of failure of the system due to welding of parts of the load-bearing construction
b) Frequency of failures (the number of failures) caused by welding parts of the load-bearing construction

2.2.2 Rollers

The main function of the rollers [13] is to carry the conveyor rubber belt, the load that needs to be transported, and to return the conveyor rubber belt (from returnable to working position), so the quality of the rollers is particularly important.

The rollers are arranged (hung) by the length of the load-bearing construction over a relatively short distance. The technical cohesion of the rollers is approximately 36,000 hours [13], and the time depends on the working conditions and it can go from 4 to 6 years [13].

There are many different causes of roller failure, but the most common causes are abrasion, corrosion, seal failure, and total roller destruction. Regular attrition or friction of the surface, from contact with the conveyor rubber belt, can limit the cohesion of the rollers**.** In this case, corrosion is directly related to abrasion, and the more corrosion there is, the greater the rate of abrasion and the weakening of the surface of the material. In this case, the corrosion is related to the abrasion, the more corrosion there is, the higher the abrasion rate, and the weakening of the surface of the material is accelerated.

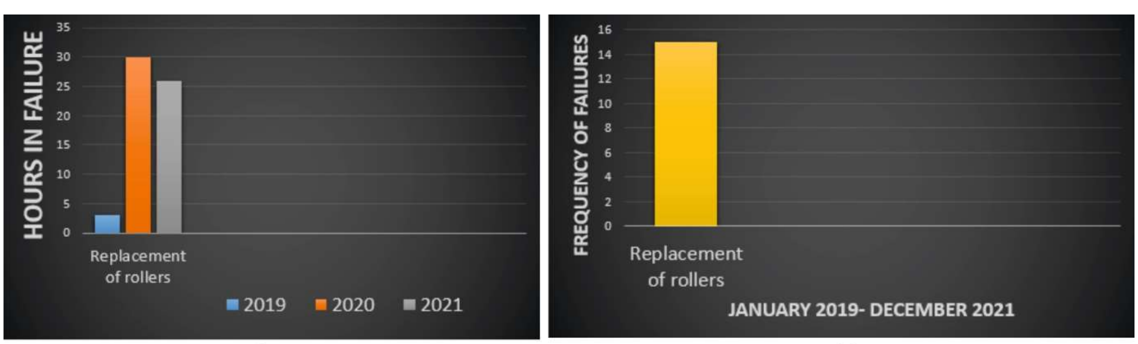
Roller failures may also occur due to tearing of the roller body, blocking of the bearings on which the roller leans, and broken axis of the roller, which damages are recognized by the sounds that are produced and the oscillations that appear, as in Figure 8. These roller conditions can result in catastrophic damage to the conveyor rubber belt, manifested by cutting and tearing of the conveyor rubber belt.

Figure 8: Damaged rollers

Table 5: Hours in failure and frequency of failures (number of failures) due to replacement of rollers

Type of failures	2019	2020	2021	Frequency (n)
Replacement of rollers	3	30	26	15

Table 5 [11], Figure 9. a) and Figure 9. b) provide information on the hours in failure and the frequency of failures (the number of failures) caused by roller defects in the period of three years (2019 - 2021).



a) b)

Figure 9: a) Failure hours system due to roller replacement
b). Frequency of failures (number of failures) caused by replacement of rollers

2.2.3 Drums

The drums are the sensitive parts of the conveyor rubber belt, they transmit the traction force of the conveyor rubber belt and enable the movement of the conveyor rubber belt. The drums consist of two bearings, a shaft, a body, and a wrapper [5], [13] Figures. 10.

The cracks that occur in the drums appear as a result of strong impacts and actions during the work process and from the friction that occurs between the rubber lining of the drum and the conveyor rubber belt.

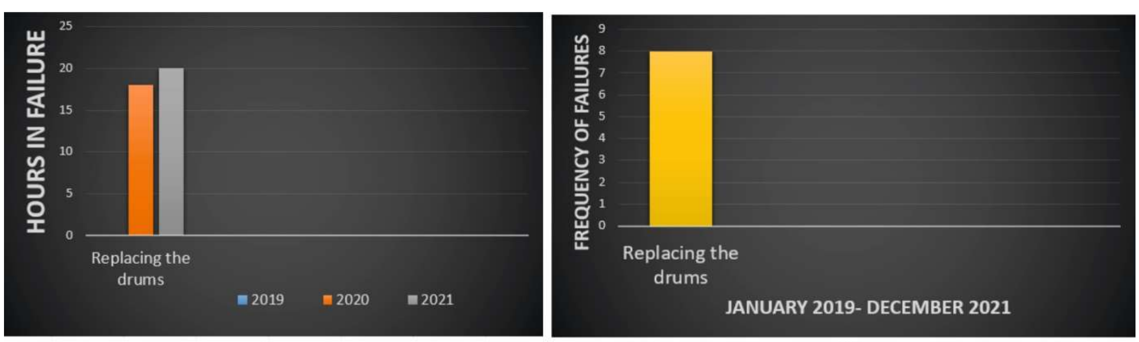
Failure of the drums also occurs from frequent fractures of the drums bending and twisting of the shafts as a result of dynamic strikes, the action of overloads than allowed, and other actions in machine parts such as solid materials getting between the conveyor rubber belt and the drum lining causing serious damage up to system failure.

Figure 10: Damaged drums

Table 6, [11] and Figures 11 a) and b) show the number of failures and the frequency of failures (the number of failures) in the period of three years caused by drum failure.

Table 6: Hours in failures and frequency of failures (number of failures) due to drum failure

Type of failures	2019	2020	2021	Frequency (n)
Replacement the drums	0	18	20	8



a) b)

Figure 11: a) Hours in failures due to the replacement of the drums
b) Frequency of failures (the number of failures) caused by drum replacement

2.2.4 Drive station

The drive station consists [13] of a drive motor (electric motor), reducer, clutch, drive drum (one or two), deflection drum, conveyor rubber belt cleaner, brake, and braking system.

Failures that occur in electric motor drives can be failures that occur on the electrical part of the motor and failures that occur on the mechanical part of the motor.

In the period from 2019 to 2021, no failures were registered due to the failure of engines or reducers from the coal system. Figure 12 shows a damaged electric motor and reducer from the coal system but in a period outside the analyzed period of failures.

Figure 12: Damaged electric motor and reducer of the coal collection station marked as Js-3

2.3 Crusher

In the crusher, the coal is broken into smaller sizes up to 35 mm with the help of hammers. Failures in the crusher [14] occur due to the replacement of hammers, replacement of ball bearings, replacement of teeth, broken chains, lubrication of parts, and frequent stalling of metal and other large objects in the crusher. Table 7, [11] and Figures 13. a) and b) shows the failures and the frequency of registered failures in the crusher, for the treated time period.

Table 7. Hours in failures and frequency of failures (number of failures) due to failure of parts in the crushing plant

Type of failures	2019	2020	2021	Frequency (n)
Replacement of defective bearings	0	10	0	2
Electrical installation or drive machinery parts	0	9	0	6
Replacement of teeth	3	0	4	2
Replacement of hammers	0	0	7	1
Lubrication	0	1	1	1

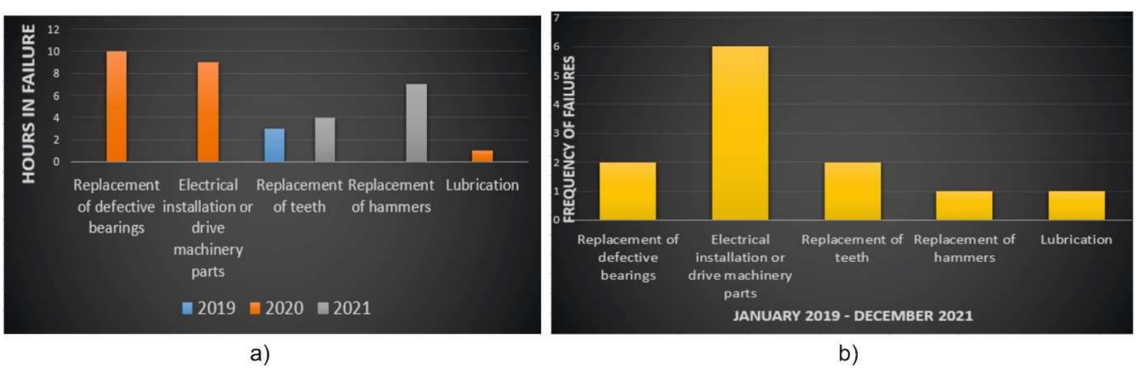


Figure 13: a) Hours in failure due to replacement of parts and maintenance of the crusher
b) Frequency of failure (number of failures) due to replacement of parts or maintenance of the crusher

3 Implementation of the FMECA analysis

FMECA is illustrated as a method used to identify the system failures, the causes of not having success, and the impact of those failures. The result of the FMECA analysis is generally the determination of a priority risk number that is used to help identify the greatest risks and point the way to corrective actions [1], [2].

The Risk Priority Number (RPN) is a relative ranking system that assigns a numerical value to the three risk factors: Severity (S), Occurrence (O) and Detection (D), with the following meaning:

S (Severity) - Rating of the severity of each potential failure effect,

O (Occurrence) - An assessment of the probability of occurrence for each potential cause of failure, D (Detection) - Assessment of the probability of detecting the cause of failure.

RPN is calculated as [10],

$$RPN = [S] \times [O] \times [D] \quad (1),$$

and can accept a maximum value of 1000 and be used only when we think it is useful for our analysis, as shown in Table 8, [6] .

Table 8: General indicator of the degree of risks

RPN Risk Indicator	
RPN <50	Low-risk zone (low)
50<RPN<100	Moderate risk zone (medium)
RPN>100	High-risk zone (critical)

Table 9 shows, FMECA - Failure Mode, Effects, and Criticality Analysis [8] for the surface mine coal system in Oslomej - Kichevo.

Table 9: FMECA for the coal system in the surface mine Oslomej - Kichevo

Order no.	Subsystem Description (the part)	Section function	Reasons for failures	S (Severity)	O(Occurrence)	D (Detection	RPN	FMECA- Analysis Prevention/Correction: Corrective action	S	O	D	RPN
1	SH 400 Rotary Excavator	Coal mining	- Hydraulics -Teeth attrition - Cracks in the structure -And others	10	10	2	200	- Lubrication -Welding of the construction and buckets - Replacement of bucket teeth - Cooling - Hydraulic service	5	5	2	50
2	Conveyor rubber belt	Transport of coal or tailings	Attrition, breakage, delamination, deviation	9	10	2	180	Centering, vulcanization, gluing, repairing, relocation, adding	4	5	2	40
3	Steel rollers	Carrying the conveyor rubber belt and the load, directing the belt	blocked, attrited	7	5	2	70	Detailed lubrication or change	4	4	2	32
4	The Driving drum(power stations drum)	The basic element of the power station	Damaged shaft, bearing, rubber lining	3	8	2	48	Detailed lubrication, the change of the rubber lining	2	8	2	32
5	Tension power drum of conveyor rubber belt	For tensioning the traction of the conveyor rubber belt	Damaged shaft, bearing, rubber lining	3	9	2	54	Detailed lubrication, the change of the rubber lining	2	9	2	36

Order no.	Subsystem Description (the part)	Section function	Reasons for failures	S (Severity)	O(Occurrence)	D (Detection	RPN	FMECA- Analysis Prevention/Correction Corrective action	S	O	D	RPN
6	Steel guides Balancers	Correct movement of the moving conveyor rubber belt	Improper position, or distortion of the bearing structure of the rollers and drums	2	3	2	12					-----
7	Electric motor	Realization of traction and the movement of conveyor rubber belt	Oscillations, damaged installation, it does not turn on	7	10	4	280	Main control, lubrication, and air passage cleaning. The checking and maintenance of electricity installation	5	5	2	50
8	Gearbox	Conveyor rubber belt speed reduction	Mechanical fatigue, oscillations, and oil accumulation	9	10	2	1 8 0	Cleaning, filling with oil	4	5	2	40
9	Returning rollers of the conveyor rubber belt	Returning and routing the conveyor rubber belt without load	blocked, and attrited	3	8	1	24					-----
10	Bearing steel construction	Connecting all elements of the conveyor in general	Fracture, short circuit of installation	5	4	3	60	Welding, the testing of other mechanisms	3	2	1	6
11	Crusher	Coal grinding	The attrition of teeth, blockage of bearings, consumption of hammer	8	9	2	144	Replacement of bearings, replacement of teeth, lubrication, welding	4	5	2	40

Table 9, shows the columns in which the data is entered by its rank for: the serial number of the subsystems of the coal system, the description and function of the subsystem, the reason for the failure, and the RPN value.

For example, in sequence number 1 of the subsystems, it can be seen that the priority number of risk for the rotary excavator SH 400 is 200, which represents a zone of high risk, which is confirmed in Table 2 (for the time interval from January 2019 to December 2021, the number of failures (frequency n) total reaches 32). After taking corrective measures, a new permitted value is received for the priority number of failures (shown in the following columns of the table), which amounts to RPN = 50 (zone of moderate risk - the risk is not clear) for the subsystem, where the further work is possible.

The high value of RPN identified for the conveyor rubber belt, which reaches RPN = 180 as a result of the number of failures n = 17 according to Table 3, which provides information that the system was in failure for a total of 59 h over a period of 3 years, due to centering. After the corrective measures, the priority risk number is reduced to 40 (RPN<40, the risk does not exist), which according to the reference numbers in Table 8 represents a low-risk zone.

According to the information from the expert team in the coal sector, this system of the power plant did not stop during the period from 2019 to 2021 electric motor did not fail, and neither did the reducer due to regular maintenance (corrective, combined, and preventive), so the assessment is RPN = 50 for the electric motor and RPN =40 for the reducer. In Table 9, the value for RPN =280 for the electric motor and the value for RPN =180 for the reducer are predicted values by the expert team in cases where these two main elements would lack proper and timely maintenance.

Often, the failures in most listed elements in Table 9 appear suddenly without having time to take corrective measures, causing great damage both in terms of time and material.

4 Conclusion

This paper provides a report and analysis of mechanical failures occurring in the system (the subsystems) for coal in the surface mine Oslomej West, Kichevo Municipality, RS. Macedonia, for the period of three years (2019-2021).

Since the entire coal system works in the open and in difficult working conditions, it is always set to external influences that lead the system to major failures, during the interruption of the system operation for hours or even days of in a week. Other factors that affect the working coal system are the age of the system itself, the large number of subsystems, as well as the improper and untimely maintenance of the system by the employees.

From the statistical data obtained by the experts from the power plant, it can be seen that there are more frequent failures occurring in the excavation subsystem of SH 400 rotary excavators. Also, many failures in the same period were registered in the conveyor rubber belt due to warped and blocked rollers and excessive friction with the drums. A large number of failures have also been recorded to the crusher: failures of the hammers, bearings, and other sensitive mechanisms, from torn parts of the steel structure that fall into the coal gauge and end up together in the hammers of the crusher, without being detected by the metal sensors installed after the conveyor construction. Because of this, this paper is analyzed from an aspect of the failures of rotary excavators, subsystems, and parts.

The practice in this factory/plant showed that the control and preventive maintenance are crucial for the reliability of the system because the work dynamics do not allow any part or subsystem of the whole system to fail. This is confirmed in the paper with the obtained value for the indicator of the risk degree after the implementation of preventive and corrective actions on subsystems and the parts with high risk.

The hope of any technical system that is directly related to failures can never be 100%, so the reliability of the coal system in the open mine in Oslomej does not reach its maximum value, which is very clearly seen from the occurrences of failures of subsystems (elements) that have occurred in three years, and what is expected for working machines such as rotary excavators and working conditions in the surface.

For the evaluation/design of the reliability of the coal system in the surface mine in Oslomej, a technique is used the FMECA (shown in Table 9 in this paper). With this approach, the possible ways of failures have been investigated, a better assessment of reliability has been provided, a qualitative criticality of analysis has been obtained, and therefore, instructions have been received to focus on the highest risks. In order to achieve the required reliability, expert technical personnel must intervene through planned, corrective, and preventive maintenance, especially in the subsystems where the priority number of risk reaches higher values than the zone with low risk, and in that way is ensured the further operation of the system.

5 Availability of Data and Material

Data can be made available by contacting the corresponding author.

6 References

[1] Давчев, Т. Надежност на техничките системи. Македонска организација за квалитет и стандардизација, Скопје, 1992.

[2] Давчев, Т. Надежност и одржување на техничките системи. НИП “ Студентски збор ”, Скопје, 2009.

[3] Hristovska, E. Correlation of deformed-stressed features and design properties of the clamp dogs with the carrying structure of the working organ on the excavators, doctoral dissertation, Skopje, June 2000.

[4] Hristovska, E. Optimization of gearboxes for the drive of the rotating wheel at excavators, Master's thesis, Skopje, April 1997.

[5] ZIMROZ, R., KRÓL, R. Failure Analysis of Belt Conveyor Systems for Condition Monitoring Purposes, Prace Naukowe Instytutu Górnictwa Politechniki Wrocławskiej, Nr. 128, 2009.

[6] Кожовска, Е.: "ПРИМЕНА НА FMEA МЕТОДА ПРИ ИНТЕГРИРАЊЕ НА СИСТЕМ ЗА БЕЗБЕДНОСТ И ЗАШТИТА ПРИ РАБОТА И ЗАШТИТА НА ЖИВОТНАТА СРЕДИНА ", магистерски труд, Битола, 2016.

[7] Krol R., Jurdziak**,** L., Gładysiewicz**,** L. Economy of Belt Conveyor Idlers Renovation based on Results of Laboratory Tests. Industrial Transport, 2(2)**,** 2008, Wroclaw.

[8] Ajdari, I. FME(C)A Methods as a Key Factor on the Reliability and Safety of the Technical Systems towards Sustainable Development in the Industry Sector. SEEJSD, 1(2), 2018: 9-16, JSC Macedonian Power Plants – Skopje, Subsidiary TPP “OSLOMEJ” – Kichevo, Macedonia.

[9] https://www.scribd.com/document/350389495/5515-BucketWheel-Excavators-REF

[10] https://www.iqasystem.com/news/risk-priority-number/

[11] OM. Technical documentation from the dispatch center for coal at the surface mine Oslomej, Kichevo municipality.

[12] Малбашић В., Челебић М., ТРАНСПОРТ РАСУТИХ МАТЕРИЈАЛА НА ПОВРШИНСКИМ КОПОВИМА КОНТИНУАЛНИ ТРАНСПОРТ, Универзитет у Бањој Луци, Рударски факултет Приједор, Приједор, 2019.

[13] https://pdfcoffee.com/skripta-mehanizacija-pretovara-pdf-free.html.

[14] Gurjar, R. S. Failure Analysis of Belt Conveyor System, IJESS., 2(10), 2012.

Mr. Sc. Safet Rika is a Ph.D. student at the Faculty of Technical Sciences, St. Kliment Ohridski-Bitola University, R. North Macedonia. He got a Bachelor's degree from the Department Faculty of Electrical and Computer Engineering, University of Prishtina, R. Kosovo, and a Master's degree in Graphics Engineering at Faculty of Technical Sciences, from St. Kliment Ohridski-Bitola University, R. North Macedonia. His research interest is the Reliability of Technical Systems.

Dr. Sc. Elizabeta Hristovska is a Full Professor at the Department of Industrial engineering and management, Faculty of Technical Sciences, St. Kliment Ohridski-Bitola University, R. North Macedonia. She got her Master’s and PhD degrees in Mechanical Engineering from St. Cyril and Methodius University in Skopje, R. North Macedonia. Her research focuses on the Design of Machine Structures, Machines, and Vehicles.