RESEARCH REGARDING THE RELIABILITY OF SUBASSEMBLIES AND MECHANICAL ENERGY LOSSES OF THE CENTRIFUGAL PUMPS

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Abstract: Mine dewatering and water supply works of the equipment (batteries cyclone etc.) of coal preparation are made using centrifugal pumps. Subassemblies wear during operation of these pumps determines stops and production losses; beside this aspect the centrifugal pumps mechanical efficiency are low reason for which it is necessary their pursuit into operation to establish the reliability and improve their energy efficiency. In the paper are quantified some mechanical performances about the reliability of subassemblies and components of energy balance real hourly of the centrifugal pumps.

Keywords: centrifugal pumps, failures, reliability parameters, mechanical losses, energy efficiency

1. INTRODUCTION

Dewatering a mine [Georgescu et al],[Patrascu and Vatavu], can be done using centrifugal pumps type turbo-pump characterized by axial and radial leaving by of scheme of figure 1.

Hydro-cyclone batteries supply from coal preparation is done with type Warman centrifugal pumps with capacity of 550 m^3/h and the discharge height over 45 m. The importance of studying the wear and failure of the centrifugal pumps subassemblies (fig. 2) result from the influence they exert these aspects on continuity of the technological flows. In this context, the reliability analyzes can be sources of knowledge and improvement of the design and management of various industrial technological lines.

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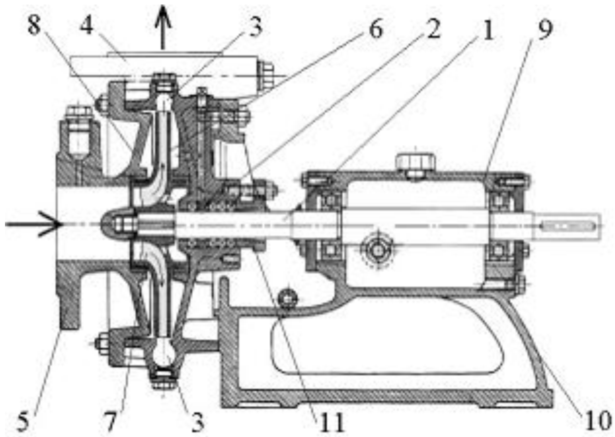

Fig. 1. Centrifugal pump:
1-shaft; 2-sealing system; 3-volute chamber; 4-discharge flange; 5-aspiration flange; 6-pump impeller; 7-rotor blades; 8-pump casing; 9-bearing block; 10-pump support; 11-gland

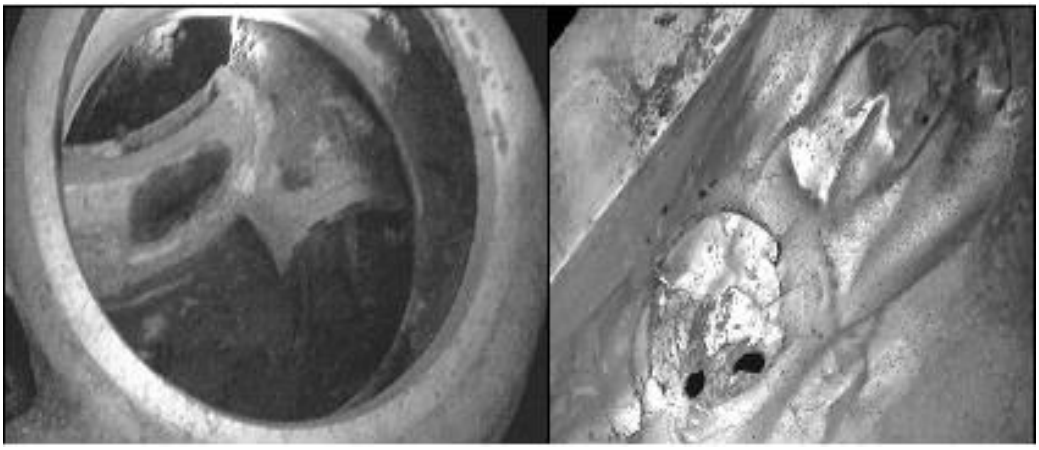

Fig. 2. Worn subassemblies of the pump Warman

2. DETERMINING THE PARAMETERS OF RELIABILITY FOR CERTAIN SUBASSEMBLIES OF THE CENTRIFUGAL PUMPS

The calculation of the reliability parameters it constitutes a methodology including the steps and analytical relations corresponding scope using databases resulting from long pursuit of the functioning of centrifugal pumps Warman.

Calculation of reliability of the Warman pump bearing housing

The expression of reliability [3] for exponential distribution is:

$$R(t_i) = e^{-\lambda \cdot t_i} \qquad (1)$$

where, λ –failures rate. In the table 1 are given values of operating time between failures T_f and time for repair T_{rem}, for n=14 events (in increasing order).

Table 1. **Values of operating time between failures and time for repair**

T_f [hours]	7	7	21	28	35	56	105
T_{rem} [min]	30	30	30	30	30	30	40
T_f [hours]	175	231	245	392	413	742	1890
T_{rem} [min]	50	60	60	60	60	100	110

The mean operating time between failures is,

$$M[t] = \frac{\sum_{i=1}^{n} T_{f_i}}{n} = \frac{4347}{14} = 310{,}5 \ [hours]$$

In the case of exponential distribution, failures rate will be:

$$\lambda = \frac{1}{M[t]} = \frac{1}{310{,}5} = 0{,}00322 \ [hours^{-1}]$$

The theoretical distribution function is:

$$F(t_i) = 1 - e^{-\lambda \cdot t_i} \quad (2)$$

and the distance between experimental and theoretical functions will be,

$$d = \left| F_c(t_i) - F(t_i) \right| \quad (3)$$

In the case of bearing housing, it is found that the law of exponential distribution validates according to concordance test Kolmogorov (table 2) because:

$$d_{max} = 0{,}2471 < \frac{1{,}36}{\sqrt{n}} = \frac{1{,}36}{14} = 0{,}363$$

Table 2. **Values of experimental and theoretical functions**

No.	**Interval size Δt**	**Average value t_i**	**Number of failures n_i**	**Relative frequency $f(t_i)$**	**Cumulative frequency $F_c(t_i)$**	**Distribution function $F(t_i)$**	**Distance d**
1	0-391	195.5	10	0.7142	0.7142	0.4671	0.2471
2	391-782	586.5	3	0.2142	0.9284	0.8487	0.079
3	782-1173	977.5	-	-	0.9284	0.9570	0.028
4	1173-1564	1368.5	-	-	0.9284	0.9878	0.059
5	1564-1955	1759.5	1	0.0714	0.9998	0.9965	0.003
			n=14				

Value of mean time to repair is:

$$MTR = \frac{\sum_{i=1}^{n} T_{r_i}}{n} = \frac{721}{14} = 51{,}4 \ \ [min]$$

For different values of the operating time, the values of reliability are given in table 3.

Table 3. **Variation of reliability of the bearing housing according to operating time**

***t* [hours]**	50	100	150	200	250	300	350
R(t)	0.851	0.724	0.616	0.525	0.447	0.380	0.324
***t* [hours]**	400	500	600	700	800	900	1000
R(t)	0.275	0.199	0.144	0.104	0.076	0.055	0.039

In a similar way it was established reliability of other subassemblies of the pump (figure 3) such as transmissions belts, seals, etc. Shall be made in evidence, in this way, the components with the weakest operating results like seals and bearings.

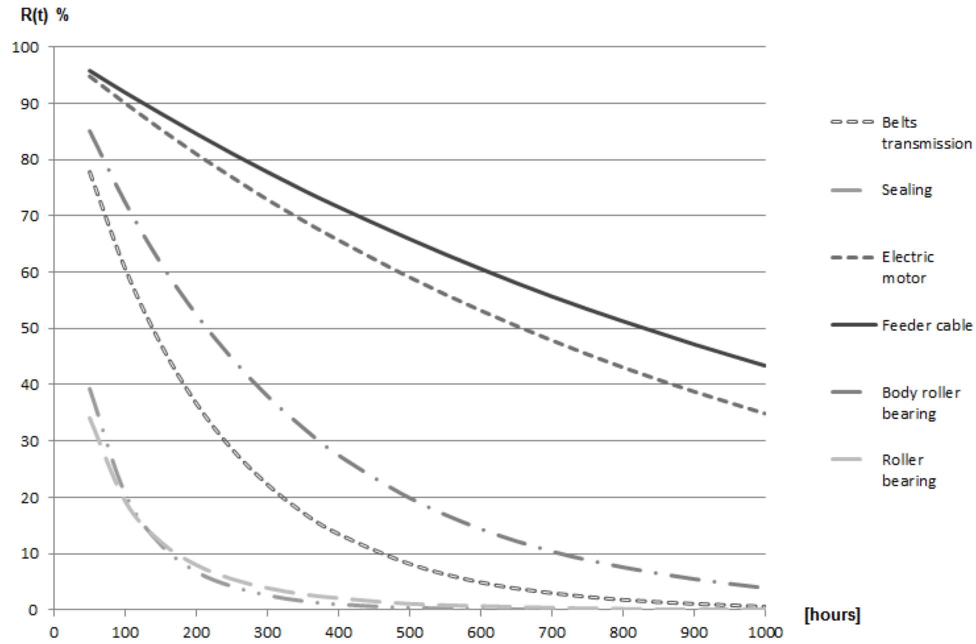

Fig. 3. Variations the reliability of the pump Warman subassemblies with defects

Knowledge reliability and maintenance activities contribution [Florea] to reduce energy consumption, should be seen as part of determining energy performance. For this purpose, the question is achieving pumps energy balance.

3. HOURLY ENERGY BALANCE OF CENTRIFUGAL PUMPS

The balance sheet elements have been determined for a centrifugal pump 5.5 kW with following technical characteristics [5]:

- Q =150 m^3/h;
- H =5 m;
- P_{engine} =5.5 kW;
- Pump shaft power P_{ps} =4.086 kW;
- Mechanical efficiency η_m =0.82;
- Hydraulic efficiency η_h =0.70;
- Volumetric efficiency η_v =0.87;
- Total pump efficiency η_p =0.50.

Mechanical efficiency, η_m takes into account the mechanical losses due to friction in the bearings and the elements of shaft and hydraulic efficiency, η_h depends losses hydraulic pump, due to friction between the fluid and the walls that come in contact all the way, from entry to exit pump.

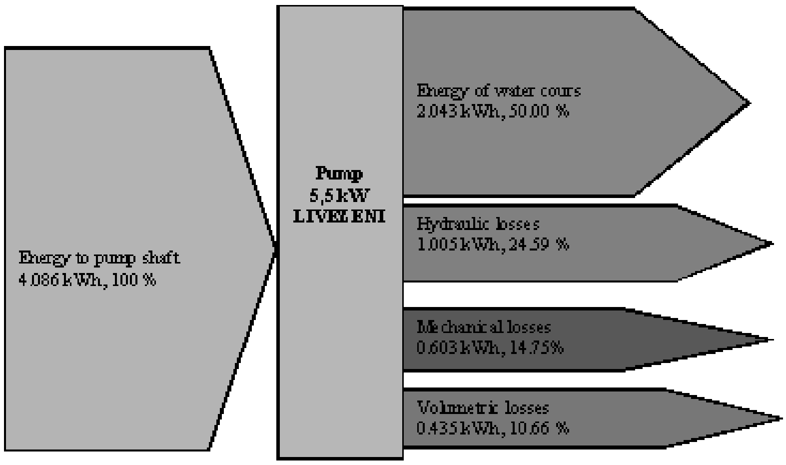

Fig.4. Sankey diagram for a centrifugal pump

The total hydraulic, mechanical and volumetric losses represents 50% of energy available to centrifugal pump shaft analyzed. Element bearings and sealing elements is not only sources of energy losses but also the high costs of spare parts. For a production of over 500,000 tons coal washing, cost of spare parts required centrifugal pumps are 280,000 lei from which element bearings and sealing elements is 50%, which underlines the necessity of timely quality revisions and repair such equipment.

4. CONCLUSIONS

Mechanical efficiency of the centrifugal pumps, depends on the mechanical losses due to friction depends on bearings and sealing elements so as to increase this parameter should be used in the execution of their, new material with anti-friction properties.

The cost of purchasing the pump is only a small part of total for their life cycle. Maintenance is a significant cost but the majority of operating costs come result from the energy consumption.

Making evident the contribution of maintenance activities in connection with reliability to reduce energy consumption of centrifugal pumps represents a modern approach to the problems regarding to finding solutions to improve equipment availability. Subassemblies that have low reliability causing interruptions in operation, energy losses and additional maintenance activities, respectively high costs.

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