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Diagnosis of technical problems related to the operation of turbopumpsat industrial scale: application to the pumping station of Kimilolo(Lubumbashi, DR Congo)

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Abstract

The rapid and accurate assessment of turbomachine problems is therefore a key factor in efficient and safe operation. The purpose of this article was to facilitate a reliable and timely diagnosis of potential problems, and the condition of turbopumps after damage to allow the operator to have quality information to decide its options vis-a-vis the equipment in default. This work also facilitates the investigation of breakdowns highlighting the most important elements of a problem in order to facilitate the choices and priorities of action on the most penalizing technical problems encountered during the exploitation of the latter in industrial circles; and whose resolution would be the most cost-effective in terms of unavailability costs. The interpretation of the PARETO diagram allowed us to identify the most important problems. Thus this study proposed a path to assist in fault diagnosis by specifying the causes and precautions necessary to take or possible remedy to facilitate a rapid diagnosis of damage for safe operation of hydraulic installations.

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1. Introduction

Today, whether in heavy industry or in the tertiary sector, the users of turbopumps are more and more concerned with guaranteeing a continuity of service, given the often enormous costs generated by a shutdown of these plants in an industrial process [1]. Most of the pumping stations located in Katanga tend to deteriorate over time due to multiple causes such as usury, deformation due to the operation or the action of corrosive agents (chemical agents, atmospheres, etc.). These deteriorations can cause the shutdown, reduce production capacity, jeopardize the safety of goods and people, cause rebuses or reduce quality, increase operating costs or reduce the market value of these means. Maintain is therefore to perform troubleshooting operations, lubrication, visit, repair, improvement, etc., which allow to retain the potential of the equipment to ensure the continuity and quality of production; but the technicians responsible for the maintenance of turbopumps in the industrial sector are confronted with the numerous problems related to the operation of the turbopumps and that from the installation of the latter until the exploitation.

Difficult identification of problems, decreasing the reliability of centrifugal pumps leads to a decrease in production efficiency and a painful maintainability of equipment which would cause the reduction of the operational availability of the machines [2]. On the other hand, a diagnostic assistance tool will lead to an easy identification of the problems, reduce the maintenance of the equipment which would enable the technicians to fix the data of the problems judiciously and to be informed of the directives to follow as well as a good management of the spare parts stocks [3, 4, 5].

Currently, there are no scientific studies that have identified the problems associated with the use of turbopumps on an industrial scale in the Lubumbashi region. In this context, the purpose of this article is to facilitate a reliable and rapid diagnosis of potential problems, and the condition of turbopumps after damage to allow the operator to have quality information to decide its options for faulty equipment.

2.1. Study area

This study was conducted in Lubumbashi, capital of the province of Upper Katanga in the Democratic Republic of Congo. The study was carried out specifically at the Kimilolo pumping station, a major REGIDESO water catchment station located about 7 km from Lubumbashidowntown.

2.2. Methods

Data collection at Kimilolo Station was carried out for a period of 6months. The data collected mainly concerned the technical failures recorded and their duration, the types of pumps and their characteristics, and finally the types of damage related to the types of pumps and their maximum downtime.

The ABC method of PARETO based on the analysis of the technical documentation and especially of the historical cards of breakdowns was used in this study [6]. Other analog distributions have been noted; which allowed to draw the law of the 20-80 or the law of Pareto. This law can apply to many problems. It is an effective tool for choice and decision support. The exploitation of this law makes it possible to determine the most penalizing elements in order to diminish their effects: to reduce the maintenance costs, to improve the reliability of the systems and to justify the setting up of a maintenance policy, etc [7]. The purpose of this method is to objectively suggest a choice; that is, sort by order of importance, parts, costs, etc. and this from a knowledge base of a previous period (history of failures for example). The results are in the form of a curve called ABC diagram whose exploitation allows to detect the most significant elements of the problem to be solved and to make the decisions allowing its resolution.

This law, which is common in quality, thus makes it possible to identify the importance of the negligible and to rank in order of importance of causes. For example, when trying to solve a problem, it is desirable to start by analyzing the causes and then to identify the main causes for the corrective action to be effective. In maintenance this law also applies and has a very good impact on the results obtained [7].

3. Results

Table 1 presents the history of the most common problems at the pump and capture station. As a result, 16 major problems are most common. The causes being varied; the duration of repair varies in the same way. The excessive wear of bearings causing damage is the problem that takes the most repair time.

Table1. Identifying the most common problems, their causes and the duration of repair

	Type of damage	**Cause**	**Repair time/Hours**
1	Water leaking at the pump	Filling in poor condition	6
2	Water leaking on the discharge pipe	Poor sealing of cable glands and discharge pipe	8
3	Pump does not start	Filling in poor condition	6
4	Abnormal noise on the suction side of the pump	Defective discharge	6
5	Abnormal noise from the pump	Defective bearing	7
6	Water leaking at discharge	Defective front valve	4
7	Leakage at joints	Seal in poor condition	7
8	No priming of the pump	Defective boot circuit	5
9	Damaged bearing	Exaggerated usury	12
10	The 2 bearings damaged	Exaggerated flow in the jacket that passes through the bearings	6
11	Damaged bearing	Exaggerated flow of water	6
12	Damage to the bearing	Exaggerated flow of water	8 heures
13	Usury of the bearing	Usured rumbling	3 heures
14	Usury ofbearing	Usured bearing and rumbling	7 heures
15	Damaged filling	Vibration of the engine	4 heures
16	Air suction at the priming line	Leaking on the priming line	7 heures

Figure 1 showing the duration of repair of rolling damage by pump type shows that the pump type CN 200-50 takes the most repair time, or 12 hours. Of the six cases of damage, a total of 44 hours is observed.

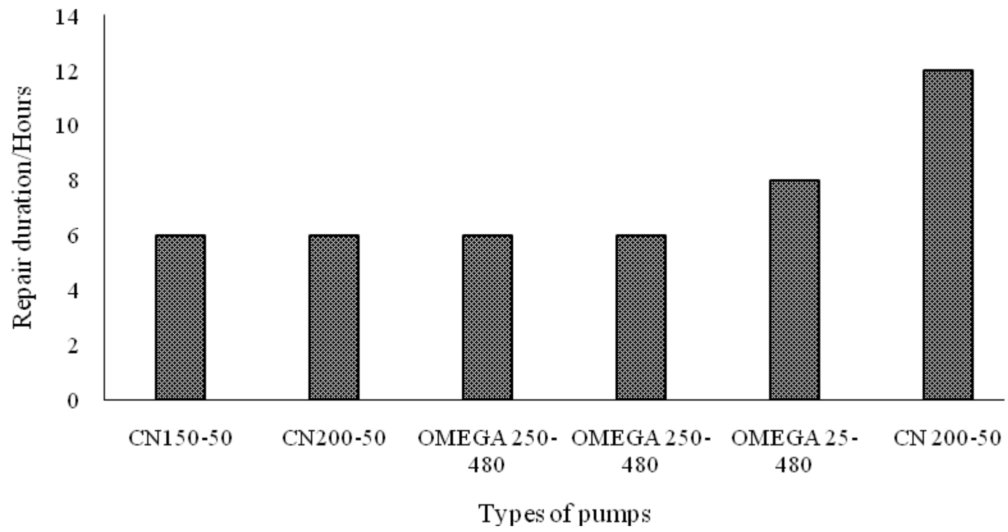

Figure 1. Statement of damage on bearings and the duration of their repair

Figure 2 shows the cases of damage to the pump guide bearing and the duration of their repair. As a result, OMEGA 250-480 takes the most time, 7 hours. The cumulative hours of repair give 16 hours for the landing.

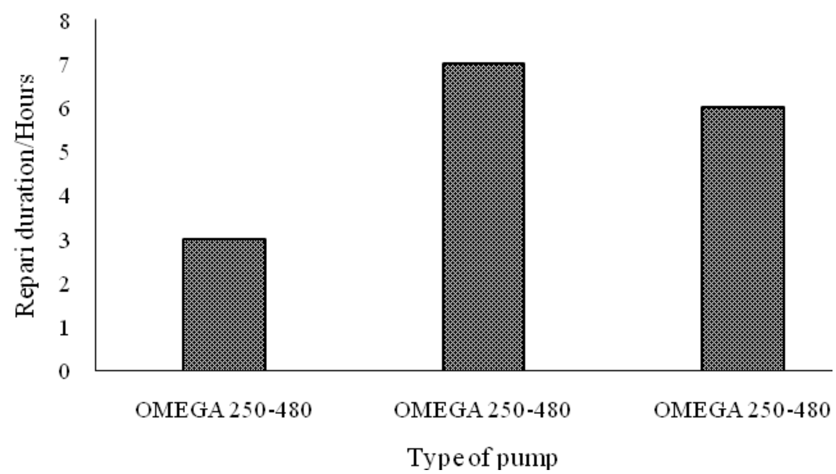

Figure 2. Statement of damage on the bearings and the duration of their repair

The failure of the discharge pipes according to the types of pumps is given in figure 3. This figure shows an increase in repair hours with the type OMEGA 20067700 and a relatively shorter repair period for the CN200-50 type.

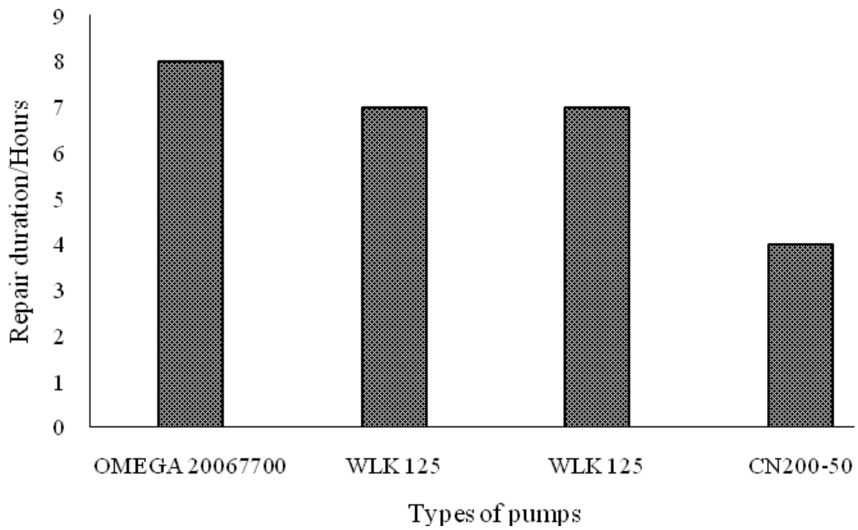

Figure 3. Failure report on the discharge line

Table 2 lists the types of damage, their number, the duration of their repair and the duration of the downtime. This table indicates that the most observed cases concern rolling accidents with the longest duration of repair and immobilization. In just one case, the cable gland has the lowest number of hours of repair and downtime.

Table 2.Overall damage statistics

N°	Type of damage	cases	Repair time/hours	Immobilisation time
1.	Rumbling damage	6	44	144
2.	Bearing damage	3	16	72
3.	Discharge damage	4	23	32
4.	Ring damage	2	10	16
5.	Stubble damage	1	8	10

According to the PARETO theory, two types of parts (bearing and bearing) are observed in zone A. Zone B, on the other hand, groups backflow and wear rings with the largest percentage of cumulative time. Finally, zone C consists solely of the cable gland with the greatest number of hours of downtime.

Table 3.Cost and cumulative breakdowns according to the different pieces

Pieces	Downtime	Cumulative downtime	% Cumulative downtime	Row of pieces	Cumulative rows	% cumulative of rows	
Strumbling	144 h	144	52.55	1	1	6.66	Zone A
Bearing	72 h	216	78.83	2	3	20	
Discharge	32 h	248	90.51	3	6	40	Zone B
Usury ring	16 h	264	96.35	4	10	66.66	
Cable glands	10 h	274	100	5	15	100	Zone C

Figure 4 showing the PARETO diagram is divided into 3 areas. Zone A: represents 20% of the breakdowns on the bearings and discharge circuit which cause 78.88% of maintenance costs. Zone B: represents only 46.6% of the additional breakdowns at the landing which cost only 96.35% of the additional costs. Zone C: represents 33.4% of the remaining breakdowns which concerns only 3.65% of the overall cost.

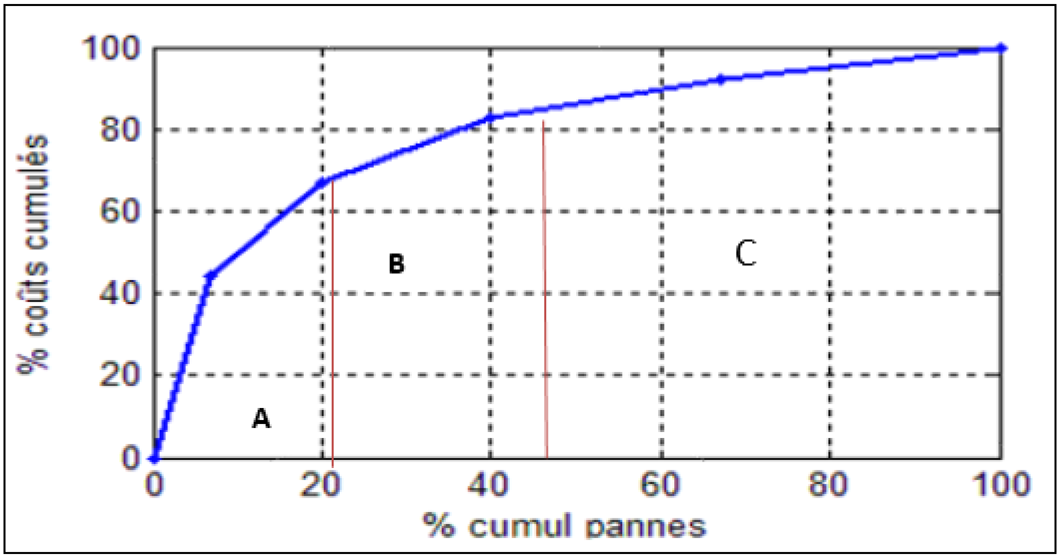

Figure 4. ABC diagram of PARETO

4. Discussion

4.1. Analysis of diagnostic results

This study lists 16 major problems are the most common. The causes being varied; the duration of repair varies in the same way. The excessive wear of bearings causing damage is the problem that takes the most repair time.

The bearings are the bearings of the driveshafts, their wear often leads to exaggerated vibrations which can cause the rupture of the shaft, the friction between the rings and the balls, rollers, friction of the guide cages and the stirring of the lubricant [8]. In hydraulic systems, failure is usually not caused by fatigue but by wear, corrosion, pollution, mounting error, poor lubrication, etc. The conditions of use and maintenance have an important influence on the service life of the bearings, among others: untimely power cuts, cavitation, misalignment of the shafts. It is obvious that the bearings in good working order emit a slight purr, soft and steady. A loud, uneven sound, with crackles, shows rolling in poor condition. Squealing can be produced by poor lubrication. Insufficient game can produce a metallic sound, even hissing. Fingerprints on the outer ring track can cause vibrations with a clear, even sound. A ring damaged by assembly shots or chipping leads to modulated sounds depending on the rotational speed of the bearing [9,10]. Intermittent noises indicate deterioration of a rolling element. Dust often causes cracks. Noise generated by a malfunctioning bearing can be detected by an experienced technician. A stethoscope is a tool to help you listen to these noises. Another index concerns warming up. The causes of an abnormal rise in temperature may be insufficient or excessive lubrication, impurities in lubricants, overloading, bearing deterioration, insufficient clearance, pinching of the bearing, or high friction of the seals.

It is reported that the daily monitoring of the pumps prevents the occurrence of anomalies such as gland leakage, mechanical seal leak, excessive noise of the pump, heating of the bearings, misalignment, foreign body, pipe stresses, overload, poor lubrication, unsuitable fluid, no-load operation, effects of cavitation [11, 12].

This study also shows that OMEGA 250-480 takes the most time, 7 hours. The cumulative hours of repair give 16 hours for the landing. The most observed cases concern rolling accidents with the longest duration of repair and downtime. In just one case, the cable gland has the lowest number of hours of repair and downtime. It is obvious that the preparation of the maintenance works must give priority to the damages which cost the maintenance service more; Zone A followed by Zone B. A good and appropriate maintenance policy must be implemented to reduce breakdowns on the bearings and the discharge circuit.

4.2. Proposal for a diagnostic assistance guide

During our research, we had to collect the most frequent breakdowns encountered when using turbopumps; but most of the failures were due to the lack of preventive maintenance practice (he is just interested in corrective maintenance) and secondly because of the lack of spare parts and the lack of knowledge of appropriate maintenance methods.

Indeed, we list the breakdowns and at each breakdown we associate the remedy. Among these failures we have:

Table 4. Some breakdowns and remedies associated[13, 14, 15, 16].

Breakdowns	**remedy**
Usury of the coupling leathers	Replacement by a new one
Filling usury	Replacement. Do not tightly squeeze jams to avoid excessive friction
Aging pipes	Replacement. If there is a problem with limescale deposits, such as in an underground plant, one might try to use limestone-resistant pipes.
Valve and strainer wear and pump coupling bolts	Replacement: The maximum clamping force must always be observed without tearing off the threads for bolts.
Cloggingstrainers and filters	Cleaning
Usury of the balance plate washers	Replacement
Leakings on supply hoses for refrigeration circuits	Use of joints adapted to eliminate leaks
Rumbling usury	Replacement: However, before making any replacement, first look for the cause of usury.

Table 5. Identification of the main failures, causes and remedies [13, 14, 15, 16].

Causes	**Remedy**
Pump does not start, engine does not run	
Loss of electrical power	Check that the starting elements and the power supply are not in question
Pump does not start, engine safety devices trip	
Overload protection is incorrectly set	Set again
The motorisoverloaded	Check that the outlet valve is closed, start the pump again, correct if necessary.
The pump starts but the discharge pressure fluctuates aberrantly	
Restriction in the suction circuit	Check that the suction valve is fully open, check that there are no seals obstructing the piping
Check that there are no joints that obstruct the piping	Open the vent connections of the frame and prime
Charge losses of insufficientdischarge circuit	Check that the pump does not discharge into an empty circuit, close the discharge valve until the pressure is stabilized, check the measurements against the operating data
Cavitation de la pompe	Vérifier que la hauteur d'aspiration disponible à la bride d'aspiration est suffisante pour les conditions de fonctionnement normal
Pump suction pressure too low	
Restriction in the suction system	Check the opening of the suction valve. Check that there are no seals obstructing the suction pipe
Changing the operating conditions	Check again and correct if necessary
The pump works but the operation is noisy, especially on the suction connection side	
Cavitation	An adequate suction height is required at the suction flange for the pump to operate normally
Presence of strange bodies in the	Disassemble the pump and remove foreign matter,

pump	check that the pump impeller and other parts have not been damaged
The pump operates normally but its operation is noisy especially on the housing side of the bearings	
Bearing breakdowns	Replace if necessary
The pump works in reverse when the engine is turned off	
Passage of the non-return valve on the discharge side	Repair or replace if necessary

5. Conclusion

The objective of this analysis is to reduce the number of unplanned shutdowns of turbopumps, to increase their operational availability in order to avoid early deterioration of turbopump elements as well as to facilitate rapid diagnosis for maintenance technicians. by highlighting the priorities to be considered in order to ensure the quality of the water supply and the operational safety of the installations. To achieve these objectives, the various problem diagnosis procedures were presented taking into account only the most frequently encountered problems. and using the PARETO method we have displayed the priorities to be examined.
We suggest to the service responsible for maintenance of this equipment:

- Orientate more to the maintenance of bearings whose breakdowns represent almost 44.56% of the damage costs.
- Have in stock the following parts: bearings, cable glands, jams and wear rings, in order to reduce the downtime for waiting spare parts and consumables.
- Compliance with the daily, weekly, fortnightly, monthly or even complete revision procedure.

6. References

[1]Sidahmed, W., 1993. *Maintenance prédictive des pompes et des ventilateurs*. Etude COREM, Publication CETIM.

[2]Bergeron P., 1962. *Complicités des phénomènes de coup de Bélier par les installations de pompe et essai de classification des solutions générales pour y remédier* (La houille blanche numéro spécial B), 77p.

[3]Bergeron P., 1950 *Coup de bélier en hydraulique ou coup de foudre en électricité,*Dunod, 54p.

[4]Ensival Morret, 1998. *Pompe industrielle,* Tome I et II, édition 1998.

[5]Pompe Sihi S.A., 1998. *Memento technique d'hydraulique*.

[6]Poulain Jean, 2009. *Pompes Rotodynamiques,* Technique de l'ingénieur, traité de génie mécanique, DOC. B4315.

[7] CERTA. 2003. *Dossier technique et méthodes,* fiche n°2.

[8]Jean HENG, 2002. *Pratique de la maintenance préventive*, DUNOD, Paris, 32p.

[9]World Pump, 1993. *Maintenance and downtime costs of centriugal pumps in finish industry*.

[10]Adkins Et Brennen, 1988. Analyses of hydrodynamic radial forces on centrifugal pump impellers. Transactions of the ASME, *Journal for fluid engineering* 8, 334-341.

[11]Du Pont André, 1974. *Hydraulique urbain*, Tome I et II, Paris, 210p.

[12]Miguel A., 1999. *Méthodologie et optimisation dans la conception et l'analyse des performances des turbomachines à fluide incompressible*. Thèse de doctorat ENSAM, Paris ,1999.

[13]BoitelDaniel et Hazard Claude, 1991. *Guide de la maintenance,* Edition NATHAN.

[14]ENSPM Formation Industrie - IFP Training (Risques et Précautions liés au Matériel-POMPES) 2005. httpwww.wontu.fr COURSCHAP-5_POMPES

[15]Abdallah Benkhattou Hocine, 2012. Analyse et diagnostic des pompes industrielles (Etude de cas au niveau de HENKEL Ain Temouchent), memoire de master en génie mécanique, Algérie, 73p.

[16]Ansimag, Installation et maintenance des pompes. Janvier 2004.