[1.]Cristian PANDELESCU, [2.]Elisa-Florina PLOPEANU,
[3.]Nicolae CONSTANTIN, [4.]Elena Mădălina VLAD

ANALYSIS OF THE CURRENT SITUATION CONCERNING THE DURATION OF USE AND THE MAIN DEFECTIONS OF THE PUMPING AGGREGATES

[1-4.]University "Politehnica" of Bucharest, ROMANIA

Abstract: The pumping units used in irrigation and for domestic and industrial users are made up of subassemblies made of metallic materials. The normal operating time of the pumping units is dependent on the reliability of the metal parts that make up the unit. In this paper the authors present an analysis of the real defects arising from an industrial operation of the pumping units, presents the presumed causes of the defects, especially of the causes related to the quality of the metallic and non-metallic materials, the reliability of the materials. For each type of defect, the real possibilities of remedying the defects are presented.
Keywords: pumping aggregates, reliability, metallic piece, defected, causes, remedied

INTRODUCTION

The pump-motor units, also called pumping groups, are the basic equipment of a pumping plant. They relate to the upstream suction-intake and downstream discharge, as a whole constituting the hydromechanical equipment of the pumping plant [1, 2].

The characteristic parameters of a pumping group are the unit flow rate, pumping height, speed, pump and motor power, the overall efficiency of the pumping unit.

At pumping installations for irrigation through automated pipes it is sometimes required to install different pumps [2, 3]

Reserve groups will be installed only when the consumption graph has a peak that lasts more than two months.

The groups with vertical pumps are preferred which, being drowned below the minimum suction level, no longer requires priming installations, and the surface of the building is smaller than the horizontal pumps. If electric motors are protected from rain, they can operate outdoors, and the superstructure of the pumping station can be removed.

The hydrophobic (hydro pneumatic reservoir) is frequently used in pumping installations for water supply, in order to compensate between the pumped flow and the required flow, for the automatic control of the installation and for the attenuation of the ram blows in the network.

The capacity of the tank is calculated based on the number of starts allowed per hour, taking into account the heating of the motor and the wear of the contacts of the switch. [4, 5] The number of starts of the pump is maxim when the flow consumed is half the pumped flow.

In order to meet the variation of the required flows, the pumping stations that supply the irrigation systems will have automatic control.

The problem of regulation is difficult, because the irrigation stations are equipped with identical pumps in order to be able to exchange them, for the purpose of balancing the wear, and with a single reserve group, the variation of the flow of the station is in stages, depending on the number of pumps in operation.

Continuous flow regulation requires adjustable speed pumps or adjustable blades [6, 7].

EXPERIMENTS

The normal operating time is the duration of use in which it recovers, from a fiscal point of view, the value that the pumping unit had at the date of commissioning. Consequently, the normal operating life is shorter than the physical life of the respective pumping unit [7, 8].

For each newly purchased pumping unit, the system of year's ranges between a minimum and a maximum value is used, thus being able to choose the normal operating time within these limits. Thus established, the normal operating time of the pumping unit remains unchanged until it has fully recovered its input value or is removed from operation.

If reliability is defined as the ability of a technical system to function flawlessly for a period of time as close to the time prescribed by the designer-builder, the normal operating time of a pumping unit is directly influenced by its actual operating time. The actual operating time is influenced by the complexity and the periodicity of the occurrence of the wear on the parts that form, in our case, a pumping unit. Reliability is the ability of a product to function without fail [9].

Mathematically it is possible to estimate with a certain degree of certainty the behaviour of a product under certain conditions of use. Reliability is one of the basic components of a product's quality. From a certain point of view, quality can be considered as a "static" trait of satisfying certain conditions at a certain time, while reliability is a quality over time or a "dynamic" trait. From this point of view reliability represents a new dimension of quality, a component over time of quality [10]. This definition contains five fundamental concepts:

— **The concept of characteristic**

Reliability is therefore a characteristic of a product, which can be determined and characterized, as well as the other technical characteristics (power, speed, etc.) and expressed quantitatively.

Reliability must have the same status as the other technical characteristics: it must be considered starting from conception to design, be properly monitored in manufacturing and be attested by tests or other estimation methods.

— **The concept of probability**

Reliability is expressed by a probability and has a value between 0 and 1. Being a probability cannot be measured directly as is the case with other physical quantities, but it is determined based on mathematical statistics methods and probability theory. This is still an important obstacle to properly assimilating this feature. Especially for design and design, reliability must be regarded as a basic feature to guide and optimize the constructive solution.

— **The concept of function**

Reliability implies the satiation of a required function. This implies the correct definition of the function that it must perform. In the case of a simple element, the function means what it has to do, within the assembly of which it is part. In complex products or equipment there may be multiple functions, depending on different states and operating regimes considered explicit or implicit. Reliability refers to all these functions.

— **The concept of operating conditions**

The concept of operating conditions (environmental use) represents the set of conditions for which the product was designed.

It is observed that in many cases the notion of reliability is not interpreted correctly, especially when the value of reliability is estimated from the perspective of laboratory tests in which the requests are not correlated with those of normal use. Operating conditions directly influence reliability.

An ideal product has the reliability corresponding to the given conditions. Failure to meet certain conditions means that the reliability does not have the desired value. From this, a series of conditions revising which concern the use, and on the other hand the conception and the design.

— **The concept of service life**

Reliability involves a service life expressed in units of time (hours, days, years, etc.) or a number of cycles, connections, manoeuvres, etc. In conclusion, the duration is expressed in the characteristic units of the respective product.

The correct expression of reliability requires clarification regarding the five concepts listed.

The analysis of the product failure mode is an intuitive analysis, representing a first step in the engineering approach of the product reliability and maintainability field. Without using a special mathematical tool, the analysis of the failure mode can only be performed by specialists in the respective field of expertise. These methods of analysis are standardized. The most used method is the AMDE method (Analysis of failure modes and their effects).

The AMDE method aims to identify defects whose consequences affect the functioning of the product.

The AMDE analysis is based on complete information and documentation activities.

There are four main steps in carrying out the AMDE analysis:

» definition of the system, functions, components and their role;
» establishing the failure mode;
» study of the effects of the failure modes;
» observations, conclusions and recommendations.

The main elaboration stages of the AMDE method are presented in the graph in figure 1.

The definition of the system (equipment) is made according to the standard specifications and specifications.

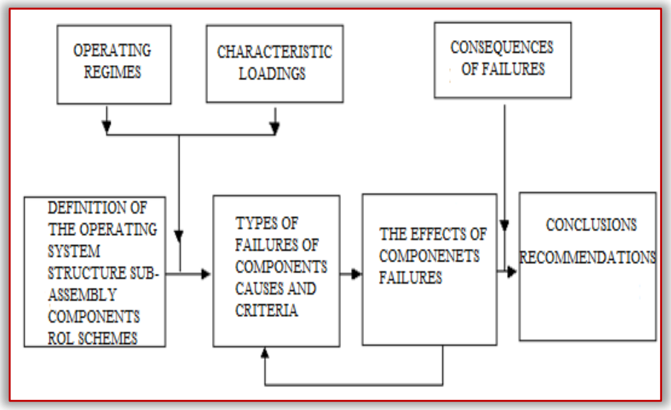

Figure 1. The development stages of the AMDE method

The AMDE method makes a census of all the defects of a system by collecting information from all the possible places where defects were found and the conditions in which they occurred.

Determining the physical mechanism of the failure process is the essential problem of this analysis. The qualitative analysis of the defective process requires a thorough knowledge of the respective field of specialty.

The potential failure modes can be reduced based on the physical parameters of the component and its functional characteristics. The failure modes are classified in:

» General failure modes, deduced by defining the reliability of the system;

» Specific modes of system failure.

— Defects of common cause

A common cause failure is the result of an event that, due to dependencies, simultaneously causes several components to come out of operation (eliminating secondary failures that result from the effects of a primary defect).

Defects in the common cause can cause performance degradation or total system failure and are due to only single sources, such as conception error, human factor error, etc.

These cases fall into the following categories:

» Effects of environmental demands (normal or accidental conditions);

» Design errors;

» Manufacturing defects;

» Mounting and commissioning errors;

» Human errors (during operation and / or maintenance).

Combined measures are used to prevent such defects from occurring. Other preventive measures include: functional diversity, redundancies of different types, physical separations of systems, additional tests.

— The way of presenting the analysis

Generally, the analysis is presented in the form of an analysis report containing a specification of the analysed system (subassemblies, component elements, schemes, etc.), functional role, process description, effects, conclusions and observations developed at the level of the requirements and use of the respective material.

This analyser may be included in a general study or may be a technical document in its own right.

The analysis ends with a sub-chapter on observations and conclusions stemming from the findings.

Proposals may also be made to improve the diagnosis of defects, maintenance activities and actions and activities regarding the phase out of operation related to material recovery and environmental protection.

— Identification of the main types of uses for pumping units

The main types of uses that appear on the parts and components of a pumping unit, selected as a result of the processing of data from the units in operation are:

» The pump shaft - material from which OL 50 is made.

The wear of the spindles for the semi-duplicate and the spindle wear for the chromed bushes, which can be seen by visual control and by measuring the diameter of the spindle with an external micrometre, after previously removing the bushes from the shaft.

The spindles for used bushes and semi-couplings are reconditioned by electric vibrating spring loading.

» Rotor chamber - material from which it is made – cast iron.

≡ Hydro-abrasive wear of the inner surface of the rotor chamber, is seen by visual control and by measuring the internal diameter of the rotor chamber in the maximum wear area.

≡ Wear or deterioration of the places corresponding to the mounting of the wear rings

» The assembled rotor - material of which it is made of pocket OT-OT 45, pallets 7 NC 180

≡ The wear of the front surfaces of the blades is ascertained by visual control, by checking the profile of the blade with a template after a new blade and by measuring the outer diameter of the rotor.

≡ Wear or damage of threaded holes.

» Stator -material from which it is made-cast iron.

≡ wear inside diameter,

≡ wear of the front surfaces of the pallets,

≡ wear of threaded holes.

» Bearing body (outer, upper or intermediate)

≡ the material from which it is made – cast iron,

≡ wear of the inner surfaces of the bearings in contact with the bearing's bushes

» The bearing - the material from which it is executed - OLT 35 sleeve, rubber lining

≡ wear of the inner surface in contact with the chrome bushing,

≡ wear of the outer surface of the bearing,

» Bush - the material from which it is made - OL 50 or OLT 35.

≡ wear of the outer surface of the bush in rubbing with the rubber bearing

≡ wear of the inner surface of the bush in contact with the pump shaft.

— Faults in operation with mention especially of those generated by the metallic materials used in the pumping units

The defects that occur frequently in the operation of the pumping units, the way they are manifested, the effects and the way to remedy them are multiple due to the great diversity of construction types and installations in which the centrifugal pumps are used. Most of the cases are in conjugated fields, so that the analysis to determine the origin of the defect must go through all possible investigations, starting with the most "at hand" and easier to find, to those that require knowledge and interpretation. complex and specialized in the field of pumping installations and pumps (example: the material of the rotor has chemical and / or mechanical characteristics incompatible with the vehicle environment and / or has not been controlled with penetrating liquids but also due to the suction conditions - NPSH -, non-compliant with those for which the pump was offered).

The interventions carried out for the removal of any kind of defect should not harm the energy balance of the pumping unit.

The corrective measures taken must be thoroughly analyzed (technical - economic calculation in the short, medium and long term) so that the adopted measure does not lead to harmful exploitation from the point of view of energy consumption.

RESULTS AND DISCUSSION

— Faults, causes and remedies

≡ **Incomplete open suction valve, due to blocking or heavy operation.**

The valves that equip the pumping units can be flat or oval. Regardless of its type, the mechanism of the drawer is composed of a screw and a fixed nut. If the screws in almost all cases are made of steel, the nuts can be either steel, cast iron or bronze. Valve locking is rarely encountered in industrial pumping installations, where their handling also takes place several times during a work shift; in contrast to irrigation or drying facilities, the rest period may be as high as ten - eleven months per year. In this period due to the justified lack of manoeuvres, the materials from which they are manufactured interact, creating a blockage that leads to the failure of the screw-nut mechanism.

Remedy: For this, metallic materials should be chosen for the manufacture of the screw and valve nut, which, after processing by cutting, and thus obtaining a minimum roughness, should not lead to a high self-braking condition of the screw-nut mechanism, which in the absence of frequent periodic manoeuvring, but also of the lack of lubrication, to lead to blockage.

≡ **The suction segment of the installation (starting with the suction) and / or the rotor are clogged.**

Also, in the irrigation and drying pumping systems, the fluids conveyed are not the cleanest, with all the systems of grids and grills with which the installation is equipped, foreign bodies penetrate which can block the rotor assembly or the elements of first transport of the water.

Remedy: To the extent that a decent manufacturing cost limit is not exceeded, these pump component parts should be made of metals with a high degree of roughness, without prominent edges and corners, thus ensuring a high flow of fluids, as well as a heavier attachment of foreign objects to moving parts.

≡ **Air penetration into the suction pipe**

Due to the corrosion the suction pipe can be perforated giving rise to holes through which the pump pulls the so-called "false air" situation which leads to the occurrence of amplified vibrations leading to a shock request on the rotor blade, eventually leading to the water column breaking and by default, defrosting the pump.

Remedy: Manufacture of metallic pipes that, with or without improvement, resist corrosion, also taking into account the natural atmospheric conditions, summer-winter to which they are subjected by the nature of the location on the ground.

≡ **Formation of air bags or vapours in the suction pipe or in the pump housing**

Their appearance can lead to the phenomenon of cavitation, which is very dangerous in the construction of pumping units.

Remedy: Making the component parts of the rotor assembly as well as the rotor chamber and stator of the pump, made of harder metallic material, which does not give way to the destructive effects of the cavitation phenomenon, especially in situations where it occurs frequently.

≡ **Air penetration on the sealing of the pump**

The sealing of the pump at the shaft side is performed both at the vertical and horizontal pumps with a gland and a graphite asbestos ring. The sealing is carried out in the immediate vicinity of one of the pump bearings generally in the bearing from the drive motor. Due to this constructive positioning near the camp, the existing thermal regime, as well as its value variation, leads, due to the expansion, to an inadequate seal.

Remedy: manufacture of the cable gland and its assembly elements made of metallic material with a lower coefficient of expansion, and a corresponding resistance taking into account that outside the thermal regime the cable gland must also face the vibration system as well as the shocks in the pump shaft.

≡ **Insufficient immersion of the vertical pump**

Depending on the pumping height, the pump has a certain immersion rating from the design, more specifically a minimum water column above the rotor so that the load of the blades is appropriate. If this condition is not met, the pump enters a vibration regime, which can even lead to so-called junctions that are transmitted as shocks to the rolling bearings of the pump shaft.

Remedy: Respecting the immersion depth is the only solution, because regardless of the hardness of the pump parts, the support of a vibration regime ended with mechanical shocks leads to the safe damage of the pump.

≡ **Deviations from the specifications regarding the manufacturing dimensions of the pump parts**

In the case where the parts are mainly made of steel, at very long lengths (30 m axle pumps) there is an arrow of the material that can be forced in one of the directions to the wrong installation of the pump with the corresponding piping in the recesses of the pumping station. .

Remedy: Use castings as much as possible due to their lower elasticity than steel.

≡ **The game between pair mazes is increased**

Labyrinths or wear rings as other designers call them are the parts that by mounting on the sides of the rotor chamber transform its architecture from the rotor chamber into a spherical chamber and vice versa. These rings are generally made of cast iron, having very large diameters, and very small thicknesses (hence their low strength) and are mounted on the rotor chamber with the help of intercalated screws.

As the spindle grows larger, a larger portion of the rotor flow returns to the suction.

Forced by the installation that requires the flow rate to be retained, the rotor will have to carry an internal flow greater than the flow rate in the case of unused labyrinths. .

Remedy: Manufacture these mazes or wear rings from a more resistant metal material.

≡ **Destruction of the bearings of a pump**

The existing pump bearings are generally of two types of roller bearings having bearings and bushings. Due to the difficulty of securing a closed, watertight and very well lubricated housing, bearings with bearings are used only at horizontal pumps. At vertical pumps with very long lengths the bearings used are composed of:

» a casing made of cast iron or steel to which is subsequently applied a layer of hard chrome with a thickness of 0.1 mm

» a bearing made of steel, in one piece or two half-pieces, on which a layer of rubber with grooved architecture is vulcanized, subjected to a bake at 160°C, for eight hours, in which regime the rubber loses elasticity, becoming brittle, adhering very well to the steel housing.

If, in the case of roller bearings, lubrication is carried out with oils and greases, at bearings and rubber bearings, the lubrication is done with clean water, coming from an auxiliary installation of the pumping station, provided with a well and filter assembly.

Remedy: making the chrome plated bush from a more resistant metallic material that may no longer require chrome plating, or applying a harder and more resistant chrome coating, which can withstand a thermal regime in the absence of the cooling liquid, and which may eventually it does not adhere to the vulcanized rubber on the bearing housing.

≡ **The decalibration of the connection couplings between the axes**

The shafts of long and very long shafts are connected together by means of assembly elements, called couplings which, on the inside, have two diametrically opposed fuses, or multiple grooves, depending on the size of the moment to be transmitted by the propeller motor to the pump rotor. Due to wear over time, these connecting couplings no longer make intimate contact between the ends of the axes, so that the rotational movement is transmitted with shocks from one axis to another. Also due to this wear also appear the beats in the bearing, the eccentric movements inside the bearing, which leads to the destruction of the bearing.

Remedy: making these couplings from harder materials, to achieve the coupling of the axes in the best possible regime, avoiding the occurrence of games between semi-couplings and obviously between axes.

≡ **Destruction of a rotor blade**

In the manufacturing architecture of pump rotors, they can be - closed radial rotor, star rotor, open rotor, closed diagonal rotor, radial shrink rotor, axial rotor with fixed blades, and axial rotor with adjustable blades. In all types of rotors, the penetration of a hard object can cause a blade to break. In addition to leaving the rotor by a blade (in the case of axial blades), or a piece of the rotor (on closed rotors), it leads to its imbalance, the piece detached from it is entrained and during the shortest time it destroys and the other blades or the closing part of the rotor.

Remedy: making rotor blades made of metallic materials to withstand these penetrations, which in conjunction with the overload protection of the pumping unit, lead to the momentary locking of the pump and decoupling from the power supply, thus avoiding damage.

≡ **Breaking the rotor chamber of a pump.**

In correlation with the anomaly from the previous point, we can say that while entering the rotor chamber of a foreign object, besides the rotor blade or sectors, the wall of the rotor chamber is also required. Given that the permissible clearance between the rotor and the rotor chamber is generally at large vertical pumps, about one millimetre, it is understood that the compression stress occurs between the blade and the wall of the rotor chamber.

As the rotor chamber is generally made of cast iron, so with a mechanical resistance lower than that of the pallet, made of steel or stainless steel, the first step that yields is the wall of the rotor chamber.

The malfunction appears as a hole in the rotor chamber, the pump unbalancing due to the fact that the liquid is no longer raised to the discharge area, but is mixed in the suction area.

Remedy: making the rotor chambers of metallic materials that confer a superior resistance to the shocks to which the pump is subjected to the penetration of hard foreign bodies into the rotor chamber.

≡ **Wear on conjugated parts inside a pump**

The appearance of wear on the vast majority of the pump's parts is manifested by detaching a number of layers from the surface of the part, which leads to the reduction of the initial quota. This results in games - in the case of pump bearings; when driving a much smaller volume of fluid - in case of wear of the pump blades and the walls of the rotor chamber, etc.

Remedy: making the parts of a pump made of metallic materials that accept the reconditioning by applying successive layers of metal and which, after the machining by cutting, return to the initial dimensions of the project.

≡ **Corrosion of the pump pipe**

Regardless of whether it is in operation or during a stationary period, submerged or dry, the pump operates in a hostile environment from the point of view of the environmental factors.

Remedy: manufacture of pipes made of metallic materials that accept the adhesion on its surface of insulating elements such as paints, varnishes, rubber or polycarbonate layers to protect the entire structure against corrosion.

CONCLUSIONS

The actual operating life of a pumping unit differs from one area of use to another. Thus, if in the industrial field for a vacuum pump in the MIL family the manufacturer offers a duration of 12 years, and for a vertical pump type DV, AV, Danube, etc., a duration of 20 years, taking into account that their operation it is permanently daily, in agriculture, both in the field of irrigation and drying, the existence of periods of months or years in which they are not started, changes the life span. However, the service life does not extend, because during the stationary period the pump is in the same hostile-corrosive environment (moisture, impurities, snow, etc.). The pumping unit is not dismantled from the installation and protected in a so-called park waiting cold.

From this point of view the durations expressed by the manufacturer are purely informative, of maximum importance being only the warranty period granted, and this is quite small depending on the actual operating conditions.

By analysing the types of defects and centralizing the results, a complete set of information about the operation of the pumping units of different types of construction can be realized.

For each type of defect based on the deviations from a functioning in the real environment of the aggregates, the causes can be determined precisely and based on the previous experience centralized in that complete set of information, the best decision can be made to correct the defects and to extend the duration functioning of the unit in question until its replacement with a new one.

Acknowledgment: The work has been funded by the Operational Programme Human Capital of the Ministry of European Funds, Work-based learning systems through entrepreneur scholarships for doctoral and post-doctoral students through the financial agreement 51668/09.07.2019, SMIS code 124705.

References

[1] Aurel Blidaru - Instalaţii de pompare pentru agricultură - Ed. Ceres Bucureşti 1984
[2] Gheorghe Negru - Instalaţii de pompare şi pompe - Ed. Estfalia Bucureşti 2006
[3] Dumitru Manea - Pompa de căldură - Ed. Tehnică Bucureşti 1982
[4] V.S.E. Volod Radcenco şi alţii - Instalaţii de pompare de căldură - Ed. Tehnică Bucureşti 1985
[5] Ursula Schreier şi alţii - Pompe de căldură -Ed. Casa Oradea 2011
[6] Florea Ştefan şi alţii - Tehnologii de reparare pentru grupuri de pompare - Ed. RMPA 1980
[7] Aversa Manufacturing SRL -Catalog Pompe
[8] S.C. Utilaje, Piese schimb şi servicii S.A. Botoşani-Catalog Pompe
[9] Rada Andrei Cristian, Teza de doctorat „Cercetări privind funcţionareasistemelor hidraulice pentru pomparea apelor din exploatările miniere în vederea îmbunătăţirii eficienţei lor “
[10] Popescu Luminiţa Georgeta, Universitatea "Constantin Brâncuşi" din Târgu Jiu, România, Monitorizarea unui agregat de pompare utilizat pentru evacuarea apelor în cariera Roşia, Analele Universităţii „Constantin Brâncuşi" din Târgu Jiu, Seria Inginerie, Nr. 2/2009, pag.253-261

ACTA TECHNICA CORVINIENSIS – Bulletin of Engineering
ISSN: 2067-3809