Study Of The Effect Of Cavitation Upon The Wheels Of Different Types Of Materials For Pump

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Abstract : The study of the phenomenon of cavitation of centrifugal pumps remains of a great importance in the field of construction as well as in the field of installation of pumps in pumping stations. In fact, with the consequences it engenders: noise, vibration, erosion and loss of efficiency, it provokes, on the one hand, a progressive degradation of the performance of the machine and, on the other hand, an increase in the costs of the maintenance of installation (a compromise between the functioning period and cost of exploitation), in addition to the loss of efficiency of pumps and the resistance of different materials to the effects of the phenomenon of cavitation. Among the techniques and methods of protecting the parts of pumps is the cladding of the parts with composite plastic materials for the purpose of increasing the resistibility and protecting the parts from the effects of cavitation. Relevant to this, our work aims at analysing this problem with the intention of preserving the efficiency of a pump by limiting the effects of cavitation through an experimental study that has been realized in a laboratory. As such, wheels of different materials are tested under conditions of cavitation taking into consideration the three types of metals used in the manufacture of the wheel, and this regarding the study of resistibility of each material subject to the effects of the phenomenon aforementioned. Thus, this present work consists in experimentally studying the physical impact of cavitational erosion upon the hydrodynamic behavior and the performances of centrifugal pumps, and that affects the weight of different wheels. This phenomenon can be obtained only through measurement: loss of efficiency that can have repercussions for the characteristics of functioning as well as the mechanical behavior.

Keywords : pump – cavitation – performances – materials - wheel.

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1 INTRODUCTION

This study was undertaken through a limited collaboration of two organizations: National High School for Hydraulics (NHSH) and Pumps – Valves of Berrouaghia (POVAL) as it is applied to their respective fields of activity. Users of pumps design their pumping installation by focusing on the characteristic curves “performances” that will be provided by the manufacturer and determined during pumping tests, and this is before being put into exploitation. First, the study consists of several realistic experiments to a large scale which permit to obtain reliable results in a wide range of variation of parameters for early anticipation of different erosions and validation of different technological techniques in order to ameliorate the functioning longevity of pumps in general. The analysis that we present is relative to the physical experimental tests of the impact of the erosion of cavitation that permits, thanks to the control of the principal parameters of this phenomenon: rate of erosion, loss of efficiency (performances), type of materials…, to study the hydrodynamic conditions of the erosion of cavitation. Andrew L. Mular, Doug N. Halbe, Derek J. Barratt (2002)[1]. For a long period and until the 1980’s, an important part of published works on the erosion of cavitation was devoted to the microscopic aspects of the phenomenon. Particularly, these works consist in carrying out tests of systematic erosion on a large number of materials subject to a given situation of cavitation. The starting point comprises the observation of the rear pockets of cavitaton attached to blades of hydraulic machines which give off structures of vapour often organized around a whirlwind filaments, and that, by experience, proved particularly effective in terms of erosion: Selmi and Hutton (1983), Soyama, Kato and Oba (1992), Oba (1994), noting also a recent study by Sato and Kondo (1996) who were able to observe in situ axial or radial implosions of cavitating whirlwinds and measure the forces exerted on the partitions of the flow. Pertinent to this, the impact of erosion of cavitation is defined and studied according to the parameters of erosion and the abilityof materials (cast iron, aluminum, and bronze) in absorb theenergy of cavitationimpact. Domingez-Cortazar M.A., (1994) "Le CAVERMOD" [2],[3],[4].

Constituent materials of pumps in general:

The most currently useful materials in the construction of pumps are cast iron, steel, stainless steel, and copper alloys. For particular cases, especially in oil and chemical industries, nickel alloys, aluminum, lead, titanium …etc, as well as non-metallic materials, are often used. We know from the double approach experimental and numerical, that these two last mechanisms are able to engender very high pressures (hardly measurable as we will see later).

2 EXPERIMENTAL DESIGN

a) Construction of the test bed

Our test bed is a closed circuit (suction and suppression are made in the same water tank of the following dimensions: length 04 m, width 02 m; depth 02 m. A test bed is designed in order to provoke cavitation on the pump with the different types of materials of the wheel. Determines the type of the material of the wheel whose erosion is lesser and which presents good characteristics of the pump after of cavitation.Figure 1.

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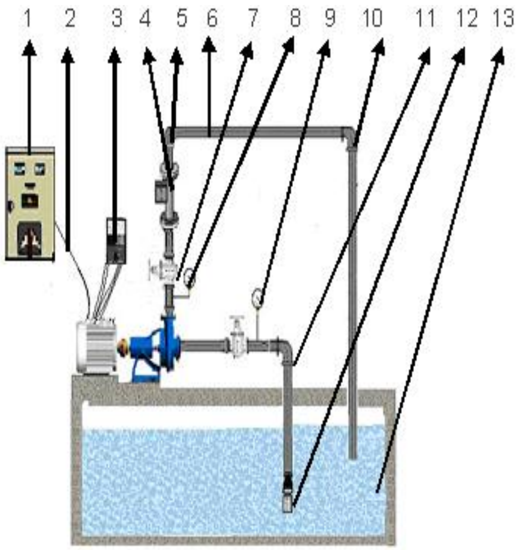


Figure 1.the effects of cavitation

Légende:

(1). electric cabinet.
(2). electric wires.
(3). a wattmeter.
(4). a counter
(5). elbow 90° of diameter 40mm
(6). discharge pipe
(7). valve stop mode 40 mm.
(8). a manometer
(9). avacumeter
(10). elbow 90° of diameter 50mm
(11). suction valve 50 mm.
(12). foot valve.
(13). water tank

b) Materials

In general, the characteristics of the pump (lifting height, delivery rate, power absorbed and performance), are provided by the constructor during the tests. In table 1, they are determined under certain conditions and according to certain installations, Figure 2.

Figure 2.Centrifugal pump of POVAL,type NVA *150-5,*[9]

Table 1. The characteristics of the pump(POVAL) Berrouaghia, 2003

Characteristics	limits
Flow (m³/h)	18
Lifting height (m)	23.5
Rotation speed (turns/min)	2900
Temperatureof the liquid	80°C avec 2% en addictions mécaniques et une granulométrie de 0,5mm
NPSH (m)	2.7
Engine power (kW)	2.2
Weight of the pump (kg)	23.1
Optimum output (%)	61
beach of proper functioning (m^3/h)	16,2 – 19,8

During the experimentation of our pump (20 hours of functioning) under the effect of cavitation by strangulation of the suction, the form of the tests is filled in (variation of flow). By using the formulas, all the parameters are going to be calculated in order to draw characteristic curves and interpret the results. Our work consists in studying the effects of the phenomenon of cavitation upon the erosion of a wheel of the pump manufactured by the company POVAL (pump 40NVA). The experiment is carried out on three types of materials used in manufacturing the wheel: figure3.

a) Cast iron b) Aluminiumc) Bronze

Figure 3. Three identical wheels made of different materials

b.1 The wheel in cast iron.

Cast iron represents all alloys meant for casting. It is different from other alloys in its excellent malleability. The fusion temperature of cast iron goes from 1135 °C to 1350 °C according to the percentage of carbon and silicon that it contains. The principal qualities of white cast iron have the following features: excellent resistance to erosion and to abrasion, it looks good, an excellent malleability. Their main defects are: difficult to be machined, hard and fragile, and heavy.(Bathia C. ,Baillou J.P.,(1980)[2],[5]

b.2 The wheel in aluminium.

Aluminum has a density of (2.7), around three times weaker than that of steel or copper. It is malleable, ductile and easily machined and molded. It possesses excellent resistance to corrosion and a great longevity. It is also paramagnetic and it does not cause sparks. It is the second metal the most malleable and the sixth the most ductile and very light.

b.3 The wheel in bronze.

Bronze is the generic name of the alloys of copper and tin. Bronze is normally composed of more than 60% of copper and a variable proportion of tin, besides variable proportions of aluminum, lead, beryllium, manganese and tungsten, and a small amount of silicon and phosphorus, but no zinc in notable quantities; yet, it resists erosion and corrosion. Wiley J.,(2002)[6].

c) Calculating method

The tests of our work comprise three main lines:

- The first consists in drawing the characteristic curves of the pump.
- The second consists in demonstrating the wheel, measuring its weight and in taking a photograph during the twenty hours of operation under the effects of cavitation by strangulation.Khodjet-Kesba O, (1996).[7],[8].
- Do the same work for the three wheels of different materials: (cast iron, aluminum, bronze)
- After putting into effect the tests as we have seen throughout the handling of the operation, and from the application of the formulas for the calculation of different parameters, we come to determine the results as well as to present them in graphs.

Wheel in castiron

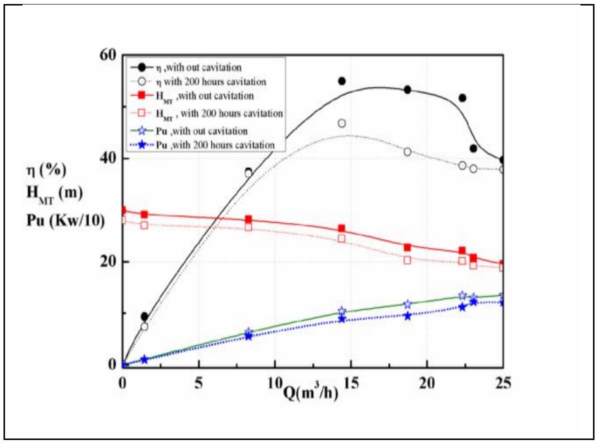


Fig .4. Characteristic curves of the pump functioning with a new wheel in cast iron and 200 hours of functioning under the effects of cavitation

Wheel in aluminium

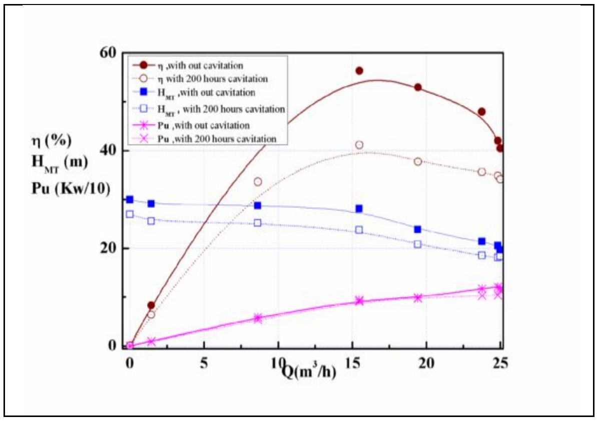


Fig. 5. Characteristic curves of the pump functioning with a new wheel in aluminum and 200 hours of functioning under the effects of cavitation

Wheel in bronze

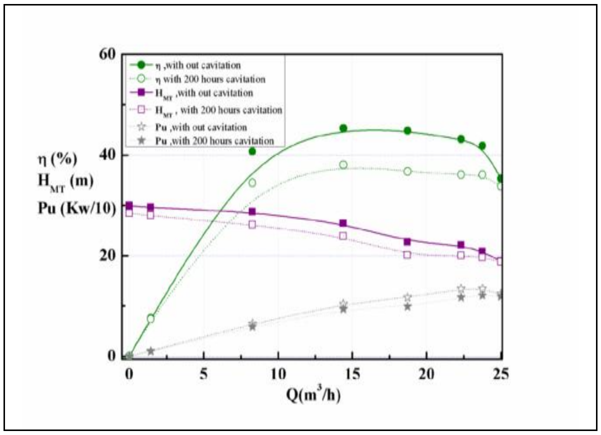


Fig. 6. Characteristic curves of the pump functioning with a new wheel in bronzeand 200 hours of functioning under the effects of cavitation

3 RESULTS AND INTERPRETATION

From figures (**4, 5, 6,**) which represent the different curves, we notice loss of efficiency (performances) of our pump (pump 40NVA), for both of the lifting height and performance, and this for a functioning period of 200 hours under the effect of cavitation.

- A drop in performance of: **8.15 %,** for the pump functioning under the effect of cavitation and with a wheel in cast iron.
- A drop in performance of: **15.18 %,** for the pump functioning under the effect of cavitation and with a wheel in aluminum.
- A drop in performance of: **5.31 %**, for the pump functioning under the effect of cavitation and with a wheel in bronze.
- Relevant to these results, we can say that:

Bronze resists better than aluminum and cast iron to the effects of cavitation. A pump functioning with a wheel in bronze presents the least drop in performance. Aluminum is the weakest metal resisting to the effects of cavitation in spite of the good performances it reveals at the initial state (new pump). Cast iron shows the average between bronze and aluminum.

Table 2. Decrease in the mass of the wheels according to functioning time

	Period (hours)	00	20	40	60	80	100	120	140	160	180	200
Mass of the Wheel (g)	Wheel in castiron	*897.1*	*897.1*	*897.1*	*897.0*	*896.9*	*895.9*	*895.1*	*894.8*	*894.03*	*894.0*	*894.0*
	Wheel in aluminium	*308.3*	*308.3*	*308.2*	*308.0*	*307.9*	*307.7*	*307.6*	*307.5*	*307.5*	*307.4*	*307.4*
	Wheel in bronze	*1115.8*	*1115.8*	*1115.8*	*1115.8*	*1115.7*	*1115.7*	*1115.7*	*1115.7*	*1115.7*	*1115.7*	*1115.7*

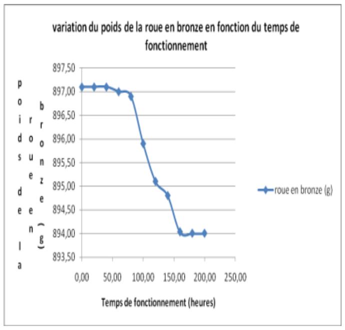


Fig. 7. Curve of the variation of Weight of the wheel in cast iron according to functioning time.

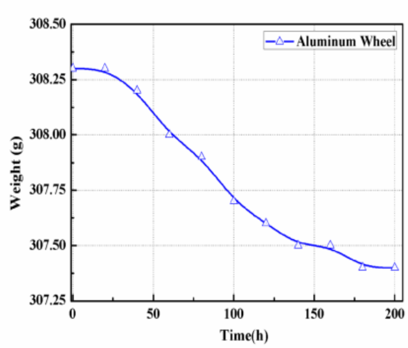


Fig. 8. Curve of the variation of weight of the wheel in aluminum according to functioning time.

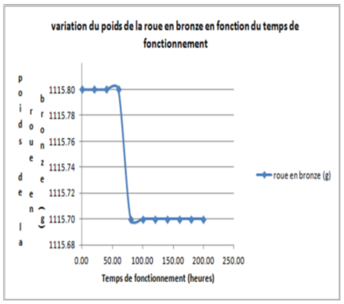
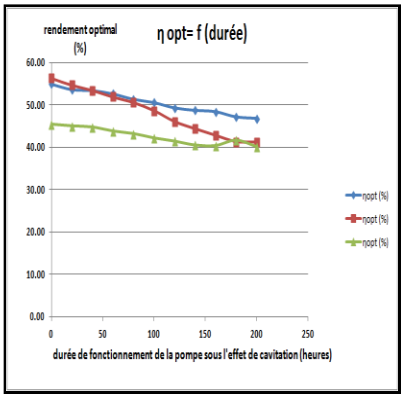
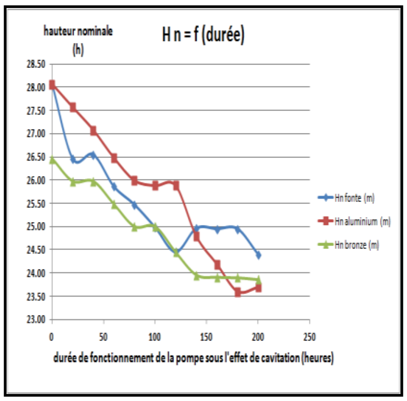


Fig. 9. Curve of the variation of the weight of the wheel in bronze according to functioning time.

From the reading of the graphs, (Fig.7,8,9),we remark that the pump functioning with a wheel in aluminum presents the best performance at the initial state. However,later on and during the two hundred hours of functioning, under the effect of cavitation, we notice an important drop of weight,**(0.29%).** In the case of the functioning of the pump with a wheel in bronze which presents a weak weigh at the initial state and a drop of **(0.008%),**after the two hundred hours of functioning under the effects of cavitation, and the same thing for the nominal rate,we remark that there is stability during the two hundred hours. Concerning the functioning of the pump with a wheel in cast iron which presents a good performance at the initial state and a drop of **(0.34%)**, after the two hundred hours of functioning under the effects of cavitation, for the nominal height,we notice an average drop in comparison to that of the pump functioning with a wheel in aluminum.For the nominal rate,we note that there is a stability during the two hundred hours.

Comparison of hydraulic performances of the wheels





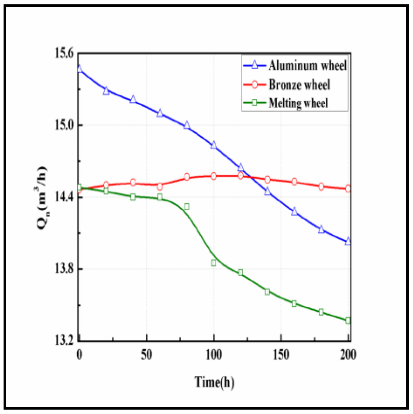


Fig. 10. Curves of the variation of optimum performance, the variation of nominal height and the variation of naminal rate according to the functioning of the pump under the effects of cavitation.

4 INTERPTETATION AND DISCUSSIONS

- **Cast iron**shows the average between bronze and aluminum. Curves of the variation of the lifting height of the pump 40 NVA according to performance during the two hundred hours of functioning under the effects of cavitation (wheel in cast iron).
- **Aluminum** is the weakest metal resisting to the effects of cavitation despite good performance revealed at the initial state (new pump or zero hour of functioning under the effects of cavitation).
- **Bronze** resists better than the aluminum and cast iron to the effects of cavitation. A pump functioning with a wheel in bronze presents the least drop of performances.
- **Cast iron** shows the average between bronze and aluminum.

5 CONCLUSION

As far as we are concerned, we have realized throughout this study a series of tests of materials under the effect of cavitation with the available means looking for a response to our expectations, namely the cavitational study and the impact of some of its effects. On the light of the experimental results obtained and knowing that this work was made through the collaboration of National High School for Hydraulics and POVAL, so it can have continuity as an objective, with a view to improve the experimental results and better understand the phenomenon of cavitation and later reduce the effects of mechanical damage on the pump. To finally arrive at ameliorating the performances of a pump with a wheel of well chosen materials, we propose the following recommendations:

1. The installation of pressure measuring apparatus (monometer and vacumeter) must be at a sufficient distance, so that it does not affect the reading of the apparatus;
2. Sudden changes of direction are not recommended and that all obstacles because they are detrimental to proper functioning; it may indeed create whirlwinds of vortex, thus the pump is disrupted;
3. Use slow convrgents to get a good flow;
4. Avoid forced connections between the pipes and during the assembly of the wheel into the casing, which can provoke a lack of parallelism of the flanges, and will result in: friction of the wheel or on the casing.

Nomenclature

ENSH.-EcoleNationaleSupérieured'Hydraulique National High School for Hydraulics

POVAL.-Pompes, Vannesd'Algérie, Pumps–Valves of Berrouaghia

40 NVA 150-5-pumptypehorizontal-axisdiameterofsuction40 mm, diameter of the wheelof150 mm, and thickness of thevane5 mm

(NPSH) -Net Posit if Suction Head

AGEP- Agence des stations d'Epuration - Agency purificationstation

ENTP – Ecole Nationale des Travaux Publics- National Schoolof Public Works

ONID –Office Nationale d'Irrigation et de Drainage- Office National Irrigation and Drainage

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