[1.]Ondřej NĚMČEK, [2.]Marcel MIKESKA

VALIDATION OF DECLARED PARAMETERS OF WATER-RING VACUUM PUMP AND ITS ENGINE

[1-2.] VŠB – Technical University of Ostrava, 17. Listopadu 15, Ostrava 70800, CZECH REPUBLIC

Abstract: The testing of the liquid-ring pump needs to take into account the operational quantities, difference in the measured differential pressures and efficiency of the motor drive. The paper describes specialised testing measurements of guaranteed operational parameters and properties of a liquid-ring pump in order to identify its real operational values, efficiency, and parameters. A special measurement stand was constructed for the purpose. We tested the efficiency of the liquid-ring pump, and the electrical quantities of the motor. The identified parameters and properties were compared with those declared by the producer – supplier. The results of the laboratory measurements show that the values declared by the producer differed by as much as 30 % to the detriment of customers.
Keywords: water-ring pump, efficiency, operational parameters, measurement verification

INTRODUCTION

Recently, products of Eastern countries of origin, particularly from China, have appeared on the European and American markets. This is not to speak only of readily available components and goods for everyday use, but even more complex components and units that embody interesting alternatives to be used in industrial applications and operations. These are products of precise engineering, electronic parts, components, mechanical parts as well as finished devices. As may be expected, their major advantage is an interesting price/performance ratio. However, it is important to be cautious, particularly if the products bear upon Chinese standards that are different to European ones [1,2].

With regard to the uncertainties when assessing product quality, a question arises – what the real quality, usage value, and real parameters of technologically more complex products are. This paper discusses a liquid-ring pump of a Chinese origin. Considering the fact that it is a machine equipment that is rather demanding as for the production process quality requirements, we aimed to assess and test the device. Similar devices supplied by established local European producers maintain a high standard of quality in the long term, which is also reflected in their price. The question is whether the parameters of a cheaper alternative device are such as declared by the producer / supplier. The testing of the liquid-ring pump needs to take into account the operational quantities, difference in the measured differential pressures and efficiency of the motor drive [3,4,5,6].

EXPERIMENTAL

— Testing the parameters of vacuum pump

Within the experimental measurements we tested a liquid-ring pump produced by CHINCO, type 2BV2-061, serial number C1611132, year of manufacture 2016. The maximum declared lifting capacity is 52 m^3/h and water consumption is 2.5 l/min.

A testing stand was used to verify the amount of extracted air and reaching the required suction pressure by the liquid-ring pump. For this purpose, the stand was equipped with a measuring segment with a centric orifice plate to measure the quantity of the flowing air for the pump suction and a draw-off to read the static suction pressure and delivery of the liquid-ring pump.

The thermal-technical parameters of air were measured for different settings of service water consumption. Several states of the liquid-ring pump, for which operational conditions were set, were tested. Based on the results of testing the different states, four tests were defined to determine the lifting capacity of the liquid-ring pump. First, the liquid-ring pump was operated at a constant amount of service water, which was not added in the course of the Test 1. Test 2 was carried out with a minimum water flow rate (1.13 l/min). The water rated consumption was gradually increased to 1.82 l/min in Test 3, and to 2.5 l/min in Test 4. All the tests lasted from 5 to 10 min. The time table of testing is listed below in Table 1.

Table 1: Parameters of water flow (consumption) during the testing of the vacuum pump at the testing stand

Test No.	1	2	3	4
Time [sec.]	16:45-16:55	16:56-17:02	17:03-17:11	17:11-17:21
Maximal Flow Rate [m3/h]	0,58	0,6	0,62	0,62
Minimal Flow Rate [m3/h]	0,03	0,06	0,03	0,02

During all the stated tests, we continuously measured and read air pressure and temperatures at the relevant metering points of the testing stand, the atmospheric pressure of ambient air, including the relative humidity (air pressure in the pump suction p1 (kPa), differential air pressure at the orifice dp (kPa), and the amount of sucked water into the liquid-ring pump Qv (l/min)). The different values were recorded during the tests using a measuring instrument Ahlborn Almemo with a storing interval of 5 s. The measured data were processed in the form of graphical records – see Figures 1 and 2.

The temperature was measured using thermocouples of "K" type placed in the pumping pits. Air flow at the testing stand input was measured using a centric orifice plate designed and made for this purpose. The mass flow was calculated on-line according to equations set in ČSN ISO EN 5167 from the values measured on the throttle device (differential pressure, static pressure, temperature). The static pressure was measured using calibrated pressure converters by Honeywell, with 0.15 precision and electric output 4 – 20 mA. The final absolute pressure was measured and evaluated according to the equations below:

$$p = pr + pa \quad (1)$$

$$pr = pm + pH_2O \quad (2)$$

where: p - final absolute pressure [MPa, kPa], pr - pressure corrected to suction head [MPa, kPa], pa - atmospheric pressure [MPa, kPa], pm - pressure measured by a pickup [MPa, kPa], pH_2O - correction to lift suction head [MPa, kPa].

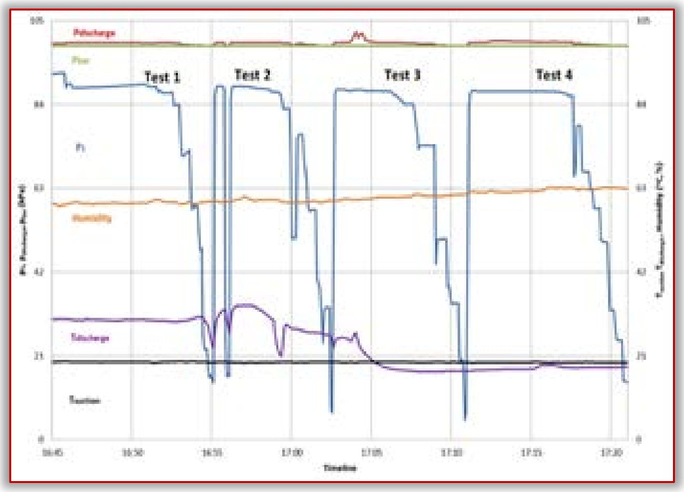

Figure 1: Parameters measured during the tests

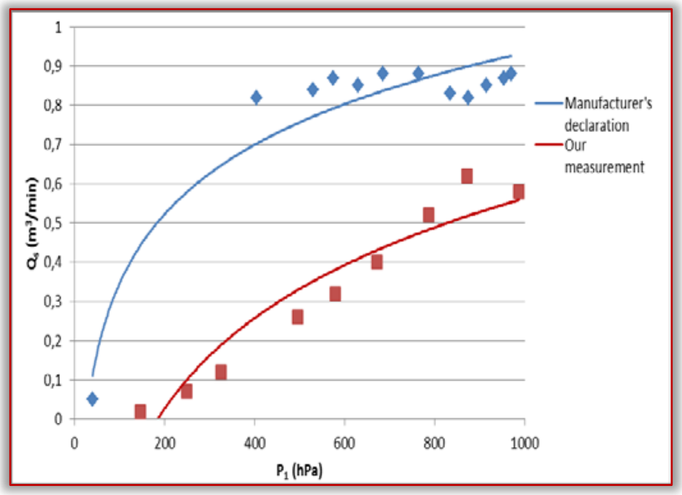

Figure 2: Measured performance of the liquid-ring pump during the tests compared to the performance declared by the producer

The measured values of pressure, temperature, and air quantity in dependence on suction pressure during the different tests were plotted into charts (Figures 1 and 2). They provide the information required to compare the real operational parameters with those declared by the producer. In this article there are also listed charts of several testing measurements to avoid possible mistakes and uncertainties of measurement.

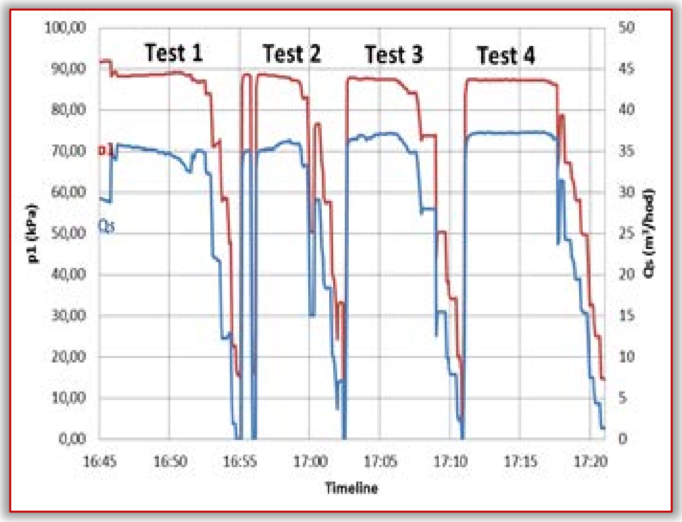

Figure 3: Measured values of absolute pressure and sucked air in vacuum pump suction

— Motor measurements

The liquid-ring pump is driven by a motor, the parameters of which we also tested. The motor parameter values declared by the producer are stated in Table 1. These are the device parameters written on the label and specified by the manufacturer. Same values are also listed within the documentation.

Table 2: Parameters on the motor label declared by the producer

TYPE YX3-90S-2T	No. 31618059 A		
P 1.45 kW	U 380 V	AC 3.2 A	
η 81.3 %	COS φ 0.84	RPM 2865 r/min	
FREQ. 50 Hz.	IP 55	CONN. Y	WT. 22 kg
INS. CL. F	DE/ODE BRG 6206N/6205N		DATE 2016/09
CE ANUI WANNAN ELECTRIC MACHINE CO., LTD Q/WN.281-2012			

The electric input was measured using an electronic wattmeter Yokogawa WT230, and own measurements were carried out on the motor terminal board of the pump. The input current was upstream the voltage inputs that were connected directly to the motor terminal board. The connection arrangement is represented schematically in Figure 4.

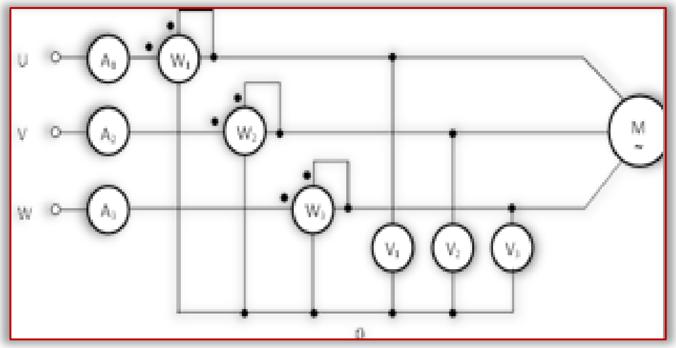

Figure 4: Scheme of measuring the electric input.

The measurements were executed under identical conditions. The basic parameters of wattmeter settings were as follows:

Table 3: Parameters of wattmeter

Voltage compliance: XU=300V~
Compliance current: XI=5A~
Acc. To measure the current: 0.1% of reading + 0.1% of range
Acc. To measure the voltage: 0.1% of reading + 0.1% of range
Acc. To measure the output: 0.1% of reading + 0.1% of range
Input resistance of the voltage input: 2 mΩ
Input resistance of the input current: 6 mΩ

— Measured results

The electric inputs were measured at the set constant flow rates of the medium. All the parameters were measured at the laboratory testing stand at constant conditions to obtain precise values. Testing was carried out multiple times to keep the measurements credible. All the parameters (voltage, current, apparent input, blind current, active current, phase factor) were measured for each phase separately. The last row in Table 2 gives an accumulated value for the whole system (Σ 3f).

The shaded cell of the three-phase active current P for the whole system may be taken for the comparisons with the value guaranteed by the producer. The measurement uncertainty is determined from a formula to calculate an error of measurement stated by the pump producer. The tables below summarize the obtained values and show the real values obtained while testing at the testing stand.

Table 4: Test No. 1. (P1=1937.9±6.4 W).

Flow rate q=0,0 l/min						
Phase	U [V]	I [A]	S [VA]	Q [var]	P [W]	PF [-]
U	234,10	3,446	806,9	484,3	654,4	0,800
V	234,20	3,442	806,2	480,0	647,8	0,803
W	234,36	3,434	804,9	481,9	644,8	0,801
Σ 3f			2418,0	1446,2	1937,9	

Table 5: Test No. 2. (P_1=1900.8±6.4 W).

Flow rate q=0,0 l/min						
Phase	U [V]	I [A]	S [VA]	Q [var]	P [W]	PF [-]
U	234,95	3,408	800,7	487,3	635,4	0,794
V	234,83	3,391	796,2	474,8	639,1	0,803
W	234,77	3,353	787,1	476,8	626,3	0,796
Σ 3f			2384,1	1438,9	1900,8	

Table 6: Test No. 3. (P_1=1955.7±6.5 W).

Flow rate q=0,0 l/min						
Phase	U [V]	I [A]	S [VA]	Q [var]	P [W]	PF [-]
U	234,77	3,407	799,8	489,7	623,4	0,791
V	234,77	3,411	800,8	474,6	645,1	0,806
W	234,30	3,333	780,0	469,0	623,3	0,799
Σ 3f			2380,7	1433,3	1900,7	

Table 7: Test No. 4. (P1=1955.7±6.5 W).

Flow rate q=0,0 l/min						
Phase	U [V]	I [A]	S [VA]	Q [var]	P [W]	PF [-]
U	235,41	3,513	827,1	508,7	652,1	0,788
V	235,29	3,505	824,9	491,1	662,7	0,803
W	234,98	3,430	806,0	488,8	640,8	0,795
Σ 3f			2457,9	1488,6	1955,7	

CONCLUSIONS

It is clear from the measured values that the liquid-ring pump does not reach the suction output (52 m^3/h) declared in the product technical documentation. Moreover, along with a falling suction pressure, the sucked amount (lifting capacity) is also decreasing, which is inconsistent with the Pump Performance Curve measured on 23 November 2016 in the producer's testing lab.

When verifying the values declared by the motor producer, the highest information value is associated with the electric input measurement results. In fact, the measured input was 1.937 kW, the producer declares 1.45 kW, though. This implies that the real input is higher by more than 30 %. The other measured quantities are of a secondary importance and do not have a significant impact on the system efficiency. The insulation state of the motor complies with the operation safety requirements.

The measurements showed that the values declared by the producer did not correspond with the identified values. It must be pointed out that the differences between the measured values and the values stated by the producer may affect the operational usage value of the device. A problem may arise when a customer needs to exploit the whole spectrum of the declared input/quantity delivered, and having installed the device, they may be dissatisfied with failing to reach the desired parameters. The working operation may be jeopardized and an economic loss may amount to 20-30 %.

Due to the scope of the paper, we do not report a number of other tests we also carried out in order to eliminate undesirable influences, or technological defects. They did not prove an influence of other factors and thus could not have affected the measurements.

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Note

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