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Paint Test for Centifugal Pump Cavitation

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1. Introduction

The cavitation phenomenon in centrifugal pumps is occurred when the static pressure within the pumps decreases below the boiling pressure of the fluid. This can cause severe damages or failures of the pumps such as the impeller wear or the pump degradation. Many researches to resolve the problem have been performed. Gluich[1] carried out wear prediction based on the Cooper's empirical relation on a cavity length. Grist [2] suggested paint test as a useful tool to measure the cavity length. In the present study, a fluid test system is made, which can create cavitation artificially. A series of visualization tests for cavitation erosion using various paints are made. By comparing the paint test results and the Cooper's correlation, the effectiveness of the paint test for the cavity length estimation is noted.

2. Test Methods and Results

2.1 Testing Apparatus

Figure 1 shows the experimental rig for pump cavitation. It consists of a vacuum pump, a compressor, an air operated valve to control the flow rate and suction pressure which generate the cavitation conditions. A flow meter, a pressure transmitter, an acoustic emission sensor are used to capture quantitative characteristics of the cavitation. Table I shows the pump specification and impeller type in this study.

Fig. 1 Experimental apparatus for pump cavitation test

Table I: Pump and Impeller Specifications

Part	Spec.	
Pump	Single-stage centrifugal type	
Power	11kW	
Head	45m	
Impeller	Type	Closed
	Vane No.	5
	Material	STS 304

2.2 Determination of Painting Test Conditions

According to Grist [2], the cavitation intensity can be predicted from the sound measurement. Also it shows that the maximum wear is generated when the maximum RMS value of SPL(Sound Pressure Level). In this study, an acoustic emission sensor was attached on the pump casing and the RMS values were obtained from the sensor by varying NPSH(Net Positive Suction Head). Figure 2 depicts the AE RMS with respect to NPSH. In the figure, it is noted that AE RMS is nearly maximum at the NPSH of about 7.5 m. To clarify the effectiveness of the present paint test, the test was performed at the flow rate of 500LPM and the NPSH of 7.5m.

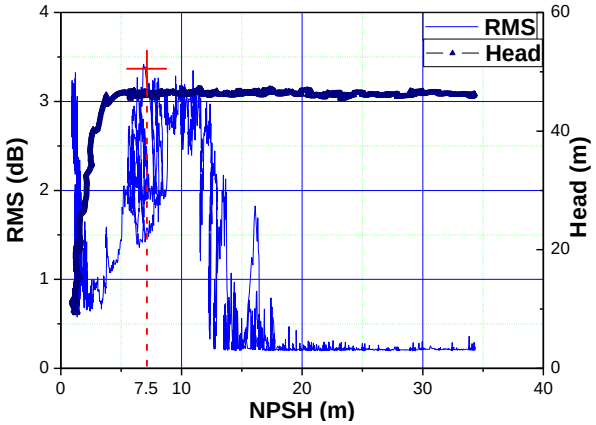

Fig. 2 Variations of AE Signal with NPSH

2.3 Test Methods

The surface treatment was conducted to remove the alien substance on the impeller surface before painting. After the painting, the impeller was exposed to the atmosphere to glue paint to impeller surface. Before the paint test, each impeller vane was taken a picture. After 4 hours later from the paint test start, a picture was taken one more time. Comparing the pictures of before and after tests, the wear area of the impeller is confirmed.

Cavity length was measured and compared with cavity length estimation by using Cooper's relation [1]. Cooper's equation for the cavity length prediction is shown in equation (1).

$$L_{cav} \cong (\pi \times D_e/n_b) \times [1 - \{(\tau_A - \tau_{3\%})/(\tau_i - \tau_{3\%})\}^{1/3}] \quad (1)$$

where $\tau = NPSH/(U_e^2/2g)$.

The predicted cavity length by the Cooper's correlation in this experiment was found to be 17mm.

The paint was sprayed on the impeller surface by an air-gun. The painting region is the middle of impeller

vane which is expected region of the cavitation erosion. Table II is shows a kind of paints used for the test. Three of them are contained zinc and the others are contained alkyd. The dilution was fixed at 10 percent of all mixture for the test. Figure 3 is the picture of painted impeller and impeller vane. The direction of impeller rotation and water flow path is shown in the figure.

Table II: Paint Types for Testing

Paint	Specification & Types
1	Epoxy Zinc rich
2	Zinc rich polyamide cured epoxy primer
3	Inorganic zinc shop primer
4	Alkyd enamel
5	Alkyd zinc primer

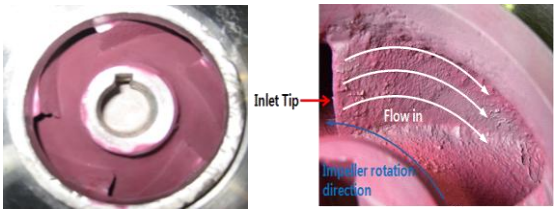

Fig. 3 Picture of impeller and vane after the painting

2.4 Test Results

Fig. 4 Picture of paint wears of impeller vane tip and the middle of vane (in the white circle)

Figure 4 shows the impeller vane after 8 hour later. The paint wear is proceeded actively, where front-shroud (at a distance about 30mm from vane inlet tip) and impeller vane are in contact. That region is similar to the wear region of Grist [2]. These results illustrate that the pressure is increasing more and more, the collapsed cavities cause the paint are more seriously in the wear region (over 50mm from vane inlet tip)

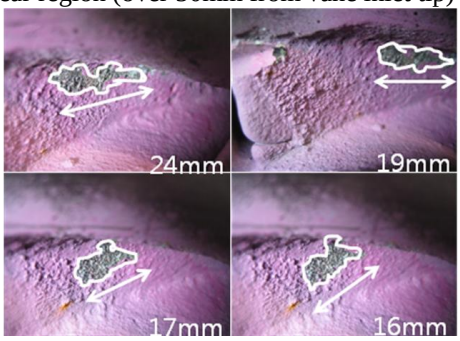

Fig. 5 Picture of paint wear region of the impeller vane

The cavity length of cavitation can be estimated from the picture like Fig. 5. The experiment carried out five times totally. The cavity length of each test was averaged for all test results. The averaged cavity length was appeared to be 19mm which is comparable with the cavity length prediction by Cooper's suggestion. As mentioned before, the cavity length predicted by the equation was 17mm.

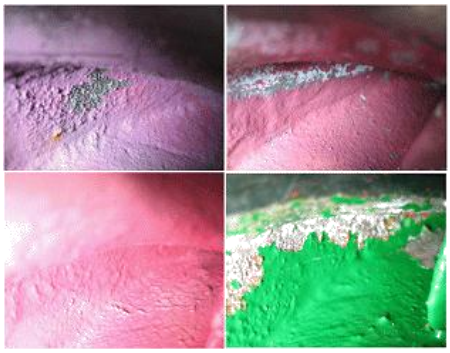

Fig. 6 Picture of impeller vanes after the 8 hour of cavitation test

Figure 6 shows the picture of impeller vanes after all kinds of the paint tests. The class of zinc rich (zinc content) is better than the class of alkyd (Chromate content) in the aspect of the adhesive property and the visualization. The classes of alkyd (right-lower) fade away all at once like an exfoliation. It is noticeable that epoxy zinc rich (left-upper) is the most adequate for paint wear test. It contains 55~60% of zinc.

3. Conclusions

This study shows that the paint wear test is useful for detection and visualization for cavitation. It will help to measure cavity length effectively. It is shown that the cavity length from the paint test is similar to the cavity length estimation by Cooper's equation. The class of zinc rich paint is more suitable for paint wear test because of suitable adhesive property.

REFERENCES

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