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# Experimental Study of The Effect Of Fluid Mass Flow Rate on Cavitation in Ebara Brand Centrifugal Pump Type 65x50 FSS4JA

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**ABSTRACT**

Cavitation is a constraint on centrifugal pumps because it affects their performance and efficiency. Experimental studies on the effect of the amount of fluid mass flow rate on cavitation in centrifugal pumps were investigated and characterized experimentally. Ebara brand centrifugal pump type 65x50 FSS4JA with 5 blades and a constant blade inclination angle of 60° was used as the object of research. Variations in fluid mass flow rate were determined with values of 1.67 kg/s, 3.33 kg/s, 5.67 kg/s, and 7.33 kg/s. The results of the study showed that the highest cavitation value was obtained at the centrifugal pump with a variation of the number of blades of 5 pcs with an NPSH value of 1.88 at a variation of the fluid mass flow rate of 5.67 kg/s, while the lowest occurred at the centrifugal pump with a variation of the fluid mass flow rate of 1.67 kg/s with an NPSH value of 0.2, but strangely when the variation of the fluid mass flow rate was 7.33 kg/s the NPSH slowly decreased by about 7% so that the centrifugal pump with the number of blades of 5 pcs working at a fluid mass flow rate of 7.33 kg/s became the optimum result in this research and could be applied practically in the field.



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## INTRODUCTION

Centrifugal pumps are one of the tools that are often applied in industry (Muhammad et.al., 2024). In its work, cavitation often causes problems with the performance aspects of centrifugal pumps (Wang et al., 2025). In addition to reducing performance, cavitation also plays an important role in damage to pump components, reduced power, and centrifugal pump efficiency (Which et al., 2025). Disproportionate pump geometry and design are also factors in cavitation (AlObaidi & Shaban, 2024). As a result, the pressure and rate of fluid flow decrease significantly below the saturated vapor pressure, so that this phenomenon causes damage to pump components such as *impellers* and so on (Lu et al., 2024). Generally, cavitation is characterized by vibration and noise in the pump (Liu et al., 2024). The effects of cavitation cause pump performance to decrease, and NPSH has become a benchmark and reference for determining pump performance (Dehghan et al., 2024).

Various methods have been developed to prevent cavitation effects in pumps, one of which is by modifying the shape of the pump *impeller,* increasing the number *of blades,* which allows cavitation results to be reduced from 45.7% to 43.1% (Song et al., 2022). The pump frequency of 10 and 12.8 kHz which was experimentally researched was carried out for cavitation detection, the results showed that the pump *head* could be increased by 8% and the NPSH could be reduced by 34% (Grandson et al., 2022). The magnitude of *the head coefficient value* on the pump of 0.80 0.84, 0.86 was characterized to determine the cavitation effect using experimental and numerical methods. The result was that the magnitude of *the head coefficient value* on the pump of 0.80 had the best cavitation effect, cavitation could be reduced by up to 20% (Wanga et al., 2023). The arrangement of *impeller blades* with *single radial vanes* and *double radial vanes* was characterized experimentally and numerically against the cavitation effect of centrifugal pumps. As a result, *the double radial vane* has a low ΔP value of 1.583 Pa and has the lowest NPSH value of 1.117 (Kang et al., 2023).

The magnitude of the fluid mass flow rate of 1.16 kg/s, 1.235 kg/s, 1.31 kg/s, 1.385 kg/s, and 1.46 kg/s was researched using experimental and numerical methods to determine the effect on centrifugal pump cavitation. As a result, the excess pressure on the pump can be reduced by up to 5% and has an NPSHr value of 5 at a variation of 1.46 kg/s (Ramirez et al., 2020). Variations in discharge of 0.4 $m^3/s$, 0.6 $m^3/s$, 0.8 $m^3/s$, 1 $m^3/s$, 1.2 $m^3/s$, 1.4 $m^3/s$, and 1.6 $m^3/s$ were studied using experimental and numerical approaches to study the phenomenon of Pump cavitation. As a result, the NPSH value can be reduced by 0.6% by increasing the discharge value (Zhao et al., 2023). *The effects of head and blade profile* were studied by varying the pump *head* to determine the cavitation phenomenon, the results of the study showed that the height *of the head* contributed to reducing the cavitation effect on centrifugal pumps (Gong et al., 2023). The effects of frequency and pump rpm affect cavitation, it is known based on research results both experimentally and numerically that the greater the frequency and pump rpm, the greater the pump NPSHa (Wang et al., 2023).

Previous studies have focused on detecting centrifugal pump cavitation against variations such as the geometry of *the impeller blade,* Rpm, vibration frequency, *head* and pressure on the influence of the centrifugal pump cavitation phenomenon. In addition, there is no experimental study of the effect of fluid mass flow rate on the centrifugal pump cavitation phenomenon so that researchers are interested in studying it further. The Ebara brand centrifugal pump type 65x50 FSS4JA was used as the object of research. The number *of blades impellers* of 5 pieces with an *impeller blade inclination angle* of 60º which were tested at fluid mass flow rates of 1.67 kg/s, 3.33 kg/s, 5.67 kg/s, and 7.33 kg/s in order to conduct an in-depth analysis of the cavitation phenomenon in the pump. Water fluid with a temperature of 5ºC was used as a medium to determine the flow characteristics and cavitation effects.

## METHODS

### Physical Model

Figure 1 is the EBARA 65x50 FSS4JA centrifugal pump which is the object of research. In this study, the centrifugal pump has the specifications described in Table 1.

Table 1. Specifications of EBARA 65x50 FSS4JA Centrifugal Pump.

| Model | 65x50 FSS4JA |
|---|---|
| *Power* (kW) | 3.7 |
| *Frame No* | 112 M |
| *Impeller Diameter* | 260mm |

| | |
|---|---|
| CLA *Coupling* | 125 |
| *Pump Shaft Diameter* (mm) | 24mm |
| *Motor Shaft Diameter* (mm) | 28mm |
| *Capacity* | 0.34 m³/m |
| *Head* | 25 m |
| *Rotating* | 1450 Rpm |
| *Frequency* | 50Hz |
| *Voltage* | 380 V |

Figure 1. EBARA 65x50 FSS4JA Centrifugal Pump.

**Experiment Scheme**

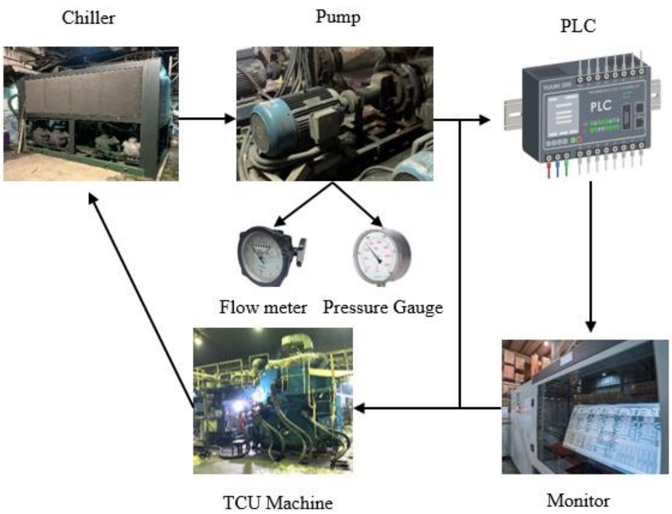


Figure 2. Experimental Scheme.

The experimental scheme of the Ebara brand centrifugal pump type 65x50 FSS4JA is explained in Figure 2. The workflow starts from the *chiller* machine. which supplies cold water with temperature of 5ºC with a pressure of 10 Bar. The properties of water material include density $\rho$ = 998 kg/m³, dynamic viscosity $\mu$ = 1.7478. $10^{-5}$kg/m², kinematic viscosity $\nu$ = 1.3763. $10^{-5}$m²/s, specific heat *Cp* = 1.0057. $10^{3}$J/kg.K, and thermal conductivity *K* = 0.024458 Wm.K flowing with a capacity of 0.34 m³/m with a fluid mass flow rate of 1.67 kg/s, 3.33 kg/s, 5.67 kg/s, and 7.33 kg/s flowed through a centrifugal pump with *a head of* 25 m. The pump is driven by motor power: 3.7 kw, power: 3 Hp, Rotation: 1400 Rpm / 4 Pole, electric voltage: 380V / 3 Phase, and frequency 50 Hz MITSUBISHI brand *Foot Mounting* is used to flow water to the TCU *Casting* machine. The PLC system works to control the pressure and temperature which is directly connected to the computer screen, water is flowed through a pipe with a diameter of 1.25 *inches* to cool the *casting* machine *roll,* after the cooling process the water comes out with temperature of 80ºC and circulates to the *chiller machine.*

**Experimental Data Reduction**

results obtained are data on the average flow rate, pressure, and pump discharge values used to find the NPSH value. In this research, water fluid is used to demonstrate the cavitation phenomenon and flow characteristics, where the viscosity of water is calculated using equation 1:

$$\mu = \frac{v}{\rho} \tag{1}$$

average speed of water flowing in the pump installation is determined to be constant at 1.67-7.33 kg/s, and the number of *impellers* consists of 5. fruit. So the Reynolds number is calculated by equation 2:

$$R_e = \frac{\rho . D . U_\infty}{\mu} \tag{2}$$

The discharge working on the pump is calculated using equation 3:

$$Q = V \times \mathrm{A} \tag{3}$$

*head* can be calculated using equation 4:

$$H_p = h_a + h_f \tag{4}$$

There are 2 types *of losses* on the pump flow side, namely:

*Head* Major *loss* is calculated using equation 5:

$$H_{my} = f . \frac{\mathrm{L}}{\mathrm{D}} . \frac{\mathrm{Vd}^2}{2\mathrm{g}} \tag{5}$$

*Minor head loss* is calculated by equation 6:

$$H_{mn} = f . \frac{\mathrm{Vd}^2}{2\mathrm{g}} \tag{6}$$

Electric motors are used for pump drive, with 1-20% rotation is chosen because of the safety factor to avoid slip. Specific rotation allows *the impeller* to transfer fluid as much as 1.67 kg/s with *a head* of 25 m, so that the pump rotation can be calculated by equation 7:

$$Ns = n . \frac{Q^{1/2}}{H^{3/4}} \tag{7}$$

The pump capacity is calculated by equation 8:

$$P = \frac{\Upsilon . \mathrm{H} . \mathrm{Q}}{\eta \text{ pompa}} \tag{8}$$

Generally, induction motors drive centrifugal pumps directly and the motor power magnitude can be calculated using equation 9:

$$Pm = P \frac{1+a}{\eta_t} \tag{9}$$

*Net positive head* is used as a measure of pump safety against cavitation phenomena and is calculated using equation 10:

$$H_{sv} = \frac{\mathrm{Pa}-\mathrm{pv}}{\Upsilon} - h_a - h_{f\ suction} \tag{10}$$

The required NPSH depends on the capacity, *head* and rotation of the pump and can be calculated using equation 11:

$$NPSH_{\ svn} = \left(\frac{n}{s}\right)^{4/3} . Q^{2/3} \tag{11}$$

## RESULTS AND DISCUSSION

The effect of fluid mass flow rates of 1.67 kg/s, 3.33 kg/s, 5.67 kg/s, and 7.33 kg/s was studied. with the experimental method being studied in order to detect the cavitation phenomenon in centrifugal pumps. The constant blade angle *in centrifugal* pumps can affect the occurrence of cavitation. This is proven by the characteristics *of the blade* which begins to erode due to the impact force of the fluid. Cavitation is a phenomenon that occurs when the local pressure is below the saturated vapor pressure of the fluid. The magnitude of the high fluid flow rate is known to be able to increase the level of cavitation in the pump. The magnitude of the fluid mass flow rate has been shown to increase the intensity of turbulence around the pump *blade,* resulting in the emergence of *swirl flow* and vortices around *the impeller* making erosion on *the impeller components* difficult to avoid. The presence of centrifugal force and drag force with very high fluid pressure results in the creation of massive air bubbles around *the impeller,* which then slowly burst due to loss of pressure. As a result of this phenomenon, cavitation occurs, which is a very detrimental phenomenon because it can have the effect of damaging pump components, especially the *impeller.* The high mass flow rate of fluid provides its own advantages because the discharge flows rapidly, but this is not a guarantee of pump performance, on the contrary, this phenomenon actually makes the cavitation effect worse. In addition, the suction pressure slowly decreases on *the impeller* also suspected to be the cause of cavitation. Figure 3 is the effect of the experimental test results of the influence of fluid mass flow rate on cavitation in the centrifugal pump *volute.*

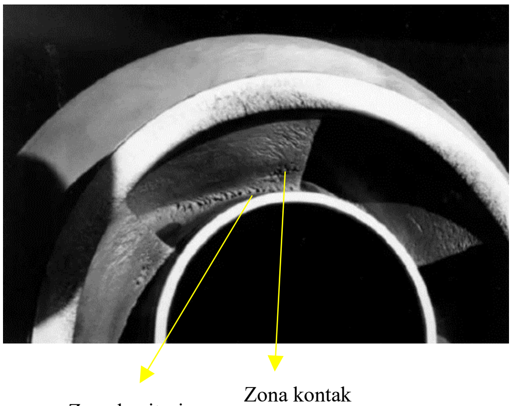


Figure 3. Cavitation in Pump *Impeller.*

Figure 4 is the relationship between fluid mass flow rate and NPSH. Increasing the value of fluid mass flow rate also plays an important role in the cavitation process. Generally, high fluid mass flow rate causes high cavitation, in this research the level of cavitation that occurs in a pump with 5 *blades* which is studied experimentally with variations in fluid mass flow rate has a cavitation value of 0.2 at a fluid mass flow rate variation of 1.67 kg/s, 0.65 at a fluid mass flow rate variation of 3.33 kg/s, 1.9 at a fluid mass flow rate variation of 5.67 kg/s, and 1.88 at a fluid mass flow rate variation of 7.33 kg/s. The results confirm that the higher the variation of the fluid mass flow rate, the higher the cavitation level, but strangely when the variation is increased from 5.67 kg/s to 7.33 kg/s the cavitation value slowly decreases, this confirms that the variation of the fluid mass flow rate of 7.33 kg/s is the optimal variation of the fluid mass flow rate and can be applied in the field.

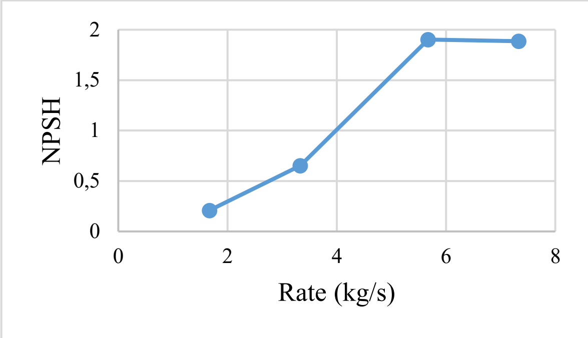


Figure 4. Relationship between Mass Flow Rate of Fluid and NPSH.

## CONCLUSION

The highest cavitation value was obtained in a centrifugal pump with a variation of 5 *blades* with an NPSH value of 1.88 at a fluid mass flow rate variation of 5.67 kg/s, while the lowest occurred in a centrifugal pump with a variation of 1.67 kg/s with an NPSH value of 0.2, but strangely when the fluid mass flow rate variation was 7.33 kg/s the NPSH slowly decreased by about 7% so that the centrifugal pump with 5 *blades* working at a fluid mass flow rate of 7.33 kg/s became the optimum result in this research and could be applied practically in the field.

## STATEMENT OF INTEREST

The authors declare that we are not aware of any competing financial interests or personal relationships that might have appeared to influence the work reported in this paper.

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