

The Effect of High Temperature (HT) Freshwater Cooling Pump Pressure on Main Engine Jacket Water Temperature on The MT. Sunrise Warrior Ship

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Abstract.

This study analyzes the effect of high temperature (HT) freshwater cooling pump pressure on the main engine jacket water temperature on the MT. Sunrise Warrior tanker, addressing operational reliability issues due to a decrease in pressure from 2.5-3.5 bar to 1.8 bar which causes overheating above 85°C. Using a quantitative approach with simple linear regression on 30 purposive samples from the engine room logbook (July 2024-July 2025), instruments including pressure gauge (X: 2.1-3.3 bar) and temperature indicator (Y: 70-90°C), analyzed through SPSS with the classical assumption test, t-test, F-test, and R². The results show a strong negative correlation (R=0.996) with the equation $Y=124.931-16.650X$ which explains 99.1% of the variation (R²=0.991), all tests are significant ($t=-56.527$, $F=3195.333$, $p<0.001$). Increasing pump pressure significantly reduces jacket water temperature, resulting in a validated prediction model different from previous qualitative studies, with implications for preventive maintenance in maritime engineering.

Keywords: Jacket Water; Main Engine; Pressure Pump; Linear Regression and Cooling System.

I. INTRODUCTION

Tankers play a crucial role in national and international energy distribution, where the reliability of the main engine is a key determinant of safe and efficient operation. The main engine generates extreme heat from continuous combustion, requiring the high-temperature (HT) freshwater cooling system to maintain jacket water temperatures within a safe range to prevent damage to vital components such as the cylinder liner and piston (Ziliwu *et al.*, 2021; Subekti *et al.*, 2022). During sea practice on the MT. Sunrise Warrior, researchers observed a drop in the HT freshwater cooling pump pressure from the normal range of 2.5-3.5 bar to 1.8 bar, which reduced the cooling water flow rate through the cylinder jacket. As a result, the jacket water temperature surged above 85°C, triggering an alarm and forcing engine load reduction to avoid further damage (Prameswari *et al.*, 2025; Parrung *et al.*, 2024; Hadi *et al.*, 2023; Utama & Santoso, 2022). Previous studies have uncovered similar issues, such as impeller and mechanical seal wear that reduces pump pressure and increases jacket water temperature that impairs combustion efficiency, but their analyses were still qualitative and descriptive without quantitative statistical measurements (Prameswari *et al.*, 2025; Parrung *et al.*, 2024; Dirhamsyah *et al.*, 2025). This gap is evident because no study has empirically measured the effect of HT pump pressure on jacket water temperature, even though this factor is critical for optimal coolant circulation in tankers (Ziliwu *et al.*, 2021; Subekti *et al.*, 2022; Kyrtatos *et al.*, 2021; el-Gohary *et al.*, 2023).

The problem is becoming increasingly pressing because unreliable cooling systems can lead to operational downtime, increased fuel consumption, and pose safety risks to hazardous liquid cargoes on tankers. On the MT. Sunrise Warrior, a gradual drop in pump pressure not only triggered a high-temperature alarm but also forced manual intervention, potentially disrupting the shipping schedule and increasing maintenance costs (Hadi *et al.*, 2023; Utama & Santoso, 2022; Theotokatos *et al.*, 2024; Lazakis *et al.*, 2022). This study aims to examine the effect of HT freshwater cooling pump pressure on the main engine jacket water temperature on MT. Sunrise Warrior and to measure its magnitude statistically quantitatively using engine room log book data. The urgency of this research lies in the need for practical contributions for engineer officers in preventive monitoring and pump maintenance, in order to minimize operational risks on tankers operating continuously. The novelty of this study is the first quantitative approach that closes the research gap with a statistical analysis of the effect of pump pressure on jacket water temperature, going beyond previous descriptive studies and providing a scalable predictive model for the maritime industry (Kyrtatos *et al.*, 2021; el-Gohary *et al.*, 2023).

II. METHODS

This study uses a quantitative approach with a causal associative design to examine the effect of high temperature (HT) freshwater cooling pump pressure on the jacket water temperature of the main engine on the MT. Sunrise Warrior through simple linear regression analysis (Sugiyono, 2021; Ardiansyah *et al.*, 2023). This approach was chosen because numerical data from the engine room logbook, such as pressure in bar and temperature in °C, allows for objective hypothesis testing and statistical measurement of variable influences (Creswell & Creswell, 2023; Subekti *et al.*, 2022). The quantitative method emphasizes primary data collection through observation and operational recording, followed by inferential analysis to produce generalizable conclusions in the context of tanker machinery (Sudaryono, 2022; Safitri *et al.*, 2025). The main research instruments include a pressure gauge at the HT pump outlet to measure pressure (variable X) and a temperature indicator at the jacket water outlet for temperature (variable Y), with a normal pressure classification of 2.5-3.5 bar and a normal temperature of 68-80°C based on ship operational standards (Subekti *et al.*, 2022; Ardiansyah *et al.*, 2023). Data analysis techniques include classical assumption tests such as normality (Shapiro-Wilk), linearity, and heteroscedasticity (Glejser), followed by simple linear regression $Y = a + bX$, partial t-test, simultaneous F-test, and coefficient of determination R^2 to measure the magnitude of the influence of independent variables (Emzir, 2021; Sugiyono, 2021). Data are processed using statistical software such as SPSS to ensure the validity of the regression model and accurate interpretation of the results (Creswell & Creswell, 2023; Sudaryono, 2022).

The study population consisted of all operational data on HT pump pressure and jacket water temperature recorded in the engine room logbook of the MT. Sunrise Warrior vessel during a 12-month sea practice period, from July 8, 2024, to July 15, 2025, under various load conditions of the Kawasaki MAN B&W 6S35MC main engine (Safitri *et al.*, 2025; Ardiansyah *et al.*, 2023). Samples were taken purposively from primary data that met normal operational criteria, including systematic recording at certain time intervals to comprehensively represent pressure and temperature variations (Sugiyono, 2021; Subekti *et al.*, 2022). This purposive sampling approach ensured that the samples were relevant to the observed pressure drop phenomenon from 2.5-3.5 bar to 1.8 bar, while avoiding bias with the support of secondary data from manual books and PMS reports (Emzir, 2021; Sudaryono, 2022). The research procedure began with direct observation in the MT. Sunrise Warrior engine room to verify measuring instruments, followed by recording primary data from logbooks and studying secondary data documentation such as instruction manuals and maintenance reports (Ardiansyah *et al.*, 2023; Creswell & Creswell, 2023). Data were then collected, validated, and inputted into software for classical assumption testing before simple linear regression analysis to test the hypothesis of a significant effect (H1) with $\alpha=0.05$ (Sugiyono, 2021; Emzir, 2021). The results are presented in categorical tables, regression equations, and statistical tests to explain the magnitude of the effect, ending with an interpretation linking the findings to practical recommendations for cooling system maintenance (Sudaryono, 2022; Safitri *et al.*, 2025).

III. RESULT AND DISCUSSION

Overview of Research Location



This research was conducted aboard the MT. Sunrise Warrior, a tanker operating in Indonesian waters. The vessel transports liquid cargo and regularly operates routes between Indonesian ports, including Balikpapan, Wayame, Kupang, Makassar, Cilacap, Surabaya, and several others.

Description of Research Variables

Table 1. HT Coolant Pressure and Jacket Water Temperature Data

No	HT Pump Pressure (bar)	Jacket Water Temperature (°C)	No	HT Pump Pressure (bar)	Jacket Water Temperature (°C)
1	3.2	72	16	3.2	71
2	3.1	73	17	3.1	74
3	3.3	71	18	2.4	85
4	3.0	74	19	2.3	87
5	3.2	72	20	2.6	82
6	2.9	76	21	3.0	75
7	2.8	78	22	2.7	80
8	3.1	73	23	2.5	84
9	3.3	70	24	3.3	70
10	3.0	75	25	3.2	72
11	2.7	79	26	2.9	77
12	2.6	81	27	2.8	79
13	2.5	83	28	2.4	86
14	2.8	78	29	2.2	88
15	2.9	76	30	2.1	90

Table 2. Descriptive Statistics of Research Variables

Variables	N	Min	Max	Mean	Std. Dev.	Unit
HT Pump Pressure (X)	30	2.1	3.3	2.84	0.346	bar
Jacket Water Temperature (Y)	30	70	90	77.70	5,784	°C

Table 2 shows that the HT pump pressure (X) ranges from 2.1-3.3 bar (mean = 2.84 bar; SD = 0.346), with variations from normal conditions (≥ 2.5 bar) to decreased (< 2.5 bar). The jacket water temperature (Y) ranges from 70-90°C (mean = 77.70°C; SD = 5.784), where the maximum value of 90°C indicates overheating exceeding the normal limit of 80°C and an alarm of 85°C.

Classical Assumption Test

1. Normality Test

Table 3. Normality Test Results

	Kolmogorov-Smirnov		Shapiro-Wilk			
	Statistics	df	Sig.	Statistics	df	Sig.
Jacket Water Temperature	.116	30	.200*	.940	30	.088

*. This is a lower bound of the true significance

a. Lilliefors Significance Correction

The normality test in Table 3 shows the significance values of Kolmogorov-Smirnov (0.200) and Shapiro-Wilk (0.088), both > 0.05 . Thus, the jacket water temperature data is normally distributed, meeting the normality assumption for subsequent regression analysis.

2. Linearity Test

Table 4. Linearity Test Results

Information	F	Sig.	Standard	Note:
Linearity	312,451	0,000	< 0.05	Linear
Deviation from Linearity	1,876	0.134	> 0.05	Linear

Based on Table 4, the linearity test shows Sig. Linearity $0.000 < 0.05$ and Sig. Deviation from Linearity $0.134 > 0.05$. Thus, the relationship between HT pump pressure (X) and jacket water temperature (Y) is significantly linear, fulfilling the linearity assumption for regression analysis.

3. Heteroscedasticity Test

Table 5. Results of Heteroscedasticity Test (Glejser Test)

Variables	t count	Sig.	Standard	Information
HT Pump Pressure (X)	1,243	0.224	> 0.05	There is no heteroscedasticity

Based on Table 5, the Glejser test shows a significance of HT pump pressure of $0.224 > 0.05$. Thus, there is no heteroscedasticity, the residuals are homoscedastic (constant variance), so the heteroscedasticity assumption is met for the regression model.

Data Analysis Test

1. Simple Linear Regression Analysis

Table 6. Simple Linear Regression Equation

Coefficients ^a					
Model	Unstandardized Coefficients		Standardized Coefficients		
	B	Std. Error	Beta	t	Sig.
(Constant)	124,931	.842		148,458	.000
HT Pump Pressure	-16,650	.295	-.996	-56,527	.000

b. Dependent Variable: Jacket Water Temperature

Based on Table 6, the simple linear regression equation is $Y = 124.931 - 16.650X$, with constant $a = 124.931$ and regression coefficient $b = -16.650$. Interpretation: Every 1 bar increase in HT pump pressure decreases the jacket water temperature by 16.650°C , or conversely, a 1 bar decrease in pressure increases the temperature by 16.650°C (ceteris paribus). The constant value of 124.931°C is a mathematical point (non-physical operational). This negative relationship is in line with the principle of the cooling system, where pressure decreases \rightarrow flow decreases \rightarrow heat absorption decreases \rightarrow temperature increases.

2. t-test (Partial)

Table 7. Results of t-Test (Partial)

Variables	t count	t table	Signification	Information
Fresh Water Cooling Pump Pressure HT (X)	-56,527	2,048	0,000	Influential

Based on Table 7, the t-test shows $t \text{ count} = -56.527$ ($\text{Sig.} = 0.000$) $> t \text{ table} = 2.048$ ($df = 28, \alpha = 0.05$). Because $t \text{ count} > t \text{ table}$ and $\text{Sig.} < 0.05$, then H_0 is rejected and H_1 is accepted. Conclusion: HT pump pressure partially has a significant effect on jacket water temperature at MT. Sunrise Warrior. The negative relationship indicates that an increase in pump pressure \rightarrow a decrease in jacket water temperature, and vice versa a decrease in pressure \rightarrow an increase in temperature.

3. F test (ANOVA)

Table 8. F Test Results

ANOVA ^a						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	961,871	1	961,871	3195.333	.000b
	Residual	8,429	28	.301		
	Total	970,300	29			

a. Dependent Variable: Jacket water temperature

b. Predictors: (Constant), HT Pump Pressure

Based on Table 8, the F test shows $F \text{ count} = 3195.333$ ($\text{Sig.} = 0.000$) $> F \text{ table} = 4.20$ ($df_1 = 1, df_2 = 28, \alpha = 0.05$). Because $F \text{ count} > F \text{ table}$ and $\text{Sig.} < 0.05$, the regression model is declared significant and suitable for use in predicting jacket water temperature based on the pressure of the HT freshwater cooling pump.

4. Coefficient of Determination (R2)

Table 9. Results of the Coefficient of Determination (R2)

Model Summary				
Model	R	R Square	Adjusted R Square	Standard Error of the Estimate
1	.996a	.991	.991	.5487

a. Predictors : (Constant), HT Pump Pressure

b. Dependent Variable: Jacket Water Temperature

Based on Table 9, the correlation coefficient $R = 0.996$ indicates a very strong relationship between HT pump pressure (X) and jacket water temperature (Y). The R^2 value = 0.991 (99.1%) means that pump pressure explains 99.1% of the temperature variation, with the remaining 0.9% influenced by other factors such as the heat exchanger, cooling water quality, engine RPM, and thermostat valve.

Discussion

1. The Effect of High Temperature Freshwater Cooling Pump Pressure on the Main Engine Jacket Water Temperature

Based on the results of data analysis, a correlation coefficient value of 0.996 was obtained with a negative relationship between the pressure of the High Temperature (HT) freshwater cooling pump and the temperature of the main engine jacket water on the MT. Sunrise Warrior ship. The correlation value is very close to one indicating that the relationship between the two variables is classified as very strong. The negative direction of the relationship indicates that changes in high temperature pump pressure are inversely proportional to the jacket water temperature. When the pump pressure increases, the jacket water temperature tends to decrease, whereas when the pump pressure decreases, the jacket water temperature tends to increase. This indicates that pump pressure plays an important role in maintaining temperature stability in the main engine cooling system.

Technically, this condition is related to the pump's primary function in the cooling system, which is to circulate coolant through the jacket water channel to absorb heat from engine components such as the cylinder liner, cylinder head, and exhaust valve. If the pump pressure is in good condition, the coolant circulation will run smoothly, so that the process of heat removal from the engine can occur optimally. Conversely, if the pump pressure decreases, the coolant circulation will be less optimal, so the process of heat absorption from engine components does not occur optimally. This condition causes the heat generated by the engine to be unable to be released properly and ultimately causes an increase in the temperature of the jacket water. Thus, the results of this study indicate that the pressure of the high temperature fresh water cooling pump has an influence on the temperature of the main engine jacket water, so that the first problem formulation in this study can be answered.

2. The magnitude of the influence of high temperature pump pressure on changes in the jacket water temperature of the main engine

In addition to determining the influence between the two variables, this study also aims to determine the extent of the influence of the high-temperature freshwater cooling pump pressure on changes in the jacket water temperature of the main engine. Based on the results of a simple linear regression analysis, a coefficient of determination (R^2) value of 0.991 or 99.1% was obtained. This value indicates that changes in the jacket water temperature of the main engine are significantly influenced by the pressure of the high-temperature freshwater cooling pump. In other words, most of the jacket water temperature variations that occurred during the observation period can be explained by changes in the high-temperature pump pressure. Meanwhile, a small portion of the temperature variations that occurred were likely influenced by other factors not included in the research variables. The magnitude of this influence indicates that high-temperature coolant pump pressure is a very dominant factor in maintaining the temperature stability of the main engine cooling system.

This confirms that coolant pump performance plays a crucial role in maintaining the engine's working condition at a safe operating temperature. In operational practice on ships, this condition is seen when the pump pressure decreases from normal conditions. This decrease in pressure causes the cooling water circulation to be less than optimal, so that jacket water tends to increase and can approach the engine's maximum operating limit. The results of statistical tests indicate that the regression model used in this study is statistically significant, so that the relationship between high-temperature pump pressure and jacket water temperature can be used as a basis for understanding the behavior of the main engine cooling system. This finding indicates that routine monitoring of high-temperature coolant pump pressure is very important for engine room officers, because changes in pump pressure can be an early indicator of problems in the main engine cooling system.

IV. CONCLUSION

This study concludes that the high temperature (HT) freshwater cooling pump pressure significantly affects the jacket water temperature of the main engine on the MT. Sunrise Warrior, with correlation coefficients $R = 0.996$ and $R^2 = 0.991$ indicating that 99.1% of temperature variations can be explained by pump pressure. The regression equation $Y = 124.931 - 16.650X$ confirms a strong negative relationship, where every 1 bar pressure decrease increases the jacket water temperature by 16.650°C , in accordance with the field phenomenon of a decrease from 2.5-3.5 bar to 1.8 bar which triggers overheating up to 90°C . Statistical tests (t count = -56.527, F count = 3195.333, all Sig. < 0.05) validate the regression model as feasible for operational prediction. While the results are statistically robust, limitations of the study include a single focus on the HT system without confounding variables such as heat exchanger condition or cooling water quality (0.9% remaining variation), and a limited sample size of 30 observations from a single vessel. Practical implications include recommendations for daily pump pressure monitoring for engineer officers for early detection of flow reductions, preventative impeller maintenance, and downtime risk reduction. Further research is recommended to integrate multivariate variables with real-time IoT data on multiple tankers for a more comprehensive predictive model for the Indonesian maritime industry.

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