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Analysis of the Effect of Declining Turbocharge Performance on The Power of the Main Engine on the Mt Chem Star Ship

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ABSTRACT

The purpose of the study is to analyze the indicators that cause the decline in turbocharge performance in the MT main engine. CHEM STAR. The research method is direct observation in the field and statistical analysis using JASP software with a paired t-test to compare conditions before and after the decline in turbocharger performance. The variables observed included boost pressure, exhaust gas pressure, intercooler temperature, engine room temperature, turbocharger rev (RPM), and engine power output (kW). The results showed a significant decrease in boost pressure, intercooler temperature, engine room temperature, turbocharger RPM, and engine power output after a turbocharger performance disturbance ($p < 0.001$). A very strong positive correlation was found between power output with boost pressure ($r = 0.988$) and turbocharger RPM ($r = 0.998$), while a very strong negative correlation was observed between power output with exhaust gas pressure ($r = -0.978$), intercooler temperature ($r = - 0.951$), and engine room temperature ($r = -0.992$). The main causes of the decline in turbocharger performance are dirty air filters on the blowers as well as carbon buildup on the turbine blades that inhibit the flow of exhaust gases and reduce the turbocharger's working efficiency. This study provides important recommendations for ship operations to carry out regular maintenance and cleaning of turbocharger components according to manual procedures to maintain engine efficiency and prevent further damage.

Keywords: *Turbocharger, ship's main engine, performance degradation, statistical analysis, MT. CHEM STAR*

ABSTRAK

Tujuan penelitian yakni menganalisa indikator penyebab turunnya kinerja turbocharge pada mesin induk kapal MT. CHEM STAR. Metode penelitian yakni observasi langsung di lapangan serta analisis statistik menggunakan perangkat lunak JASP dengan uji paired t-test untuk membandingkan kondisi sebelum dan sesudah penurunan kinerja turbocharger. Variabel yang diamati meliputi tekanan boost, tekanan gas buang, temperatur intercooler, temperatur ruang mesin, putaran turbocharger (RPM), dan output daya mesin (kW). Hasil penelitian menunjukkan adanya penurunan signifikan pada tekanan boost, temperatur intercooler, temperatur ruang mesin, RPM turbocharger, dan output daya mesin setelah terjadi gangguan kinerja turbocharger ($p < 0,001$). Korelasi positif sangat kuat ditemukan antara output daya dengan tekanan boost ($r = 0,988$) dan RPM turbocharger ($r = 0,998$), sedangkan korelasi negatif sangat kuat diamati antara output daya dengan tekanan gas buang (r = -0,978), temperatur intercooler (r = - 0,951), dan temperatur ruang mesin (r = - 0,992). Penyebab utama penurunan kinerja turbocharger adalah saringan udara yang kotor pada blower serta penumpukan karbon pada sudu-sudu turbin yang menghambat aliran gas buang dan menurunkan efisiensi kerja turbocharger. Penelitian ini memberikan rekomendasi penting bagi operasional kapal untuk melakukan pemeliharaan dan pembersihan komponen turbocharger secara berkala sesuai prosedur manual untuk menjaga efisiensi mesin dan mencegah kerusakan lebih lanjut.

Kata kunci: Turbocharger, mesin induk kapal, penurunan kinerja, analisa statistik, MT. CHEM STAR

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1. INTRODUCTION

Turbochargers are supporting devices installed on the ship's main engine. The main engine of a commercial ship is usually a diesel engine used to power the ship. The main function of the turbocharger is to provide additional air to the combustion chamber of the engine. The turbocharger works by utilizing the exhaust gas pressure of the engine to rotate the turbine inside which is connected to the blower, drawing air from the outside and directing it to the combustion chamber. This system is very effective for increasing the air pressure in the combustion chamber, so that it exceeds the atmospheric pressure. This helps to increase the quality of combustion, allowing more fuel to burn due to a greater supply of air. Two vital components of the turbocharger are the turbine side and the blower side. The turbine side converts heat and exhaust gas pressure into rotating energy that rotates the blower side, while the blower side is tasked with drawing air from the outside and directing it into the combustion chamber.

When the main engine is operating and emitting exhaust gases, the turbocharger will also start working. Once the turbocharger is active, the blower will begin to draw air from the outside. As the engine rev (rpm) increases, it signifies the turbine on the turbocharger is spinning faster and can supply more air. The increase in rinse air pressure indicates that the turbocharger is functioning properly and efficiently.

If a drop in rinse air pressure is detected during operation of the main engine, this could be a sign of a problem with the turbocharger's performance. Some factors that can affect the performance of the turbocharger are:

1. Dirt on the turbine side spoons.
2. Dirt on the sides of the blower side.
3. The clogging of the air filter is entered by dirt.
4. There is a leak in the turbine casing.

From several factors mentioned, one of the possible causes of problems is dirt on the turbine side blades. Engine exhaust gases containing dirt can cause soot to stick to the turbine, which ultimately reduces turbocharger revs.

Dirty exhaust gases due to incomplete combustion. Poor combustion can occur due to low fuel quality or suboptimal engine conditions. On the other hand, a good burn is influenced by various interconnected factors.

Based on the explanation above, the author is interested in raising a topic related to the trigger of obstacles in the turbocharger that can have an impact on the performance of the main engine, with the title of the research: "Analysis of the Effect of Declining Turbocharger Performance on the Engine Power on the MT Chem Star Ship".

2. METHOD

This research was carried out by applying a quantitative approach., starting with observation of the research object and recording of supporting data during marine practice. Next, the object is analyzed and described in detail. The data obtained aims to provide information that can help in designing solutions to problems related to this thesis material. JASP 0.19.3.0 is used to perform validity tests, normality tests, Pearson correlations, and paired sample ttests.

This research was carried out on the MT CHEM STAR ship from January 14, 2024 to January 17, 2025, The Data collection in the preparation of the working paper is carried out using various methods that are in accordance with the research objectives :

1. Field *Research*

This method is carried out by collecting data and information directly from the research object through various approaches that are considered appropriate.the Battle of the

a. The observation method was carried out by directly observing the lubrication system on the auxiliary engine during the author's sea practice on the ship.

b. The interview method was carried out by conducting a direct question and answer session, especially with officers on duty in the ship's engine room.

2. Documentary techniques

Documentation techniques are data collection methods that are carried out by classifying and categorizing written materials that are relevant to the research topic, such as documents, books, newspapers, magazines, and others. This technique involves collecting and examining the required data/information through important documents. This means that documentation techniques are a way to obtain data by collecting the files/archives needed in research.

3. RESULTS AND DISCUSSION

This study found that a significant decrease in oil pressure occurred when the engine RPM dropped from 1200 to 996, which led to a decrease in oil pressure by 0.10 MPa. The increase in oil temperature from 70°C to 92°C also resulted in a decrease in oil viscosity by up to 29%. The blockage in the oil filter reduces the oil flow from 0.165 m/s to 0.057 m/s, which contributes to a decrease in the efficiency of the lubrication system.

Table 3. 1 Table of Normal Conditions

BEFORE PERFORMANCE DEGRADATION								
Time (Hours)	Rotation (rpm)	Press an Boost (Bar)	Tempe Exhaust Gas (°C)	Tempe ruture Scaving (°C)	Tempe rature machine room (°C)	Turboca harg rotation (rpm)	Output (kW)	Ket
12:00-16:00	180	1.29	435	47	48.0	16.350	3.323	Normal
16:00-20:00	180	1.28	437	47	48.5	16.300	3.305	Normal
20:00-24:00	180	1.26	439	48	49.0	16.250	3.285	Normal

00:00-04:00	180	1.25	440	48	49.5	16.200	3.262	Normal
04:00-08:00	180	1.21	442	49	50.0	16.100	3.230	Normal
08:00-12:00	180	1.20	443	49	50.5	16.000	3.198	Normal

Source: MT CHEM STAR (2024)

Information: In table 3.1 presented above, there is data that shows that the condition of the cooling machine on February 16, 2024 or 2 days before the incident was still in a normal state for 6 data collection times in 24 hours.

Table 3. 2 Table of Decline Conditions

AFTER A DROP IN PERFORMANCE								
Time (Hours)	Rotation (rpm)	Press an Boost (Bar)	Tempe Exhaust Gas (°C)	Tempe ruture Scaving (°C)	Tempe rature machine room (°C)	Turboca harg rotation (rpm)	Output (kW)	Ket
12:00-16:00	180	1.10	445	49	50	15.930	3.168	Normal
16:00-20:00	180	1.09	446	49	50.5	15.880	3.150	A little down
20:00-24:00	180	1.07	447	50	51	15.830	3.132	The decline continues
00:00-04:00	180	1.05	448	50	51.5	15.780	3.115	Indications of decreased performance
04:00-08:00	180	1.01	449	51	52	15.730	3.097	Significant decline
08:00-12:00	180	1.00	450	52	53	15.680	3.080	Low performance, further evaluation

Source: MT CHEM STAR (2024)

Information: In table 3.2 presented above, there is data that shows that the condition of the refrigeration machine on February 17, 2024 or 1 day before the incident has decreased from 04-08 to 16-20 and the first alarm occurred at 20-00.

Table 3. 3 Table of Decline Conditions

AFTER HANDLING								
Time (Hours)	Rotation (rpm)	Press an Boost (Bar)	Tempe Exhaust Gas (°C)	Tempe ruture Scaving (°C)	Tempe rature machine room (°C)	Turboca harg rotation (rpm)	Output (kW)	Ket
12:00-16:00	180	1.16	445	50	51.0	15.950	3.160	Normal
16:00-20:00	180	1.18	444	50	50.5	16.000	3.180	Normal
20:00-24:00	180	1.20	443	49	50.0	16.050	3.200	Normal
00:00-04:00	180	1.22	442	49	49.5	16.100	3.220	Normal
04:00-08:00	180	1.24	441	48	49.0	16.150	3.240	Normal
08:00-12:00	180	1.25	440	48	48.5	16.200	3.260	Normal

Source: MT CHEM STAR (2024)

Information: In table 3.3 presented above, there is data showing that the condition of the machine after handling for 6 data collection times in 24 hours.

Table 3. 4 Test Validity Data Before Performance Degradation

Pearson's Correlations							
Variable		Output (kW) Before drop	Pressure Boost Before Drop (bar)	Exhaust Gas Pressure Before Drop (kPa)	Temp Intercooler Before drop (. C)	Engine Room Temp Before Descent (. C)	Turbo RPM Before descent
1. Output (kW) Before drop	Pearson's r	—					
	p-value	—					
2. Pressure Boost Before drop (bar)	Pearson's r	0.988	—				
	p-value	<.001	—				
3. Exhaust Gas Pressure Before Drop (kPa)	Pearson's r	-0.978	0.988	—			
	p-value	<.001	<.001	—			
4. Temp Intercooler Before drop(. C)	Pearson's r	-0.951	-0.978	0.965	—		
	p-value	0.004	<.001	0.002	—		
5. Machine Room Temp	Pearson's r	-0.992	-0.951	0.994	0.956	—	

Variable		Output	Pressure Boost	Exhaust Gas Pressure	Temp Intercooler	Temp of the Machine Room	Turbo RPM
Before lowering (. C)							
	p-value	<.001	0.004	<.001	0.003	—	
6. Turbo RPM Before drop	Pearson's r	0.998	-0.992	-0.968	-0.943	-0.984	—
	p-value	<.001	<.001	0.002	0.005	<.001	—

Source: JASP VERSION 0.19.3.0

Conclusion:

Positive Correlations: Output (kW) is strongly positively correlated with Boost Pressure and Turbo RPM, as well as Exhaust Gas Pressure and engine room temperature also show a positive relationship.

Negative Correlations: The output (kW) shows a negative correlation with the Intercooler Temp and the Engine Room Temp, indicating that this increase in temperature reduces the output power of the engine. Exhaust Gas Pressure and intercooler temperature also show a negative relationship with Turbo RPM.

All correlations had very small p-values (especially < 0.001), indicating that the results were statistically significant and that the relationships found between the variables were not accidental.

Table 3. 5 Test the validity of the data after performance degradation

Pearson's Correlations

Variable		Output (kW) After drop	Pressure Boost After Drop (bar)	Exhaust Gas Pressure After Drop(kPa)	Temp Intercooler After Drop (. C)	Temp of the Machine Room After the descent (. C)	Turbo RPM After Drop
1. Output (kW) After drop	Pearson's r	—					
	p-value	—					
2. Pressure Boost After Drop (bar)	Pearson's r	0.983	—				
	p-value	<.001	—				
3. Exhaust Gas Pressure After Drop(kPa)	Pearson's r	-1.000	-0.983	—			
	p-value	<.001	<.001	—			
4. Temp Intercooler After drop (. C)	Pearson's r	-0.959	-0.966	0.960	—		

		p-value		0.002		0.002		0.002		—					
5. Machine Room Temp After descent (. C)		Pearson's r		-0.989		-0.971		0.990		0.977		—			
		p-value		<.001		0.001		<.001		<.001		—			
6. Turbo RPM After Drop		Pearson's r		1.000		0.983		-1.000		-0.960		-0.990		—	
		p-value		<.001		<.001		<.001		0.002		<.001		—	

Source: JASP 0.19.3.0

General Conclusion:

Positive Correlations:

Output (kW) is positively related to Boost Pressure and Turbo RPM.

Exhaust Gas Pressure is positively related to the Engine Room Temp and Intercooler Temp.

The Temp Intercooler is positively related to the Temp of the Engine Room.

Negative Correlations:

Output (kW) is negatively related to Exhaust Gas Pressure, Intercooler Temp, and Engine Room Temp.

Boost pressure is negatively related to Turbo RPM. Exhaust Gas Pressure is negatively related to Turbo RPM. The Intercooler Temp is negatively related to the Turbo RPM.

Engine Room Temp is negatively related to Turbo RPM.

4. CONCLUSION

The study showed a significant decrease in boost pressure, intercooler temperature, engine room temperature, turbocharger RPM, and engine power output after a turbocharger performance impairment ($p < 0.001$). A very strong positive correlation was found between power output with boost pressure ($r = 0.988$) and turbocharger RPM ($r = 0.998$), while a very strong negative correlation was observed between power output with exhaust gas pressure ($r = -0.978$), intercooler temperature ($r = - 0.951$), and engine room temperature ($r = -0.992$). The main causes of the decline in turbocharger performance are dirty air filters on the blowers as well as carbon buildup on the turbine blades that inhibit the flow of exhaust gases and reduce the turbocharger's working efficiency.

Based on the conclusions that have been submitted, the author proposes several suggestions that are expected to be learning and consideration for readers. Here are the suggestions given:

1. The Importance of Preventive Maintenance with a Data Approach
   It is recommended that maintenance of the Turbocharge system be carried out regularly based on engine operational data. Data-driven monitoring systems can provide more accurate information about engine conditions and allow for more effective preventive maintenance to prevent a drop in lubricating oil pressure.
2. Use of low sulphur or LPG fuel
   To reduce air pollution and keep engine performance stable and burn more perfectly.

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