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Thermal Analysis of Discharge Valve Overheating in the Make-Up Side of Compressor 200-C-1-A/B

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Abstract: Reciprocating compressors are essential in the oil and gas industry for their ability to deliver high-pressure gas and maintain process stability under varying loads. At PT Kilang Pertamina Internasional Refinery Unit II Dumai, the 200-C-1-A/B reciprocating compressor plays a vital role in regulating vessel pressure in Unit 200 Area HSC by supplying compressed mixed gas. During operational monitoring, an increase in discharge temperature was observed, nearing the alarm threshold and raising concerns regarding equipment performance and operational safety. This study analyzes field data including operational parameters, cooling system performance, lubrication status, and gas composition to identify the factors contributing to the temperature rise. The discharge temperature is also evaluated using an isentropic adiabatic compression approach, incorporating the specific heat ratio of the gas mixture to validate thermodynamic behavior. The analysis indicates reduced cooling effectiveness and possible degradation of system components, which are closely linked to maintenance intervals and procedures. These insights emphasize the critical role of routine maintenance supported by data-driven evaluations to sustain compressor reliability and prevent performance deterioration in refinery operations.

Keywords: Reciprocating Compressor, Discharge Temperature, Isentropic Compression, Specific Heat Ratio, Maintenance Strategy.

I. INTRODUCTION

A compressor is a mechanical device used to increase the pressure of a gas by reducing its volume, thereby facilitating its transport through piping systems in industrial applications[1]. Among various types of compressors, the reciprocating compressor remains widely employed in the oil and gas industry due to its ability to achieve high compression ratios, operate reliably under fluctuating conditions, and efficiently compress mixed gas compositions [2], [3]. This type of compressor operates by means of a piston’s reciprocating motion within a cylinder to compress gas in stages before discharging it at elevated pressure.

PT Kilang Pertamina Internasional Refinery Unit II Dumai (PT KPI RU-II Dumai) is a major refining facility under the Refining & Petrochemical Subholding of PT Pertamina (Persero), responsible for processing crude oil into vital energy products such as fuel, liquefied petroleum gas (LPG), and petrochemical feedstocks [4]. The refinery relies heavily on the stable operation of critical mechanical systems, including reciprocating compressors, which are essential for maintaining gas flow and process pressure stability[5].

One of the key units supporting these operations is the 200-C-1-A/B reciprocating compressor, operating within the Unit 200 Area HSC. This compressor is tasked with supplying compressed mixed gas to maintain the required vessel pressure, thus playing a pivotal role in sustaining process continuity. During routine operational monitoring, a gradual but consistent rise in the compressor's discharge temperature was detected, approaching the alarm threshold defined in the plant’s safety standards. If left unaddressed, this anomaly could compromise efficiency, accelerate mechanical wear, and increase the risk of unplanned downtime or safety incidents.

To evaluate the thermodynamic performance of a compressor, the concept of isentropic compression is often used as a reference. Isentropic compression is an idealized thermodynamic process in which the gas is compressed adiabatically (without heat exchange with the surroundings) and reversibly (without entropy change). In such a process, all the energy supplied to the gas is used solely to increase its pressure and temperature, without any loss due to heat transfer or friction[6]. Although real compressors are subject to

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inefficiencies and heat losses, the isentropic model serves as a benchmark to assess deviation from ideal behavior and to estimate efficiency losses. Applying this model enables engineers to evaluate the theoretical discharge temperature based on inlet conditions, compression ratio, and the specific heat ratio of the gas mixture[7].

This study focuses on identifying the underlying causes of the elevated discharge temperature by evaluating the performance of the 200-C-1-A/B compressor over a defined operational period. The analysis is based on historical field data and supplemented by component inspections, particularly of internal elements suspected to influence thermal behavior, such as valves and piston assemblies. In addition, the observed temperature trends are assessed using an isentropic adiabatic compression model, allowing for a thermodynamic validation of the results. The findings are expected to support the development of targeted technical recommendations to restore optimal compressor performance and enhance maintenance planning in similar industrial environments.

II. RESEARCH METHODOLOGY

The methods used for data collection to determine the causes of temperature increase in compressors 200-C-1 A and 200-C-1 B at PT Kilang Pertamina Internasional, Refinery Unit II Dumai are as follows:

1) Observation

This data collection technique was conducted through direct observation of the centrifugal compressors 200-C-1 A/B in operation within the utility or process unit at Refinery Unit II Dumai.

2) Literature Study

This method involved studying general and specific operational procedures within the Maintenance Planning & Support division, particularly in the Rotating Equipment Inspection Engineering section. It also included gathering and analyzing theoretical references related to centrifugal compressors, especially the 200-C-1 A/B models.

3) Interviews and Discussions

Discussions were conducted through interviews with supervisors and several staff members from the Rotating Equipment Inspection Engineering department at PT Kilang Pertamina Internasional Refinery Unit II Dumai.

2.1 Primary Data

1) Actual Operational Data of Centrifugal Compressors 200-C-1 A/B

Actual operational data for centrifugal compressor 200-C-1 A/B at PT Kilang Pertamina Internasional RU-II Dumai were obtained through a performance test conducted on 5 February 2025 until 11 February 2025. The results indicated a significant increase in discharge temperature, approaching the alarm threshold. The alarm limit had been set at 130°C, and the recorded discharge temperature during the test was found to be close to this critical value. This condition suggests the presence of abnormal operating behavior, which may indicate potential mechanical or thermal issues within the compressor system.

Table 1: Actual Data Compressor 200-C-1-A/B

Date	Pressure Suction (Pa)	Pressure Discharge (Pa)	Suction Temperature (°C)	Discharge Temperature (°C)
Design	22.56	53	38	113
5 Feb 2025	22.56	53	42	127
6 Feb 2025	22.56	53	42	126
7 Feb 2025	22.56	53	42	126
10Feb 2025	22.56	53	41	125
11 Feb 2025	22.56	53	41	125

2) Mixed Gas Composition Data

Mixed gas composition data at the time of initial design and current data are shown in the following table.

Table 2: Mixed Gas Composition Data

Komponen	MCp	Mol Fraksi (*y*)					
		Desain	05 Feb	06 Feb	07 Feb	10 Feb	11 Feb
Hydrogen	6,91	0,8419	0,92	0,91	0,8998	0,9062	0,9019
Nitrogen	6,96	0	0	0	0	0	0
Air	6,96	0	0	0	0	0	0
Carbon Dioxide	9	0	0	0	0	0	0
Methane	8,65	0,045	0,03	0,035	0,0415	0,0349	0,0374
Ethylene	10,72	0	0	0	0	0	0
Ethane	12,95	0,0466	0,02	0,025	0,0248	0,0239	0,0256
Propylene	15,75	0	0	0	0	0	0
Propane	18,17	0,0311	0,02	0,02	0,0209	0,0209	0,0208
Butene	21,61	0	0	0	0	0	0
Iso Butane	23,95	0,0115	0,01	0,01	0,006	0,0061	0,006
n Butane	24,08	0,0092	0	0	0,0042	0,0045	0,0044
Iso Pentane	29,42	0,0035	0	0	0,0019	0,0021	0,0022
n-Pentane	29,71	0,0012	0	0	0,0006	0,0008	0,0008
n-Hexane	35,37	0,01	0	0	0,0003	0,0006	0,0009
Heptane plus	41,07	0	0	0	0	0	0
Water	8,03	0	0	0	0	0	0
Hydrogen Sulfide	8,18	0	0	0	0	0	0
Hydrogen Chloride	0	0	0	0	0	0	0

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2.2 Troubleshooting Procedure

To analyze the factors contributing to the increase in discharge temperature of compressor 200-C-1 A/B, a preliminary literature review was conducted to identify conditions and mechanisms that can lead to elevated discharge temperatures in centrifugal compressors. This review served as a theoretical basis for further investigation. The analysis was supported by the use of a fishbone diagram (Ishikawa diagram) to systematically identify and classify potential contributing factors, including those related to equipment, operational procedures, environmental conditions, and instrumentation.

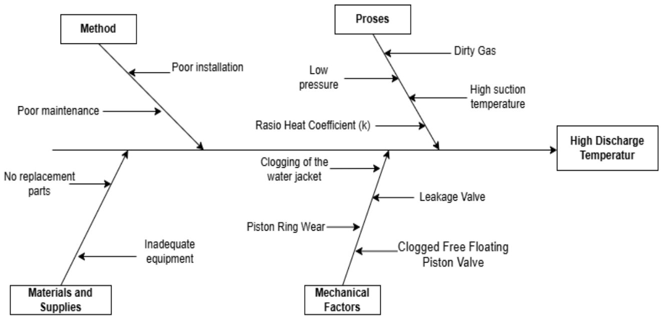

Figure 1: Fishbone Diagram High Discharge Temperature Reciprocating Compressor

A mathematical analysis was also carried out based on isothermal and adiabatic compression models. The parameters calculated to estimate the discharge temperature of compressor 200-C-1 A/B included the compression ratio, temperature suction, gas constant, and specific heat ratio[8]. These calculations provided a theoretical comparison to the actual operating data obtained from the compressor.

1) Specific heat of gas at constant pressure (C_p)

Specific heat of gas at constant pressure is the specific heat of gas when the process takes place at constant pressure.

$$M_{Cp\ total} = yMcp_{gas\,1} + yMcp_{gas\,2} + \cdots yMcp_{gas\,-n}$$

2) Panas spesifik gas pada volume konstan (C_V)

Specific heat of gas at constant volume is the specific heat of gas when the process takes place at constant volume.

$$M_{Cv\ total} = M_{Cp\ total} - \frac{Ro}{778} = M_{Cp\ total} - 1.986$$

3) Specific Heat Ratio

Ideal gas has a specific heat ratio of 1.4, while for gas mixtures consisting of several different types of gases the following Equation 2.3 is used.

$$R = \left(\frac{P_d}{P_s}\right)^{\frac{1}{n}}$$

4) Temperature Discharge Adiabatic Isentropic

Adiabatic discharge temperature is the temperature resulting from isentropic (adiabatic) compression that occurs in reciprocating compressors.

$$T_d = T_s\left(\frac{P_d}{P_s}\right)^{\frac{k-1}{k}}$$

III. RESULTS AND DISCUSSIONS

3.1 Process Factors

One of the factors that influence the increase in discharge temperature in reciprocating compressors is process factors. This factor relates to the conditions that occur during the compression process, such as gas composition, pressure, and temperature. This process factor is closely related to adiabatic temperature changes in the 200-C-1-A/B compressor.

1) Comparison of specific heat ratio values

Table 3: Comparison of initial design specific heat ratio values with current data

Date	Mcp_{total}	Mcv_{total}	k
Design	8.3646	6.3786	1.311352
05 Feb 2025	7.4786	5.4926	1.361577
06 Feb 2025	7.5175	5.5315	1.359034
07 Feb 2025	7.6066	5.6206	1.353338
10 Feb 2025	7.6142	5.6282	1.352865
11 Feb 2025	7.6350	5.6490	1.351562
Average	7.5703	5.5843	1.355675

Table 3 presents a comparison between the initial design values and the current measured data for the specific heat ratio (k-value). It can be observed that the current k-value has increased compared to the original design specification. This change is primarily influenced by variations in the total specific heat at constant pressure (MCp) and at constant volume (MCv), which are directly affected by changes in the composition of the inlet gas. The altered gas composition modifies the

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thermodynamic properties of the working fluid, resulting in a higher specific heat ratio under current operating conditions.

2) Comparison of Temperature Discharge Adiabatic Isentropic

Table 4: Comparison of Temperature Discharge Adiabatic Isentropic

Date	Pressure Suction (Pa)	Pressure Discharge (Pa)	Temperature Suction (°C)	k	Temperature Discharge(°C)
Design	22,56	53	38	1,31	108,90
05 Feb	22,56	53	42	1,36	123,31
06 Feb	22,56	53	42	1,36	122,84
07 Feb	22,56	53	42	1,35	121,78
10 Feb	22,56	53	41	1,35	120,44
11 Feb	22,56	53	41	1,35	120,20

Table 4 presents the calculated discharge temperatures based on the adiabatic-isentropic compression model. The results show a noticeable increase in discharge temperature in the current operating data compared to the original design conditions. This increase is primarily influenced by changes in suction temperature and the specific heat ratio (k-value). In contrast, suction pressure and discharge pressure remain constant between the design and current data, and therefore do not contribute to the observed temperature variation in this case.

3.2 Mechanical Factors

Inspection of components of the 200-C-1-A/B compressor is carried out to find out which components cause an increase in discharge temperature in the 200-C-1-A/B compressor.

1) Piston Ring Wear

Piston ring wear can cause compressed gas recirculation, so that compressed gas with a certain hot temperature becomes even hotter because the gas that should come out on the discharge side is compressed again. This can result in an increase in temperature on the suction and discharge sides of the compressor. In the 200-C-1-A/B compressor, the piston ring wear is obtained as shown in the figure below.

Figure 2: Piston Ring Wear

2) Leakage at Suction and Discharge Valve

Valve leakage in compressors is a condition where gas that should enter or exit the cylinder leaks due to the valve that does not open and close perfectly. Leaks in the suction valve cause the gas that should enter the cylinder to leak back into the suction line. Meanwhile, a leak in the discharge valve causes the compressed gas to leak back into the compression chamber, which has the potential to increase the compressor discharge temperature. One of the main causes of valve leakage is tapered seat wear, which is the part that functions as a contact profile on the valve. If the tapered seat experiences wear, the gap in the valve will widen. The leaked gas will be recompressed in the cylinder and cause an increase in temperature on the discharge side.

Figure 3: Leakage Discharge Valve

3) Clogged Free Floating Piston Valve

Foreign material that escapes the strainer, can enter the free floating piston valve which has the potential to cause the free floating piston valve to experience clogging so that it cannot function. This results in a decrease in the position of the piston rod or rod drop. The piston rod drop will result in piston ring wear, especially at the bottom. As a result, the lower piston ring experiences wear and tear and over time it breaks and has an impact on the occurrence of recirculation of compressed gas and an increase in discharge temperature valve.

4) Clogging on the Water Jacket

Water jacket works by circulating cooling water around the compressor cylinder wall to absorb the heat generated during the compression process. However, under certain conditions, there can be clogging in the cooling channel due to the accumulation of dirt, scale, or sediment from the cooling water used. This

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blockage causes the flow of cooling water to be disrupted, resulting in a suboptimal heat release process. As a result, the compressor temperature increases, which can lead to an increase in discharge temperature.

Figure 4: Clogging on the Water Jacket

3.3 Solution

After analyzing the cause of the increase in discharge temperature, a solution can be analyzed to overcome the problem. The solutions used in the problem of temperature rise discharge compressor are:

1) Restore the process gas composition to that of the original design, to reduce the specific heat ratio (k) of the mixed gas if possible.
2) Cleaning the strainer on the suction line to avoid foreign material (solid waste) as an effort to avoid clogging the free floating piston valve.
3) Replace suction and discharge valves to avoid leakage valve problems.
4) Replace worn piston rings to prevent gas recirculation back from discharge to suction, which can cause the suction temperature to increase.
5) Replace the FFP (Free Floating Piston) valve every major overhaul, which is every five years to avoid clogging of the FFP valve.
6) Clean the water jacket to prevent blockage of the cooling channel.
7) Perform good and planned maintenance, through the application of Preventive Maintenance and Predictive Maintenance such as once every six months consistently, disciplined, and in accordance with established standards. The maintenance schedule for Compressor 200-C-1-A/B can be seen in the attachment.

IV. CONCLUSION

Based on the investigation of the discharge temperature increase in Compressor 200-C-1-A/B, it can be concluded that the anomaly was primarily caused by two major factors: process-related conditions and mechanical degradation. The process-related factors include elevated suction temperature and variations in gas composition, both of which influence the specific heat ratio (k), thereby increasing the discharge temperature. Meanwhile, the mechanical factors involve wear of the piston rings, damage to the discharge valve, clogging in the water jacket that impedes cooling efficiency, and obstruction in the free-floating piston passage. To address these issues, a combination of corrective and preventive measures is recommended. These include restoring the gas composition and suction temperature to optimal levels where feasible, and replacing worn or damaged components such as piston rings, discharge valves, and any blocked sections of the water jacket and free-floating piston ports. In addition, the implementation of routine and disciplined maintenance procedures is essential to ensure sustained compressor performance and reliability.

REFERENCES

[1] Syawaluddin and M. Yusuf, “Perencanaan Kompresor Piston Pada Tekanan Kerja Max 2 N/mm^2,” ___, vol. _, no. _, pp. 18–29, 2011.

[2] Y. Ding *et al.*, “Lifespan prediction of the piston ring set of oil-free reciprocating compressors coupled with pressure distribution variation,” *Eng. Fail. Anal.*, vol. 171, no. January, p. 109317, 2025, doi: 10.1016/j.engfailanal.2025.109317.

[3] X. Li, A. Diao, Y. Guo, X. Jia, C. Zhang, and X. Peng, “Quantitative diagnosis of loose piston rod threads in reciprocating compressors for hydrogen storage and transport,” *Int. J. Hydrogen Energy*, vol. 48, no. 94, pp. 37013–37030, 2023, doi: https://doi.org/10.1016/j.ijhydene.2023.06.032.

[4] M. Dzakkiy, N. Ahmad, and T. S. Soegiarto, “ANALISA EFISIENSI KERJA SCREW COMPRESSOR MM 45 DI UNIT,” vol. 4, no. November, pp. 412–419, 2024.

[5] M. Y. I. Pasau and M. Hetharia, “ANALISIS DAYA PADA KOMPRESOR RECIPROCATING 3K-O1-B TPYE P 116H 280csh DI PERTAMINA UNIT VI KASIM,” *J. Voering*, vol. 7, no. 2, pp. 61–68, 2022.

[6] J. Schmitt and R. Langebach, “High-pressure liquid refrigerant injection for reciprocating compressors,” *Int. J. Refrig.*, vol. 164, no. April, pp. 29–37, 2024, doi:

Volume 2, Issue 5, pp 1-6, May 2025
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Available Online at https://www.cjesr.com

10.1016/j.ijrefrig.2024.04.017.

[7] E. Navarro, E. Granryd, J. F. Urchueguía, and J. M. Corberán, “A phenomenological model for analyzing reciprocating compressors,” *Int. J. Refrig.*, vol. 30, no. 7, pp. 1254–1265, 2007, doi: https://doi.org/10.1016/j.ijrefrig.2007.02.006.

[8] P. C. Hanlon, *Compressor Handbook*. 2001. doi: 10.1201/9781003151517.

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