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Evaluation of Caterpillar C15 Diesel Engine Performance in Petroleum Applications Before and After Reconditioning Using Dynotest Testing

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Abstract
This research aims to analyze the performance improvement of the Caterpillar C15 diesel engine based on dynotest data before and after the reconditioning process in petroleum applications. In field practice, low power conditions often become an issue that directly impacts unit productivity. The test results show that before the reconditioning, the engine could only produce a maximum power of 357 HP with a BMEP of 165.3 psi. After reconditioning, the performance significantly improved with power reaching 524 HP, an increase of approximately 46.8%. Additionally, the torque increased to 1313 lb·ft and the boost pressure reached 28 psi, followed by an increase in BMEP to 213.5 psi. This improvement indicates that the combustion process has become more efficient due to enhancements in the air and fuel supply systems. The performance curve shows a pattern that remains stable but shifts to a higher level, indicating an increase in efficiency without changing the basic characteristics of the engine. Thus, the reconditioning has proven effective in restoring engine performance and enhancing operational efficiency in petroleum applications.
Keywords: *caterpillar C15 engine, low power, dynotest engine, BMEP, engine performance*

Abstrak
Penelitian ini bertujuan untuk menganalisis peningkatan performa engine diesel Caterpillar C15 berdasarkan data dynotest sebelum dan sesudah proses rekondisi pada aplikasi petroleum. Dalam praktik lapangan, kondisi *low power* sering menjadi permasalahan yang berdampak langsung terhadap produktivitas unit. Hasil pengujian menunjukkan bahwa sebelum rekondisi, engine hanya mampu menghasilkan daya maksimum sebesar 357 HP dengan BMEP sebesar 165.3 psi. Setelah dilakukan rekondisi, performa meningkat secara signifikan dengan daya mencapai 524 HP atau meningkat sekitar 46.8%. Selain itu, torque meningkat menjadi 1313 lb·ft dan boost pressure mencapai 28 psi, yang diikuti oleh peningkatan BMEP menjadi 213.5 psi. Peningkatan ini menunjukkan bahwa proses pembakaran menjadi lebih efisien akibat perbaikan pada sistem suplai udara dan bahan bakar. Kurva performa menunjukkan pola yang tetap stabil namun mengalami pergeseran ke arah yang lebih tinggi, yang mengindikasikan peningkatan efisiensi tanpa perubahan karakteristik dasar mesin. Rekondisi terbukti efektif dalam mengembalikan performa engine serta meningkatkan efisiensi operasional pada aplikasi petroleum.
Kata kunci: *caterpillar C15 engine, low power, dynotest engine, BMEP, performa engine*

1. Introduction

Diesel engines serve as the primary power units in a wide range of heavy industrial operations, particularly within the petroleum industry, where continuous operation, high power output, and long-term dependability are essential requirements. Under these demanding operational environments, engines are expected to sustain high-load performance over prolonged periods without experiencing substantial declines in efficiency or reliability. Consequently, engine performance condition becomes a critical aspect that directly influences productivity levels, operational effectiveness, and maintenance expenditures.

As operating hours and loading cycles continue to accumulate, diesel engines commonly experience gradual performance deterioration. This condition is generally reflected through several symptoms, including reduced power output, declining torque, and slower engine response during loading conditions. Such degradation is typically associated with decreased combustion efficiency caused by disturbances within the air intake system, fuel delivery system, or internal mechanical components of the engine. When these issues are not identified and corrected at an early stage, they may result in higher fuel consumption, lower operational efficiency, and the risk of severe damage to engine components.

One of the most widely applied methods for conducting a comprehensive engine performance evaluation is testing using an engine dynamometer (dynotest). This testing procedure enables direct measurement of major performance indicators, including power, torque, boost pressure, fuel pressure, and engine load characteristics under varying operating conditions. Data obtained from the dynotest provides a factual representation of the engine's capability to generate mechanical power and respond to increasing operational loads.

In diesel engine performance analysis, Brake Mean Effective Pressure (BMEP) is recognized as an important parameter used to indicate combustion efficiency. BMEP describes the average effective pressure acting on the piston throughout one complete working cycle and has a direct relationship with the engine's capability to transform combustion energy into useful mechanical work. A relatively low BMEP value under high-load operating conditions generally suggests that the combustion process is not occurring optimally, despite the engine still maintaining relatively stable basic operating characteristics.

The case examined in this research involves low-power conditions identified in the Caterpillar C15 engine utilized in petroleum industry applications, based on dynotest results obtained prior to the reconditioning process. Heavy-duty diesel engines such as the Caterpillar C15 function as the primary driving units in petroleum operations, where high reliability and optimum performance are essential to maintain production continuity [1]. Engine performance degradation resulting from prolonged operating hours is an unavoidable condition, commonly characterized by decreasing output power, increasing Brake Specific Fuel Consumption (BSFC), and declining thermal efficiency [2].

According to [3], reduced engine performance in heavy industrial equipment may decrease Overall Equipment Effectiveness (OEE) by approximately 15–25%, directly affecting productivity and operational expenses. In petroleum sector applications, the Caterpillar C15 diesel engine frequently experiences performance deterioration after extended service periods, including power losses ranging from 15–20% and torque reduction from 2,200 Nm to 1,800 Nm due to wear in the piston assembly and turbocharger components. Furthermore, fuel efficiency may decline by up to 12% after 8,000 operating hours, accompanied by a 25% increase in NOx emissions exceeding the EPA Tier 4 standard. To address these conditions, a repair or reconditioning process is performed with the objective of restoring engine performance to a condition approaching its optimal state. Reconditioning, commonly referred to as engine overhaul, represents a maintenance strategy intended to recover engine performance to a near-original or as-new condition. This approach emphasizes the importance of comprehensive condition monitoring both before and after the overhaul process to verify the effectiveness of the repair activities conducted.

The performance assessment in this study is carried out by comparing the primary engine parameters before and after reconditioning using data obtained from the dynotest. Dynamometer testing (dyno test) has been internationally recognized as a standard quantitative method for evaluating engine performance parameters [4]. Through comparative analysis of parameters such as power, torque, boost pressure, and BMEP, this study is expected to provide a comprehensive understanding regarding the effectiveness of the reconditioning process in improving combustion efficiency and overall engine performance, particularly in petroleum industry applications that require high operational performance and stability.

2. Material and Methods

Type and Approach of the Research

This study applies a quantitative descriptive method combined with an experimental case study approach. The selection of this method is based on the objective of the research, which emphasizes the analysis of engine performance using testing data collected before and after the reconditioning process. The case study approach was implemented to enable a comprehensive examination of a single engine unit that experienced low-power conditions. Through this approach, changes in engine performance could be directly identified and evaluated using measurable technical parameters. The testing procedures were carried out using a dynotest in accordance with established standard protocols to evaluate the power curve, smoke opacity, transient response, vibration characteristics, and thermal imaging results. These testing methods provide approximately 95% accuracy in fault detection and are considered effective for validating reconditioning processes in offshore petroleum industry applications [5].

Research Object

The object examined in this study is a single unit of the Caterpillar C15 diesel engine operating in petroleum industry applications. The engine specifications used in this research are presented as follows:

C15 Engine Specifications	
Cylinders and Arrangement	In-line six cylinder
Bore	137.2 mm (5.4 inch)
Stroke	171.5 mm (6.8 inch)
Displacement	15.2 L (928 in^3)
Firing Order	1-5-3-6-2-4
Rotation (flywheel end)	Counterclockwise

Fig. 1: Specification and C15 Engine Model
Source: Caterpillar Service Information System (2026)

Table 1. Detailed information and testing method

Product Identification			
Engine model:	Caterpillar C15	Testing system:	Engine dynotest
Serial number:	JDY00568	Testing condition:	Before and after repair
Fuel type:	Diesel	Application:	Petroleum

The engine was tested under loaded operating conditions using a dynotest system to obtain accurate and controlled performance data across various loading levels.

Parameters Analyzed

The engine performance parameters evaluated in this research consist of the following variables:

Table 2. Parameter Analyzed

Engine performance parameters	Description
Engine Power (HP)	This parameter represents the engine's capability to generate output power at different loading conditions.
Torque (lb·ft)	Torque describes the engine's ability to produce rotational force in response to applied loads.
Boost Pressure (psi)	This parameter is utilized to assess the performance of the air intake system, particularly the effectiveness of the turbocharger during engine operation.
Fuel Pressure (psi)	Fuel pressure indicates the stability and consistency of the fuel supply system throughout the testing process.
Brake Mean Effective Pressure (BMEP)	BMEP is used as the primary indicator for evaluating combustion efficiency and the average effective pressure generated within the engine cylinder.

These parameters were selected because they have a direct relationship with the operational performance and efficiency of heavy-duty diesel engines.

Testing Procedure

Engine performance testing was conducted using an engine dynamometer based on the standard procedures recommended by [4] and [6], with testing parameters referring to those described in Section Parameters Analyzed. The tests were carried out under full-load operating conditions with engine speed variations ranging from idle speed to rated speed, following the recommendations presented in [7] to obtain a comprehensive characterization of engine performance. The engine performance evaluation using the engine dynotest was conducted through the following stages:


Fig. 2: Engine Dynotest

Testing Before Reconditioning

The engine was tested under several loading conditions, including:

a. Low idle
b. High idle
c. 25% load
d. 50% load
e. 75% load
f. 100% load

At each loading stage, engine performance data were recorded, including engine speed, power output, torque, boost pressure, fuel pressure, and engine oil pressure.

Repair/Reconditioning Process

Following the initial testing phase, the engine underwent a repair or reconditioning process based on the results of the performance evaluation and the identified technical condition of the engine components.

Testing After Reconditioning

After the reconditioning process was completed, the dynotest was performed again using the same procedures and loading conditions applied during the pre-reconditioning test. This approach was intended to ensure that the test results could be compared objectively and consistently.

BMEP Calculation Method

The Brake Mean Effective Pressure (BMEP) value was calculated to evaluate the combustion efficiency of the engine during operation. The calculation of BMEP was carried out using the following equation:

$$\boldsymbol{BMEP} = \frac{150.8 \times T}{V_d} \tag{1}$$

Where:

$\boldsymbol{BMEP}$ = Brake Mean Effective Pressure (psi)
T = Torque (lb·ft)
V_d = Engine displacement (in^3)

The Caterpillar C15 engine has a displacement volume of 928 in^3, which was used as a constant parameter in all BMEP calculations across every loading condition.

Data Analysis Techniques

The collected data were analyzed using a comparative analysis method by comparing engine performance results before and after the reconditioning process under identical loading conditions. The analysis procedure included the following stages:

a. Comparing the maximum values and performance trends of each analyzed parameter.
b. Examining the relationship between boost pressure, torque, and BMEP in relation to engine output power.
c. Identifying changes in combustion efficiency based on the increase in BMEP values obtained after the reconditioning process.

The results of the analysis are presented in the form of tables and graphs to simplify the visualization of performance differences and to support a clearer interpretation of the research findings.

3. Results and Discussion

Table 3. Spec sheet factory data of C15 engine petroleum application

Test Element	Eng Updates	Test Value	Test Spec Value	Measure
Spec Number		0K8942	0K8942	
Arrangement Number		3730061	3730061	
Corr Fl Power		521	540	HP
Speed		2,100	2,100	RPM
COR FL FUEL RATE		27.3	27.5	GAL/HR
CSFC		0.371	0.359	LB/HP-HR
Adj Boost		48.6	48.0	IN HG
Fuel Pressure		104	101	PSI
Oil Pressure		63	63	PSI
TQ COR FUEL RATE		22.8	22.5	GAL/HR
TQ CK CSFC		0.338	0.327	LB/HP-HR
TQ CK ADJ BST		48.0	46.2	IN HG
Torq Ck Speed		1,400	1,400	RPM
TQ CK COR TQ		1,790	1,819	LB.FT
Low Idle Speed		602	600	RPM
Low Idle Oil Pressure		21	21	PSI
High Idle Speed		2,309	2,310	RPM
FL Static Fuel Setting			0.335	IN
FT Static Fuel Setting			0.33	IN
Full Load Setting(FLS) Intercept	-26	-23	-21	
Full Torque Setting(FTS) Slope	44	29	22	

Source: Caterpillar TMI Web (2026)

Table 4. Testing data of the C15 engine petroleum applications before the repair/recondition.

Load (%)	Engine Speed (RPM)	Power (HP)	Torsi (Lb-Ft)	Engine Oil Pressure (Psi)	Boost Pressure (Psi)	Fuel Pressure (Psi)	BMEP (Psi)
Low Idle	700	2	12	56	0	61	2
High Idle	2300	10	25	72	3	68	4.1
25%	2299	92	220	69	7.1	65	36.3
50%	2205	191	463	65	12	70	76.3
75%	2169	275	698	63	16.5	68	115.1
100%	1847	357	1017	61	22.6	70	165.3

Table 5. Testing data of the C15 engine petroleum applications after the repair/recondition

Load (%)	Engine Speed (RPM)	Power (HP)	Torsi (Lb-Ft)	Engine Oil Pressure (Psi)	Boost Pressure (Psi)	Fuel Pressure (Psi)	BMEP (Psi)
Low Idle	700	2	12	69	0	72	2
High Idle	2310	13	29	84	3	91	4.8
25%	2313	130	293	77	12.8	90	48.3
50%	2223	267	634	67	21.6	86	104.5
75%	2182	414	998	63	26	86	164.4
100%	2101	524	1313	61	28	85	213.5

Analysis Before Repair or Reconditioning

Based on the collected testing data, the engine condition prior to the reconditioning process indicated a considerable decline in overall performance. This condition can be identified from several major parameters, including output power, torque, boost pressure, and Brake Mean Effective Pressure (BMEP). Under full-load conditions (100%), the engine only produced 357 HP of output power, with a torque value of 1017 lb·ft, boost pressure of 22.6 psi, and a BMEP value of 165.3 psi. These values are categorized as relatively low when compared to the normal performance characteristics of heavy-duty diesel engines used in petroleum applications, which generally operate with BMEP values exceeding 200 psi at maximum load conditions.

From a theoretical perspective, BMEP represents the average effective pressure acting on the piston throughout the combustion cycle. A low BMEP value indicates that the combustion energy generated inside the cylinder is not being converted efficiently into mechanical work. Several factors may contribute to this condition, including:

a. Reduced efficiency of the combustion system.
b. Imbalance between the air and fuel supply systems.
c. Suboptimal performance of the turbocharger system.

Furthermore, the trend of BMEP increase along with the rise in engine load still exhibited a relatively linear pattern, although at a lower performance level. This condition suggests that the engine was still capable of operating in a stable manner; however, it was unable to achieve the expected maximum performance output.

Analysis After Repair or Reconditioning

Following the reconditioning process, substantial improvements were observed in all engine performance parameters. Under full-load conditions (100%), the engine output power increased to 524 HP, while torque improved to 1313 lb·ft. In addition, boost pressure increased to 28 psi, and the BMEP value rose significantly to 213.5 psi. The improvement in brake power and brake torque measured during the post-reconditioning dynamometer test supports the findings presented in [8], which state that restoring the effective compression ratio through cylinder kit replacement contributes significantly to engine performance recovery.

The reduction in Brake Specific Fuel Consumption (BSFC) after reconditioning is also consistent with the findings reported in [9], which identified a fuel consumption reduction of approximately 8–12% in Caterpillar engines after the overhaul process. Moreover, the increase in boost pressure indicates that the air induction system, particularly the turbocharger, had returned to its optimum operating condition.

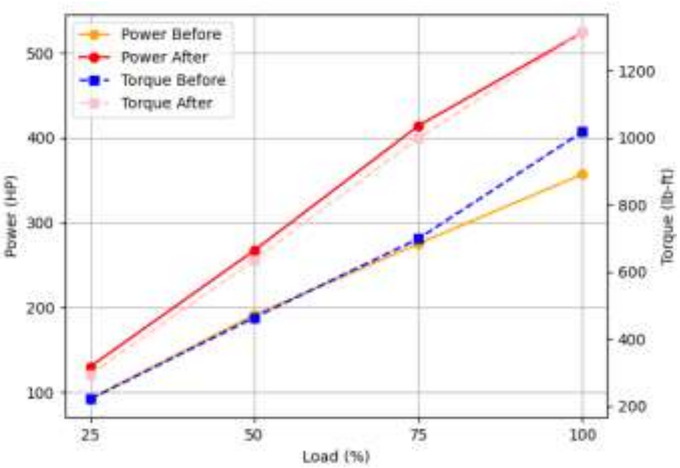

Fig. 3: Power and Torque Characteristics under Various Load Conditions.

The increase in air supply entering the combustion chamber resulted in a more complete combustion process, thereby producing greater energy output. The improvement in thermal efficiency achieved after reconditioning indicates enhanced combustion quality, which according to [10] is closely associated with the optimal performance of the fuel injection system and the integrity of the combustion chamber components. Improved combustion efficiency also contributes positively to emission reduction, although emission analysis was not the primary focus of this study [11].

Furthermore, the substantial increase in torque demonstrates the engine's improved capability to generate mechanical work. This condition is reinforced by the rise in BMEP values, indicating that the average effective pressure generated inside the cylinder became significantly higher after the reconditioning process.

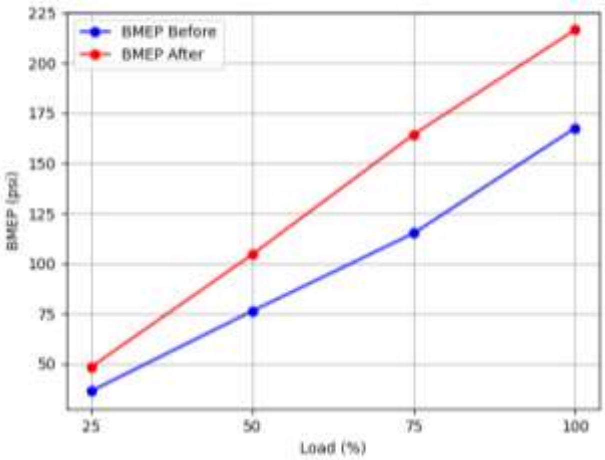

Fig. 4: Comparison of BMEP Values Before and After Reconditioning.

Overall, the increase in BMEP from 165.3 psi to 213.5 psi demonstrates a significant improvement in combustion efficiency and energy conversion effectiveness. These results indicate that the engine performance has returned to the normal operating range commonly required for petroleum industry applications. **Table 6** shows comparison of engine performance before and after.

Table 6. Comparison of Engine Performance Before and After Repair/Reconditioning

Parameter	Before	After	Unit	Description
Boost	22.6	28	Psi	Increased
Torque	1017	1313	Lb.ft	Increased significantly
BMEP	165.3	213.5	Psi	More efficient
Power Output	357	524	HP	Increased

4. Conclusion

Based on the analysis of engine performance data obtained before and after the repair/reconditioning process in petroleum industry applications, it can be concluded that the reconditioning procedure provided a significantly positive effect on overall engine performance improvement. The enhancement was consistently observed across all major performance parameters, including power output, torque, boost pressure, and Brake Mean Effective Pressure (BMEP). Under full-load operating conditions (100%), engine power increased from 357 HP to 524 HP, representing an improvement of approximately 47%. In addition, torque increased from 1017 lb·ft to 1313 lb·ft, while the BMEP value rose from 165.3 psi to 213.5 psi. The boost pressure also improved from 22.6 psi to 28 psi, indicating better performance of the air supply and turbocharging system.

The improvement in these parameters demonstrates that the combustion process inside the cylinder became more efficient after the reconditioning process. This condition is reflected by the increase in BMEP values, which directly contributed to the enhancement of engine power output. The evaluation results indicate that the reconditioning of the Caterpillar C15 diesel engine was effective in restoring engine performance to a condition approaching the manufacturer's specifications, which is consistent with the findings reported in previous studies [9].

Apart from the increase in maximum performance values, the analysis also revealed that the relationship between engine load and performance parameters remained linear and stable throughout the testing process. This finding indicates that the fundamental operating characteristics of the engine were maintained, while the overall operational efficiency improved significantly. In petroleum industry applications, where engines are required to operate continuously under high-load and long-duration conditions, improvements in performance stability and operational reliability are highly important. Therefore, it can be concluded that the reconditioning process not only successfully restored engine performance but also improved the engine's operational efficiency and reliability.

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