

AIP Conference Proceedings

Journal Development Team

Director, Publishing Development: [Bridget D'Amelio](#)

Manager, Conference Proceedings: [Emily Prendergast](#)

Editorial Assistant, Conference Proceedings: [Francesca Tangreti](#)

For journal related inquiries, please contact: confproc@aip.org


Issues

Select Decade

Select Year

Issue

PRELIMINARY


Preface: The 3rd International Conference on Engineering and Applied Science (The 3rd INCEAS 2021) 

AIP Conf. Proc. 2578, 010001 (2022) <https://doi.org/10.1063/12.0012161>

[View article](#)

 [PDF](#)

CHEMICAL ENGINEERING

The effect of volume ratio of methanol and temperature on yields and properties of biodiesel from callophylum inophylum oil 


[Haryanto Haryanto](#); [Raja Rajeswary Suppiah](#); [Ade Rohman](#); [Abdul Haris Mulyadi](#)

AIP Conf. Proc. 2578, 020001 (2022) <https://doi.org/10.1063/5.0106494>

[Abstract](#) 

[View article](#)

 [PDF](#)

Production and decolorization of lignin from industrial waste of pulp and paper based on the coagulation method using poly aluminium chloride 

[Calaelma Logys Imalia](#); [Bambang Pramudono](#); [Slamet Priyanto](#); [Rosemerry Fatmawati](#); [Maureen Yudith Tiurma](#)

AIP Conf. Proc. 2578, 020002 (2022) <https://doi.org/10.1063/5.0111314>

[Abstract](#) ▾[View article](#)[PDF](#)

The effects of feedstock on the bioconversion of organic solid waste with black soldier fly larvae 🛒

[Ika Pruwita](#); [Agus Prasetya](#); [Chandra Wahyu Purnomo](#)

AIP Conf. Proc. 2578, 020003 (2022) <https://doi.org/10.1063/5.0106648>

[Abstract](#) ▾[View article](#)[PDF](#)

Theobromine content of non fermented cacao powder with steam roasting related with health 🛒

[Melia Ariyanti](#); [Rosniati Rosniati](#); [Medan Yumas](#); [Wahyuni Wahyuni](#); [Dwi Indriana](#)

AIP Conf. Proc. 2578, 020004 (2022) <https://doi.org/10.1063/5.0106566>

[Abstract](#) ▾[View article](#)[PDF](#)

Sodium lignosulfonate flocculation kinetic study on Kawengan crude oil emulsion destabilization 🛒

[Nicola Ardana S. G.](#); [Sandi Estrada](#); [Bambang Pramudono](#); [Slamet Priyanto](#); [Harsa Pawigya](#)

AIP Conf. Proc. 2578, 020005 (2022) <https://doi.org/10.1063/5.0106862>

[Abstract](#) ▾[View article](#)[PDF](#)

CIVIL ENGINEERING

The California bearing ratio and unconfined compressive strength of clay–palm kernel shell mixtures 🛒

[Yulian Firmana Arifin](#); [Muhammad Ridha](#)

AIP Conf. Proc. 2578, 030001 (2022) <https://doi.org/10.1063/5.0107315>

[Abstract](#) ▾[View article](#)[PDF](#)

Pull out strength and slip modulus of glued-in rod perpendicular to the grain with two edge distance variations on laminated bamboo 🗑

[Synthia Jayanthi](#); [Karyadi Karyadi](#); [Nindyawati Nindyawati](#)

AIP Conf. Proc. 2578, 030002 (2022) <https://doi.org/10.1063/5.0106353>

[Abstract](#) ▾

[View article](#)

[PDF](#)

Experimental study on the strength development and setting time of wet-mix shotcrete with alkali-free accelerator 🗑

[M. Afif Shulhan](#); [Galing Probo Iswoyo](#); [Iskandar Yasin](#); [Zainul Faizien Haza](#)

AIP Conf. Proc. 2578, 030003 (2022) <https://doi.org/10.1063/5.0106248>

[Abstract](#) ▾

[View article](#)

[PDF](#)

Evaluation of the requirement for road support facilities to promote road safety 🗑

[Juanita Juanita](#); [Afiya Nurul Kharisma](#)

AIP Conf. Proc. 2578, 030004 (2022) <https://doi.org/10.1063/5.0107388>

[Abstract](#) ▾

[View article](#)

[PDF](#)

Sustainable reservoir management by bypass channel (Soedirman reservoir case study) 🗑

[Iskahar Iskahar](#); [Suripin Suripin](#); [Isdiyana Isdiyana](#)

AIP Conf. Proc. 2578, 030005 (2022) <https://doi.org/10.1063/5.0107774>

[Abstract](#) ▾

[View article](#)

[PDF](#)

Basic properties of fiber concrete with the utilization of banana tree wastes 🗑

[Besty Afriandini](#); [Cremona Ayu Novita Sari](#); [Fadillawaty Saleh](#); [Hakas Prayuda](#); [Fanny Monika](#); [Berkat Cipta Zega](#); [Martyana Dwi Cahyati](#)

AIP Conf. Proc. 2578, 030006 (2022) <https://doi.org/10.1063/5.0109881>

[Abstract](#) ▾

[View article](#)

[PDF](#)

ELECTRICAL ENGINEERING

Comparison of efficiency power plant method in generation expansion planning 🛒

[Amrisal Kamal Fajri](#); [Sarjiya Sarjiya](#); [Lesnanto Putra Multanto](#)

AIP Conf. Proc. 2578, 040001 (2022) <https://doi.org/10.1063/5.0106958>

[Abstract](#) ▾

[View article](#)

[PDF](#)

Conductivity tensor in rectangular quantum wire for the case of electrons-optical phonon scattering 🛒

[Hoang Van Ngoc](#)

AIP Conf. Proc. 2578, 040002 (2022) <https://doi.org/10.1063/5.0106463>

[Abstract](#) ▾

[View article](#)

[PDF](#)

Hydrothermal synthesis and dielectric analysis of transition metal (Ni) doped p-type SnO nanocrystals 🛒

[Viswanath G. Akkili](#); [R. Thangavel](#); [Viranjay M. Srivastava](#)

AIP Conf. Proc. 2578, 040003 (2022) <https://doi.org/10.1063/5.0106178>

[Abstract](#) ▾

[View article](#)

[PDF](#)

Data communication performance of multi-node wifi and LoRa by testing range and packet delivery 🛒

[Dian Nova Kusuma Hardani](#); [Latiful Hayat](#)

AIP Conf. Proc. 2578, 040004 (2022) <https://doi.org/10.1063/5.0106352>

[Abstract](#) ▾

[View article](#)

[PDF](#)

IoT based electrical energy monitoring system 🛒

[Itmi Hidayat Kurniawan](#); [Latiful Hayat](#); [Danang Karunia Pratama](#)

AIP Conf. Proc. 2578, 040005 (2022) <https://doi.org/10.1063/5.0107194>

[Abstract](#) ▾[View article](#)[PDF](#)

3D simulation analysis of p-channel cylindrical thin film transistors (CTFT) for RF electronic applications

[Viswanath G. Akkili](#); [Viranjay M. Srivastava](#)

AIP Conf. Proc. 2578, 040006 (2022) <https://doi.org/10.1063/5.0106180>

[Abstract](#) ▾[View article](#)[PDF](#)

Design and development prototype of measurement oxygen saturation in blood (SpO₂) as early detection happy hypoxia in Covid-19 patients

[M. T. Tamam](#); [A. J. Taufiq](#); [A. Kusumawati](#)

AIP Conf. Proc. 2578, 040007 (2022) <https://doi.org/10.1063/5.0106962>

[Abstract](#) ▾[View article](#)[PDF](#)

Single phase on grid solar power inverter design

[Bandiyah Sri Aprillia](#); [Ridho Alfayet Umar](#); [Kharisma Bani Adam](#)

AIP Conf. Proc. 2578, 040008 (2022) <https://doi.org/10.1063/5.0107797>

[Abstract](#) ▾[View article](#)[PDF](#)

Design of automatic energy flow shift control system in standalone solar power system

[Bandiyah Sri Aprillia](#); [Fauzan Miftah Mauludy](#); [Kharisma Bani Adam](#)

AIP Conf. Proc. 2578, 040009 (2022) <https://doi.org/10.1063/5.0112452>

[Abstract](#) ▾[View article](#)[PDF](#)

Maintenance of 60 MVA power transformers in Pauh Limo Padang substation

[Ridwan Ridwan](#); [Jeheskiel Putra Kowaas](#); [Djubir Edy Kembuan](#)

AIP Conf. Proc. 2578, 040010 (2022) <https://doi.org/10.1063/5.0111721>

[Abstract](#) ▾[View article](#)[PDF](#)

INDUSTRIAL ENGINEERING

System modeling analysis in utility system to increase flow and minimize head loss in a manufacturing plant 🛒

[Muhamad Ali Pahmi](#); [Wilarso Wilarso](#)

AIP Conf. Proc. 2578, 050001 (2022) <https://doi.org/10.1063/5.0116776>

[Abstract](#) ▾

[View article](#)

[PDF](#)

Proposing IoT and big data implementation model for business performance 🛒

[Jonny Jonny](#); [Kriswanto](#); [Matsumura Toshio](#)

AIP Conf. Proc. 2578, 050002 (2022) <https://doi.org/10.1063/5.0106211>

[Abstract](#) ▾

[View article](#)

[PDF](#)

Designing sustainable supply chain risk monitoring in distribution and return process using fuzzy AHP-Promethee 🛒

[Fahmi Aulia Rachman](#); [Ari Yanuar Ridwan](#); [Nia Novitasari](#); [Rosad Ma'ali El Hadi](#)

AIP Conf. Proc. 2578, 050003 (2022) <https://doi.org/10.1063/5.0106249>

[Abstract](#) ▾

[View article](#)

[PDF](#)

Workload analysis of manual epoxy packing line process using NIOSH lifting index method 🛒

[Miftahul Imtihan](#); [Suwaryo Nugroho](#); [Kristanto Mulyono](#); [Annisa Nurul Islami](#)

AIP Conf. Proc. 2578, 050004 (2022) <https://doi.org/10.1063/5.0107801>

[Abstract](#) ▾

[View article](#)

[PDF](#)

INFORMATICS

Genetic algorithm optimization for image classification of coconut wood-based on GLCM 🛒

[Finki Dona Marleny](#); [Nurhaeni](#); [Bayu Nugraha](#)

AIP Conf. Proc. 2578, 060001 (2022) <https://doi.org/10.1063/5.0107332>

[Abstract](#) ▾

[View article](#)

[PDF](#)

Fake news detection: An image-based semi-automated method using statistic feature 🛒

[Erick Alfons Lisangan](#); [Astrid Lestari Tungadi](#); [Feri Wibowo](#)

AIP Conf. Proc. 2578, 060002 (2022) <https://doi.org/10.1063/5.0106217>

[Abstract](#) ▾

[View article](#)

[PDF](#)

Comparison of random forest algorithm, support vector machine and neural network for classification of student satisfaction towards higher education services 🛒

[Didi Supriyadi](#); [Purwanto Purwanto](#); [Budi Warsito](#)

AIP Conf. Proc. 2578, 060003 (2022) <https://doi.org/10.1063/5.0106201>

[Abstract](#) ▾

[View article](#)

[PDF](#)

User interface/user experience revamp and usability investigation of Indonesian pharmaceutical mobile commerce app 🛒

[Sandra Dewi Buntoro](#); [Clara Hetty Primasari](#); [Yohanes Priadi Wibisono](#); [Putri Nastiti](#)

AIP Conf. Proc. 2578, 060004 (2022) <https://doi.org/10.1063/5.0106480>

[Abstract](#) ▾

[View article](#)

[PDF](#)

Strategic planning of an Indonesian IT company using TOGAF ADM

[Ardi Wibowo](#); [Yohanes Priadi Wibisono](#); [Clara Hetty Primasari](#); [Putri Nasiti](#); [Aloysius Bagas Pradipta Irianto](#)

AIP Conf. Proc. 2578, 060005 (2022) <https://doi.org/10.1063/5.0106486>

[Abstract](#) [View article](#)[PDF](#) 

The suitable distance function for fuzzy C-Means clustering

[Joko Eliyanto](#); [Sugiyarto Surono](#)

AIP Conf. Proc. 2578, 060006 (2022) <https://doi.org/10.1063/5.0106185>

[Abstract](#) [View article](#)[PDF](#) 

Improvement recommendation for functionality, usability, and efficiency aspect in credit surveyor application using ISO 9126

[Limia Kristiani](#); [Clara Hetty Primasari](#); [Aloysius Bagas Pradipta Irianto](#)

AIP Conf. Proc. 2578, 060007 (2022) <https://doi.org/10.1063/5.0106408>

[Abstract](#) [View article](#)[PDF](#) 

A decision support system based on support vector machine for employee recruitment

[Fitriana Masrurroh](#); [Bayu Surarso](#); [Budi Warsito](#)

AIP Conf. Proc. 2578, 060008 (2022) <https://doi.org/10.1063/5.0109462>

[Abstract](#) [View article](#)[PDF](#) 

Implementation of smartcity in the field of personnel, mobile attendance case study

[Dimara Kusuma Hakim](#)

AIP Conf. Proc. 2578, 060009 (2022) <https://doi.org/10.1063/5.0111893>

[Abstract](#) [View article](#)[PDF](#) 

Logarithmic transformation for enhancing keypoint matching of SIFT in augmented reality 🛒

[Elindra Ambar Pambudi](#); [Achmad Fauzan](#); [Abid Yanuar B.](#); [Sigit Sugiyanto](#)

AIP Conf. Proc. 2578, 060010 (2022) <https://doi.org/10.1063/5.0106221>

[Abstract](#) ▾[View article](#)[PDF](#)

K-Means cluster optimization for potentiality student grouping using elbow method 🛒

[Muhammad Hamka](#); [Ngatik Ramdhoni](#)

AIP Conf. Proc. 2578, 060011 (2022) <https://doi.org/10.1063/5.0108926>

[Abstract](#) ▾[View article](#)[PDF](#)

Selection of the most accurate training algorithm in the backpropagation network based on the accuracy of data pattern matching 🛒

[Hidayati Mustafidah](#); [Uji Bagus Pambudi](#); [Suwarsito Suwarsito](#)

AIP Conf. Proc. 2578, 060012 (2022) <https://doi.org/10.1063/5.0111243>

[Abstract](#) ▾[View article](#)[PDF](#)

Implementation of the canny edge detection algorithm on mobile cameras 🛒

[Tito Pinandita](#); [Oki Tri Rasdianto](#); [Sigit Sugiyanto](#)

AIP Conf. Proc. 2578, 060013 (2022) <https://doi.org/10.1063/5.0119148>

[Abstract](#) ▾[View article](#)[PDF](#)

MECHANICAL ENGINEERING

The pressure relief venting for air insulation cable box at power transformer 🛒

[Asep Saepudin](#); [Asep Dharmanto](#); [Wilarso Wilarso](#)

AIP Conf. Proc. 2578, 070001 (2022) <https://doi.org/10.1063/5.0116405>

[Abstract](#) [View article](#)[PDF](#) 

Design & development of friction welding machine based on lathe machine

[Ade Sunardi](#); [Mariyana Mariyana](#); [Adhes Gamayel](#); [M. N. Mohammed](#); [Mohamad Zaenudin](#)

AIP Conf. Proc. 2578, 070002 (2022) <https://doi.org/10.1063/5.0106341>

[Abstract](#) [View article](#)[PDF](#) 

2D finite element study of contact pressure on CoCrMo-on-CoCrMo total hip arthroplasty during peak loading based on body mass index

[Muhammad Imam Ammarullah](#); [Ilham Yustar Afif](#); [Mohamad Izzur Maula](#); [Tri Indah Winarni](#); [Mohammad Tauviquirrahman](#); [Akbar Teguh Prakoso](#); [Hasan Basri](#); [J. Jamari](#)

AIP Conf. Proc. 2578, 070003 (2022) <https://doi.org/10.1063/5.0106320>

[Abstract](#) [View article](#)[PDF](#) 

Analysis of engine piston damage to the generator set using the fishbone analysis method

[Wilarso Wilarso](#); [Firmansyah Azharul](#); [M. Ali Pahmi](#); [Dan Mugisidi](#); [Kholqillah Ardhian Ilman](#)

AIP Conf. Proc. 2578, 070004 (2022) <https://doi.org/10.1063/5.0116742>

[Abstract](#) [View article](#)[PDF](#) 

Vortex-Induced vibration of triangular bluff body to piezoelectric energy harvester in laminar flow

[Adhes Gamayel](#); [Fajar Mulyana](#); [Brainvendra Widi Dionova](#)

AIP Conf. Proc. 2578, 070005 (2022) <https://doi.org/10.1063/5.0106260>

[Abstract](#) [View article](#)[PDF](#) 

Analysis of engine piston damage to the generator set using the fishbone analysis method

Cite as: AIP Conference Proceedings **2578**, 070004 (2022); <https://doi.org/10.1063/5.0116742>
Published Online: 03 November 2022

Wilarso Wilarso, Firmansyah Azharul, M. Ali Pahmi, et al.



View Online



Export Citation

ARTICLES YOU MAY BE INTERESTED IN

[K-Means cluster optimization for potentiality student grouping using elbow method](#)
AIP Conference Proceedings **2578**, 060011 (2022); <https://doi.org/10.1063/5.0108926>

[Implementation of the canny edge detection algorithm on mobile cameras](#)
AIP Conference Proceedings **2578**, 060013 (2022); <https://doi.org/10.1063/5.0119148>

[The pressure relief venting for air insulation cable box at power transformer](#)
AIP Conference Proceedings **2578**, 070001 (2022); <https://doi.org/10.1063/5.0116405>

Trailblazers. ^{New}

Meet the Lock-in Amplifiers that measure microwaves.

Zurich Instruments [Find out more](#)

Analysis of Engine Piston Damage to the Generator Set Using the Fishbone Analysis Method

Wilarso Wilarso^{1,a)}, Firmansyah Azharul^{1,b)}, M Ali Pahmi^{2,c)}, Dan Mugisidi^{3,d)},
Kholqillah Ardhian Ilman^{4,e)}

¹ Department Mechanical Engineering, Sekolah Tinggi Teknologi Muhammadiyah Cileungsi, Bogor, Jawa Barat-Indonesia 16820

² Department Industrial Engineering, Sekolah Tinggi Teknologi Muhammadiyah Cileungsi, Bogor, Jawa Barat-Indonesia 16820

³ Department Mechanical Engineering, Universitas Muhammadiyah Prof. DR. HAMKA, Indonesia

⁴ Department Mechanical Engineering, Universitas Muhammadiyah Surakarta-Indonesia

a) Corresponding author: wilarso@sttmcileungsi.ac.id

b) Firmansyah.azharul@gmail.com

c) ali_pahmi@yahoo.co.id

d) dan.mugisidi@uhamka.ac.id

e) kai252@ums.ac.id

Abstract. The generator set unit operating at PLTD Leung Bata-Aceh suffered damage to the piston component, which initially indicated thick white smoke coming out of the breather. The purpose of this study was to determine the root cause of piston damage. The method in this study using fishbone analysis. Based on the research results, the damage to the piston top was caused by the imperfect angle of the injector, so that the injector spray widened on the outer side of the piston crown top, causing the piston surface to be damaged on the edge. Corrective steps so that the same incident does not occur again, the injectors must be tested before use, they must be tested, to determine the performance of the injectors used.

INTRODUCTION

Diesel engine generator set operating at PLTD Leung Bata-Aceh for the back operation of the Diesel Power Plant within the PLN (State Power Plant) environment. Generator set capacity of 1825 kVA, with an operating power of 1000 kW or 1 MW per unit. This diesel engine generator set uses diesel fuel supplied by PLN for the operational needs of the plant. Each generator that operates is adjusted to the power needs of PLN. While operating the generator, it is necessary to carry out routine maintenance starting from changing the oil, oil filter, fuel filter, and cleaning the air filter.

Monitoring of operating units is carried out by an operator on duty manually, starting from recording exhaust gas temperature, engine oil pressure, coolant temperature, recording kWh, to recording fuel consumption. If there is a change in generator set parameters, the operator on duty always provides information to the leader operator to take action to stop the unit. However, when monitoring one of the operating units there is an indication of an abnormality in the use of engine oil. To avoid fatality damage to the generator set unit, the operator is in charge of extra monitoring.

When the generator set unit operating at the PLTD was damaged, it started from thick white smoke from the engine breathing pipe (breather), where the white smoke coming out of the breather was quite thick and white. Under these conditions, the operator on duty immediately stops the operation of the working unit. After checking the

maintenance data on the unit that had added oil, as well as finding that the breather smoke was quite thick and under the attached list, where the addition of oil from September 13, 2013, to September 19, 2013, the addition of oil tended to increase, according to table 1.

TABLE 1. History unit

Scope of Work	SMU (Service Meter Unit)	Description
PM500	2,542	Preventive Maintenance
Add oil	2,784	Add oil 40 liter
Add oil	2,830	Add oil 30 liter
Add oil	2,881	Add oil 30 liter
Add oil	2,904	Add oli 60 Liter
Operation Abnormal	2,922	Engine blowby

From the data on the addition of oil, it is known that the engine indicates damage to the combustion process, wherein the combustion process piston moves from TMB to TDC and vice versa, to compress air for the combustion process.

The piston which is an important part of the engine functions to form the combustion chamber with the cylinder liner and cylinder head, withstand the explosion pressure when the gas burns, and works outward through the connecting rod and crankshaft [1] . To carry out its function, the piston ring functions as an insulator so that compression does not go down to the oil pan and oil does not enter and burn in the combustion chamber.

In the process of repairing the cylinder head and injectors # 5 and # 12 due to damage to the walls of the combustion chamber where the maximum temperature appears on the edge of the combustion chamber [2] and become one of the parts that are often damaged [3,4] . Damage to piston components in diesel engines caused by failure of adjustment bolts [5] .

In Figure 1, the liner wall flows scratches caused by friction with the piston that is damaged. Scratches that occur cause the liner not to be used again and the damage to the liner is the result, not the cause. Figure 1 scratch on the inner liner was found during a fault investigation component.

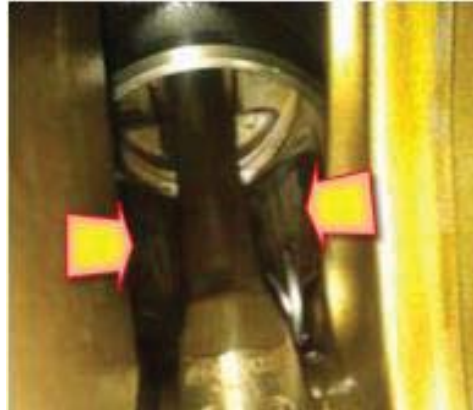


FIGURE 1. Fuel leakage from the liner and piston.

Whereas Figure 2 shows the piston debris attached to the liner wall, discovered during a fault investigation of the generator set. The piston material attached to the liner wall is caused by the piston working at high temperatures. The piston moves in the process of experiencing stress, temperature, pressure which often occurs due to thermal and mechanical fatigue [6]. Figure 2 piston material debris was found during the investigation.

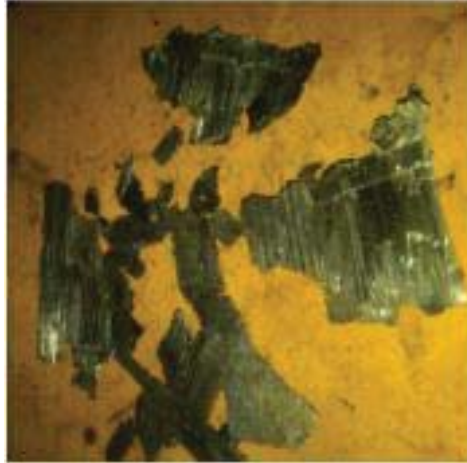


FIGURE 2. Flakes of piston material.

To find the cause of the damage to the cylinder liner and then take precautions, this study aims to identify the cause of the cylinder wall damage by using the “fishbone” diagram introduced by Ishikawa [7]. The purpose of this study was to determine the root cause of the top crown piston damage.

METHOD

This study using the fishbone analysis method to determine the root cause of piston damage. As for the research process, this piston damage begins with primary data and secondary data to collect the data needed in the study. Then identify the damage that occurred, as well as pre-analysis of the components. Then, the analysis is finalized to determine the solution in the research being carried out.

Collecting data on the history of maintenance that has been carried out, then problem identification on the initial findings of blowbys up to the findings of component damage. Pre-analysis of the possibilities that occur to determine the cause. While the analysis using fishbones categorizes the potential problems that occur. The conclusions in this study are in accordance with the predetermined objectives.

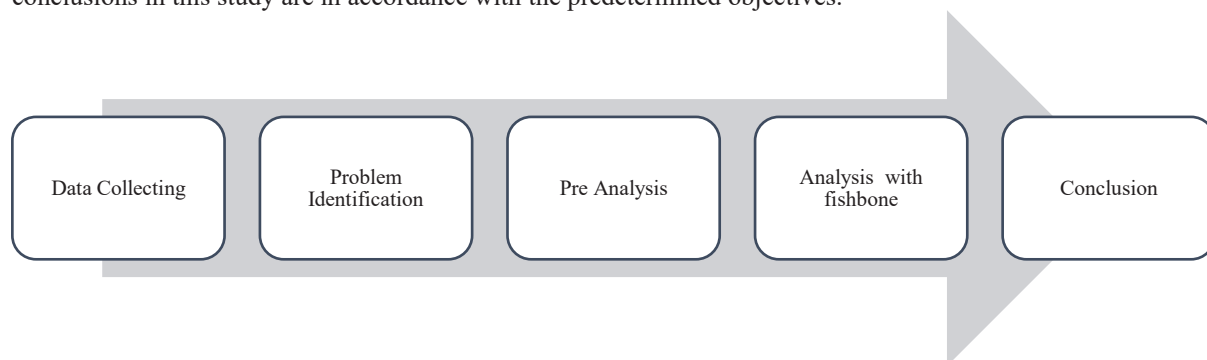


FIGURE 3. Research flow

RESULT AND DISCUSSION

The shape of the piston crown top is irregular because the angle of spraying the injector is not normal [8], this is known to be the shape of the corrugated piston crown top. When the piston material melts it closes the ring groove causing the piston ring to stack and contact with the liner [9].

Damage to piston skirt #12 experienced the same as piston # 5. Self-explanatory on the top crown the piston spray injector is abnormal. If this is left for a long time then the condition of the #12 piston will have a shape similar to that of cylinder #5 [5].



FIGURE 4. Top melting piston crown on cylinder # 12.

In Figure 5, it is explained that the high scratches piston wall where the piston works at high temperature so that the piston wall is melting and the town crown piston is indicated as a black discoloration on the side that gets the spray from the injector (right photo), ash on the town crown piston is caused by the abnormal angle at the injector [10] . Changes in the thermal expansion coefficient for the alloy in the raw state and after heat treatment and the piston made of the new composite material before the motor test and after this test [11] . As for the piston components that are used using aluminum, it is adjusted to the diesel engine serial number from the manufacturer.



FIGURE 5. Spray injector on piston-cylinder #5

Heavy scratches on the liner walls due to the tow crown piston melting and closing the piston ring seat so that it contacts with the liner (scuffing). Measurement of the secondary motion of each piston was carried out to analyze piston friction, and the following findings were obtained. Cast iron pistons exhibit limited lubrication at die center over-compression (TDC). This is probably due to the larger piston tilt angle due to the greater piston clearance. Steel pistons exhibit hydrodynamic lubrication conditions at TDC and BDC through each cycle, due to good oil supply [12] .

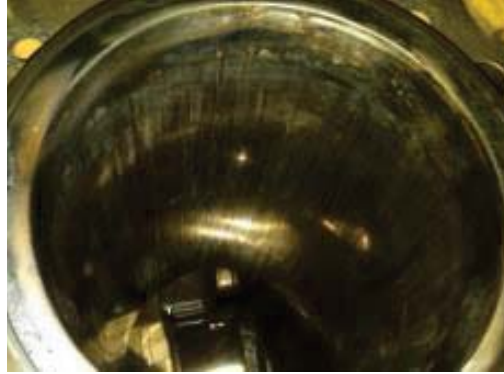


FIGURE 6. Wall liners high scratches

3.1 Fishbone analysis

The analysis was carried out using fishbone analysis where in this study there were 4 categories in determining the root cause of piston damage (Top piston crown).

A. Man.

At the time of installing the injector, the technician failed to install it, and the tip of the injector collided with the engine component. Then it was wrongly installed, where this condition was caused by the knowledge of the technician who did not understand the injector installation process.

B. Material

Angle spray injector is damaged due to the design of the manufacturer because it does not match the engine type or product failure.

C. Machine

Piston damage caused by high operating load or overload is not identified for piston damage, then the damage caused by fuel containing biodiesel is not indicated. Meanwhile, the error in using the injector is not indicated [7]. The delay in the execution of the engine overhaul will affect the performance of engine components. In determining the unit's overhaul work there is no maintenance strategy, so the overhaul work is based on the unit's condition.

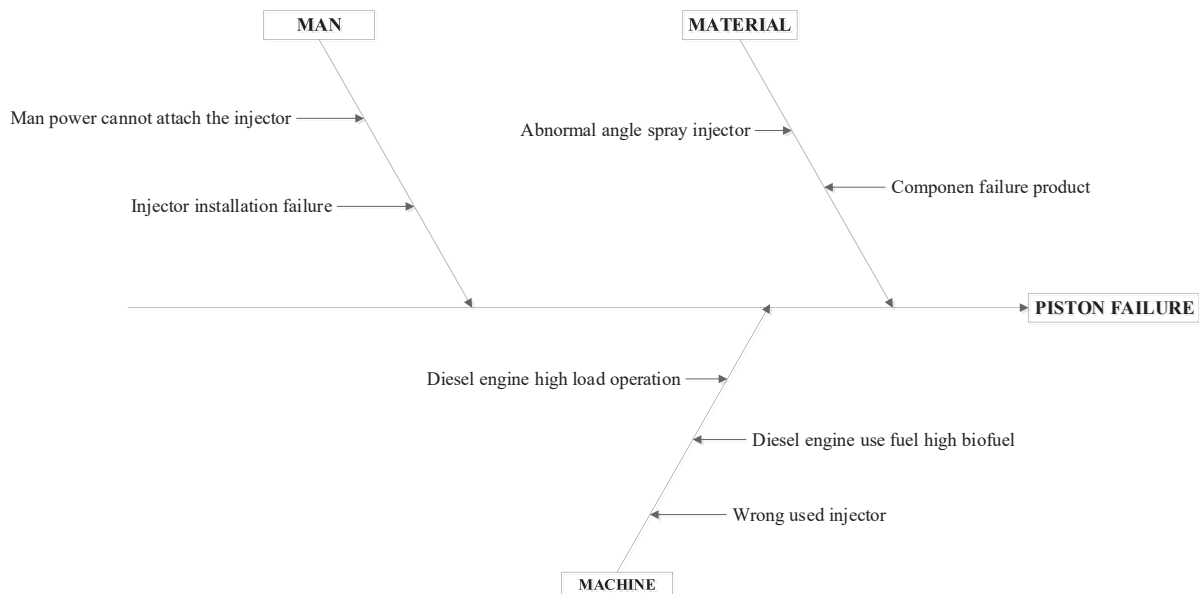


FIGURE 7. Fishbone analysis

CONCLUSION

Trending in addition to 150 liters of engine oil starting high school: 2,784-2,922, during the unit operating 138 hours, at the hour meter 2,922 a blowby occurred in the operating unit, where the damage was caused by damage to the piston components. Based on the fishbone analysis, the damage was caused by an abnormality in the angle of the injector.

ACKNOWLEDGMENT

We would like to convey our gratitude to LPPM STTMC for supporting the publication of articles

REFERENCES

1. Liu XF, Wang Y, Liu WH. Finite element analysis of thermo-mechanical conditions inside the piston of a diesel engine. *Appl Therm Eng*. 2017;119:312–8.
2. Lu Y, Zhang X, Xiang P, Dong D. Analysis of thermal temperature fields and thermal stress under steady temperature field of diesel engine piston. *Appl Therm Eng*. 2017;113:796–812.
3. Deulgaonkar VR, Ingolikar N, Borkar A, Ghute S, Awate N. Failure analysis of diesel engine piston in transport utility vehicles. *Eng Fail Anal*. 2021;120(April 2020):105008.
4. Wang R, Chen H, Guan C. A Bayesian inference-based approach for performance prognostics towards uncertainty quantification and its applications on the marine diesel engine. *ISA Trans*. 2021;(Article in Press).
5. González JL, Rivas D, Beltrán MA. Failure analysis of a diesel engine. *Procedia Struct Integr* [Internet]. 2017;3(05):41–7. Available from: <http://linkinghub.elsevier.com/retrieve/pii/S2452321617300100>
6. Mumbai N, Mumbai N. \$Qdo\Vlv Ri 3Lvwrq)Dloxuh \$ 5Hylhz. :1–9.
7. Kumar MP, Krishna M, Raju NVS, Kumar MVS. Failure Criticality Analysis Using Fishikawa Diagram (a Case Study of Dumpers At Ocp , Ramagundam). *Int J Creat Res Thoughts*. 2018;378–84.
8. Thongchai S, Lim O. Macroscopic spray behavior of a single-hole common rail diesel injector using gasoline-blended 5% biodiesel. *Energies*. 2020;13(9).
9. Zhang Z, Liu J, Xie Y. Design approach for optimization of a piston ring profile considering mixed lubrication. *Friction*. 2016;4(4).
10. Daly S, Cenker E, Pickett L, Skeen S. The Effects of Injector Temperature on Spray Characteristics in Heavy-Duty Diesel Sprays. *SAE Int J Engines*. 2018;11(6).
11. Jankowski A. Design of Novel Composite Pistons for Diesel Engine. *J KONES Powertrain Transp*. 2014;21(4):211–6.
12. Kim D, Ito A, Ishikawa Y, Osawa K, Iwasaki Y. Friction characteristics of steel pistons for diesel engines. *J Mater Res Technol*. 2012;1(2):96–102.