MARINE ENGINEERING UNDERGRADUATES' PRACTICAL SKILL DEVELOPMENT: AN ANALYSIS OF ENGINE PARAMETERS BY A HYBRID MARINE ENGINE SIMULATOR

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ABSTRACT

Diesel engines are widely used for industrial applications and predominantly in maritime transportation as a propulsion source for ships and power generation. Accurate handling of propulsor onboard has become vital to meet a high degree of operationality of a vessel and effective functioning of the machine. This paper describes an approach for analyzing parameters simulated by a Hybrid Marine Engine Simulator (HMES), which has been established as a skill development tool for engine room watchkeepers onboard ships. The design is based on a microcontroller-based platform that can create simulated operational disturbances for the main engine and makes opportunities to rehearse remedial actions for situations. Further, hands-on experience on starting – loading – unloading a medium speed 4-stroke diesel engine and respondents for emergencies, are facilitated through the system by providing separate consoles for respondence in simulation and general operation of the main engine. Moreover, the developed model can simulate possible main engine malfunctions based on operational parameters. Therefore, it is possible to obtain the engine response to failures without having to invite them to a real engine and develop fault identification skills by following an accurate analysis of data.

KEYWORDS: *Hybrid Marine Engine Simulator, Niigata 6M26AGT Marine Diesel Engine, Exhaust temperature, Peak pressure, Engine parameters, Engine room watch keeper*

1. INTRODUCTION

Four-stroke diesel engines are commonly used in maritime transportation both as propulsors and auxiliary generator sets, being the most critical equipment in onboard ships. Therefore, the reliability optimization of marine diesel engines has a significant impact on operation and cost. [1] The most trending reason for the installation of a diesel engine as propulsors in the maritime sector is due to its high-power density, efficiency, reliability, and better response to load changes compared to other solutions such as gas turbines and steam engines [2]. Simulator-based learning programs were initiated in the 1970s with the evolution of computers and software, which has become an effective academic orientation compared to traditional teaching. Engine diagnostic systems proposed in the literature can be classified among statistical, physical, and hybrid/ semi-physical systems [3]. Hybrid Marine Engine Simulator (HMES) is designed and developed with a large-scale marine diesel engine and a microcontroller based on an embedded controlled environment to conduct realistic engine room scenarios and to evaluate the performance of the current technical state of engines and devices.

Accordingly, this system facilitates fault finding by analyzing simulated parameters which develop skills in detection and diagnosis of failures that occur in a diesel engine before they become a catastrophic failure in actual conditions. Further, timely respondence for a simulated emergency is a powerful tool available for users in developing reliable skills in watch keeping.

Literature divulges that 90% of engine room breakdowns occur due to operator's negligence or human errors [4], [5] which comprehends the necessity of seeking more reliable training aids to educate ship's crew. The realistic engine room operation scenarios generated in the HMES contribute invaluably to driving away operational fear among the users and improving decision-making traits, preparing them for unforeseen hardships and emergencies at sea.

Most common analytical techniques are based on limit values and trending monitoring. Statistical systems are more accurate when improvised with advanced statistical and Artificial Intelligence-based algorithms. However, such models require a large amount of data for system validation to ensure reliable operation.

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The HMES of General Sir John Kotelawala Defence University is developed with two main consoles for responding and simulation which is operated by the trainee and an instructor respectively, where all scenario-based working conditions and operational disturbances are created by the instructor, manually. Disturbances are generated by the parameters entered by the instructor once the main engine is in simulation mode. Students are monitored and evaluated as per the respective decisions/ conclusions made by them [6].

2. METHODOLOGY

A. OUTFIT

Basic engine data implemented for the HMES are given in Table 1.

Table 1: Main engine parameters

Parameters	Value	Unit
Type	Inline, single acting, 4 strokes, diesel engine	
Make	Niigata	
Model	6M26AGT	
Weight	12,700	kg
Cylinder Bore	260	mm
Piston Stroke	400	mm
Cylinder Number	06	
Idle rom	245	rpm
Max rpm	510	rpm
Max continuous output	850	HP
Rotation	Clockwise	
Starting System	Compressed Air	
Governor	Hydraulic	

Source: Operation manual of Niigata 6M26AGT Marine Diesel Engine

The HMES comprises several subsystems (Figure 1) and several exercises based on engine systems are designed under the sub-system of parameter simulation. Further, it integrates Microcontroller based workstations inside the machinery Control Room which is comprised of two workstations; one is controlled by the instructor and the other is operated by a trainee during simulations.

Students are given time to familiarize themselves with all engine systems such as coolant system, fuel system, exhaust system, lubricating oil system, and high-pressure air system by preparing characteristics for each system, visual inspection, and starting/ stopping the main engine manually.

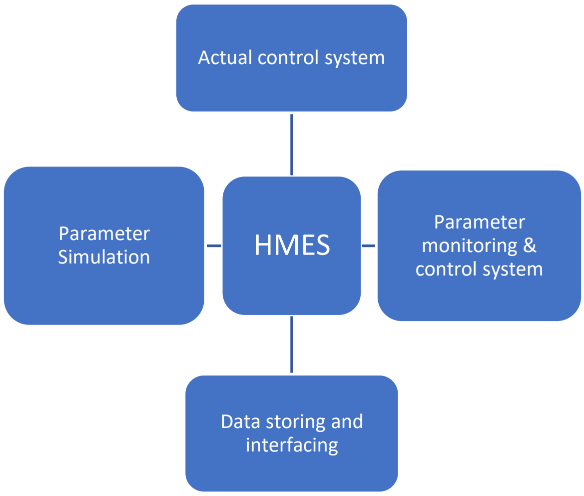

Figure 1: Subsystems of HMES

B. EXPERIMENTAL MEASUREMENTS

Initially, the main engine is started by the students and all system data is uploaded to the system on activation of simulation mode. Subsequently, the engine is virtually loaded 20%, 40%, 60%, and 80%, out of the total BHP of the engine, allowing a settling time of 15 – 20 minutes in each stage.

Accordingly, as such the key parameters registered for the analysis are engine load (%), peak pressure of each cylinder (bar), charged air pressure (bar), exhaust air pressure (bar) and exhaust temperature (°C) of each cylinder.

Apart from the above, the following parameters are also logged as a practice for analysis.

- Peak pressure of units
- Engine power output
- Exhaust gas temperature
- Coolant temperature
- Lubricating oil pressure and temperature
- Fuel oil pressure
- Ambient air temperature
- Charged air pressure

The main engine is only virtually loaded in this set up, software program itself generates corresponding values for specific fuel consumptions, power output, and other parameters against the engine loading percentage, once the instructor enters abnormal dependently varying parameters for the exercise.

Accordingly, the analysis of data obtained from the above activity revealed that abnormal exhaust temperature rises in No. 02 & No. 05 units which are shown in Figure 2.

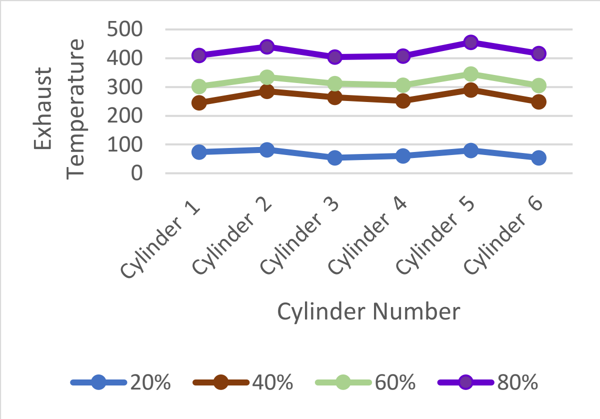

Figure 2: Exhaust gas temperature analysis

In the same situation, the peak pressures of each unit were shown in Figure 3.

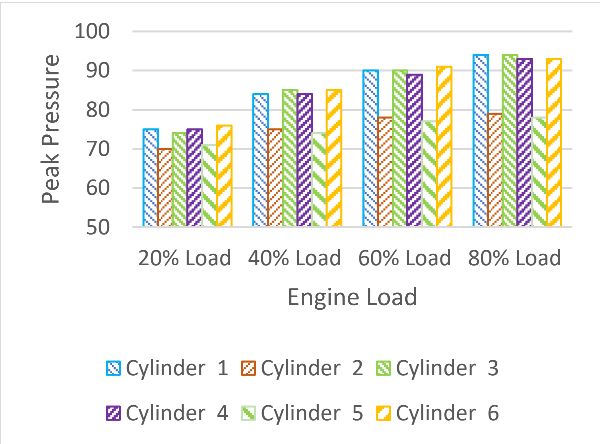

Figure 3: Peak Pressure of units for loading conditions

According to Figure 4, it can be perceived that peak pressures of No. 02 and No. 05 units display a significant drop compared to other units, with the increase in engine load. Therefore, the above condition of malfunction has to be compared with a selected cylinder unit that operates in perfect condition. Accordingly, the following analysis was done comparing with No. 01 cylinder which was observed to be normal compared to No. 03, No. 04, and No. 06 units.

It is apparent that No. 02 and No. 05 units comparatively produce less amount of peak pressure. Further, the peak pressures of the same cylinder units have not increased compared to the engine load.

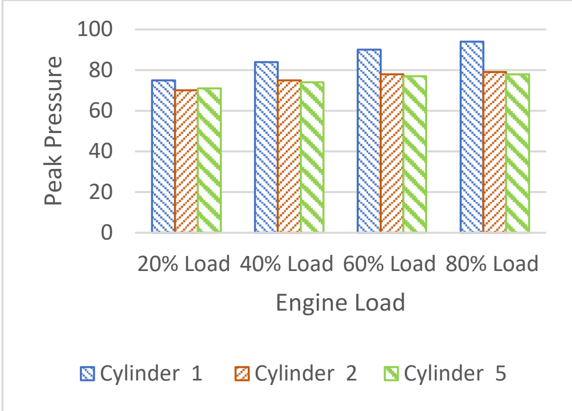

Figure 4: Comparison of faulty peak pressures

Concerning the above situation, Figure 5 shows the comparison of the engine load curve against the existing loading Vs engine rpm as a further study.

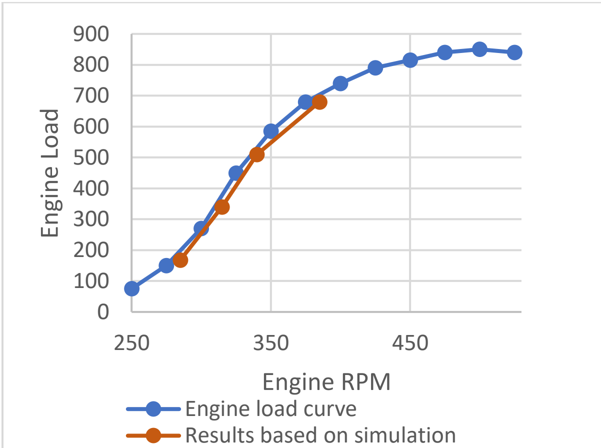

Figure 5: Comparison of Engine load curve and simulated results

3. DISCUSSION

According to the above analysis, the temperature upswing of No. 02 and No. 05 units was observed. Further, it is comprehended that relatively low levels of peak pressures of said units have a relationship with the observed malfunctioning situation.

General variation of peak pressures against the engine load can be taken into the discussion, reasoning out an escalation of reduced peak pressure that would cause severe blow–by conditions, as discussed in [1].

As per the results obtained from the simulation, loss of peak pressure has caused low performance as indicated in Figure 2. The engine has increased rpm to meet the same engine load of 20%, 40%, 60%, and 80% from total loads which has reduced the efficiency of the engine. It is taught that this fact can be further verified by obtaining readings of specific fuel consumption and fuel rack position reading in the real-time environment, which has not been implied in this simulator design. Accordingly, students can clearly understand the effects caused by high exhaust temperature in units. Further, students have a chance to analyze data with the existing, to find out possible root causes and remedial actions.

The acquired knowledge from the exercise is evaluated through a written report including the following content

- Introduction to the exercise
- Procedures followed
- Parameters considered
- Data analysis and presentation
- Identification of root causes and remedial actions

Consequently, the reports will be evaluated based on the descriptive writing adhered to the above criteria.

4. CONCLUSION

Teaching through this simulator broadens the student's knowledge and experience in the marine engine room environment before performing onboard. Activities conducted through this facility prepare the students to face such conditions and timely react to even harder situations at sea. Therefore, the training of marine engineers utilizing the HMES is the least expensive and the safest training method in the present day context.

5. ACKNOWLEDGEMENT

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