The Simulation of Electronically Controlled Engines and the Need for Change of STCW.

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1. Introduction

The simulation of the electronically controlled engines has been evolving for a number of years. A good example are the simulators for marine gas turbine engine (Fig. 1) which, from the outset included both automated and so called ‘manual mode’ electronic controls.

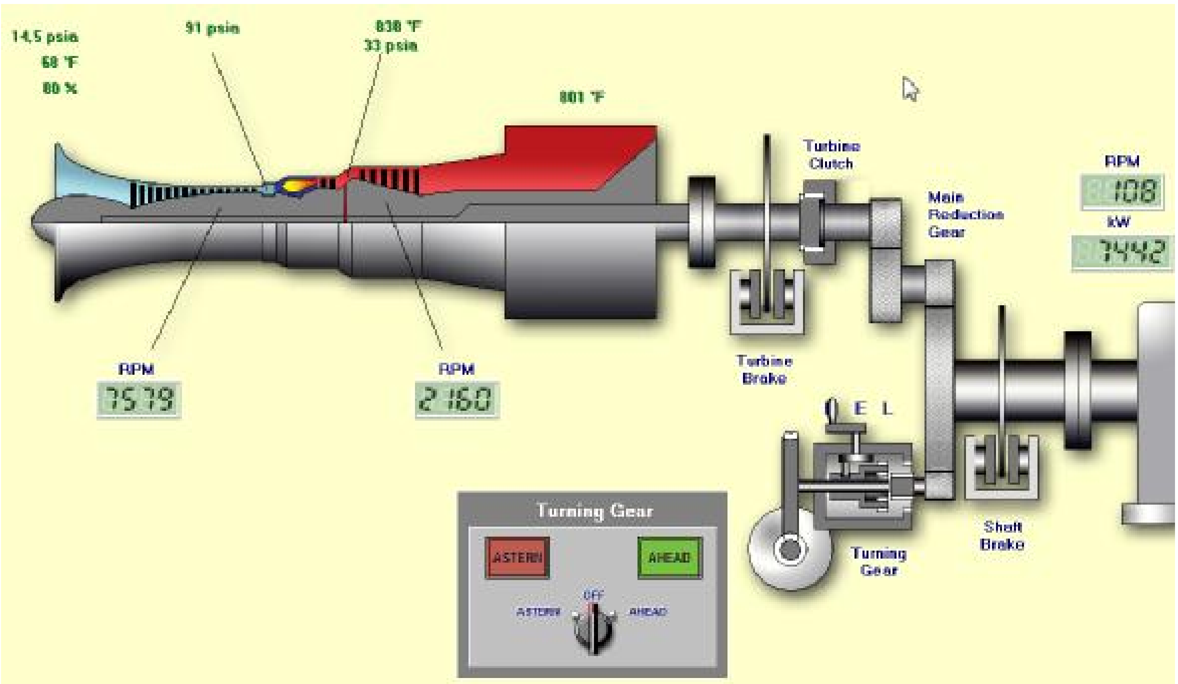

Fig. 1 The gas turbine simulator (GTS) example [7].

These types of engines cannot operate without the electronic control function, even if we believe that we are running with manual control (Fig. 2) [7]. Further, the simulation of such an engine type would not be a complicated issue if there were standard versions of these electronic control system available to the industry; however in reality. there are a number of systems with different key functionality. This means, that an engineer who has had the training on one system of automation will not be equally well prepared for the other versions.

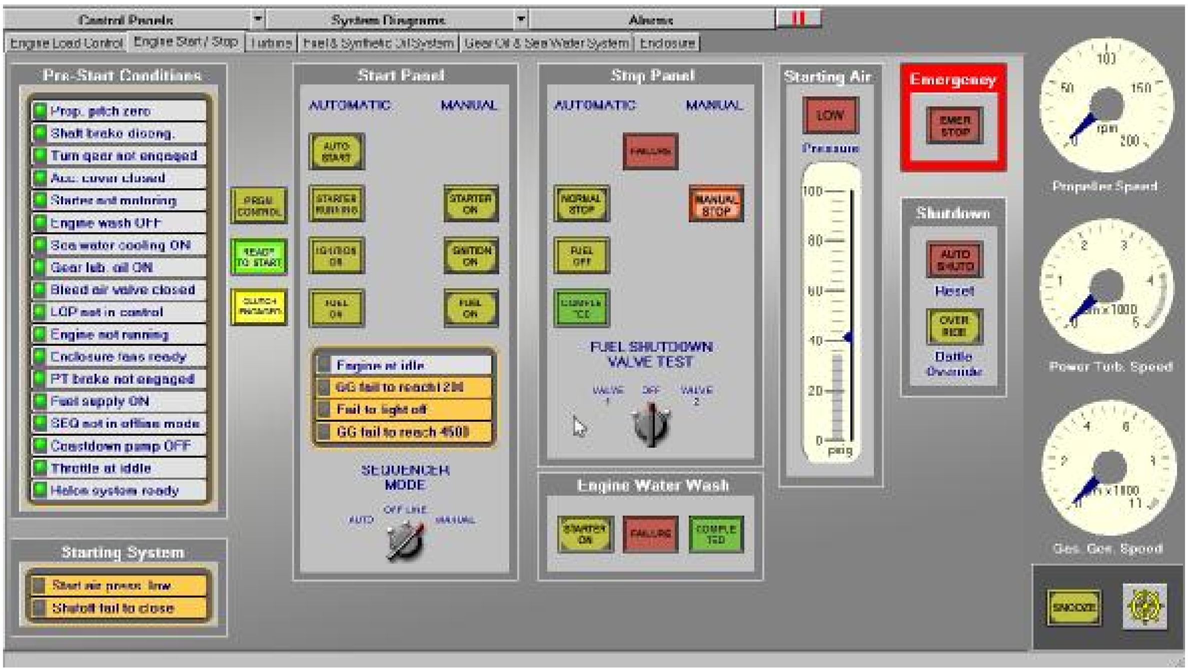

Fig. 2 The gas turbine simulator (GTS) screen with controls for start and stop [7].

2. Electronically Controlled Engines

The introduction of the electronically controlled low-speed diesel engines has raised a number of new problems - caused mainly by the influence of these electronic system settings on the day-to-day engine operation. These days, the engineer can expect not only basic operations i.e. the engine starting, stopping or load change, but also they can easily change the injection timing, compression ratio, exhaust gas temperature, or load balance of the engines. Moreover, many of all these essential operator functions have to be simulated within the modern simulator. This makes it difficult for the software developer to establish the boundaries between the operational functionality and the key maintenance tasks. On the other side of the equation, the engine manufacturer could update the engine control system software version, its function, and the way the engine is operated, so we continually consider how these electronic controls should be implemented into the engine room simulator themselves.

You could think that the operation of the electronically controlled engines should be easier than a conventional one, because of the high automation level. This is not supported in reality, mostly because the operation of a modern engine (even if planned as a simple one) is very different than the operation of the classic engine [5]. Despite the differences between the construction and operation of the conventional engines, their operation is quite similar i.e. the actions taken in order to start, stop, or load the engines - even if the actual control element is different.

Indeed, there are several important differences between the operation of the conventional and electronically controlled low-speed engine. All of these functions have to be implemented into the simulators as well.

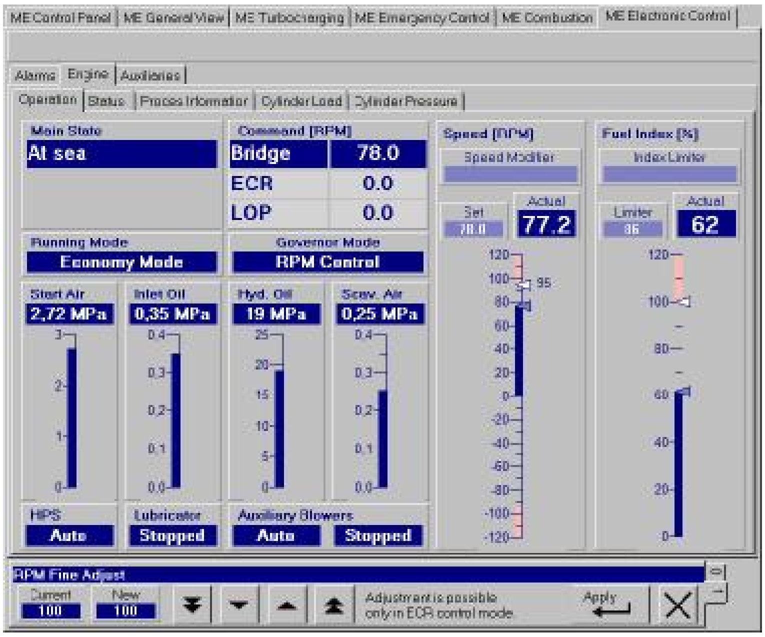

Fig. 3 The governor screen of the VER5 simulator [8].

Fig. 3 Shows a typical simulator screen where the electronic governor has been implemented. The engineer operator can set both the engine speed-limit and the engine fuel-index limit. The user settings will be combined with the internal operation layout which, can be shown in the engine schematic in the simulator control program. These types of feature are generally not available in most 2-stroke engine solutions, but some of the conventionally controlled engines with an electronic governor will have this functionality.

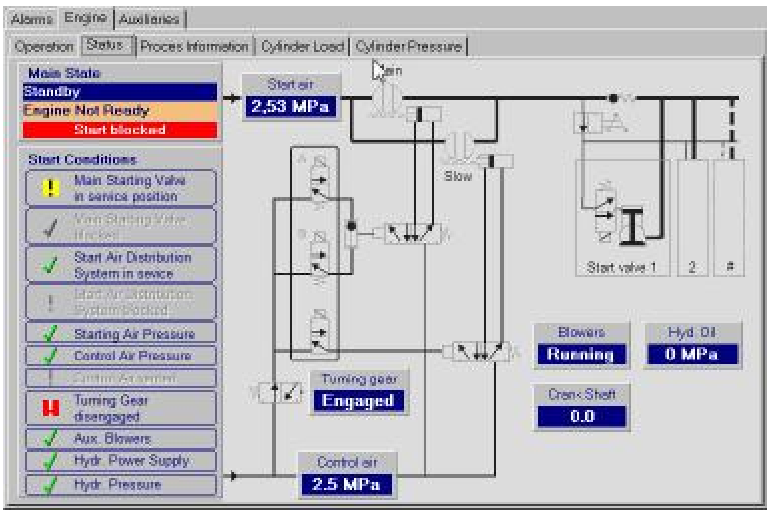

Fig. 4 The VER5 simulator MOP screen showing main engine state in Standby mode [8].

The main operation panel (MOP) screen informs the user about the engine state (shown at Fig. 3). This can be most useful when not only preparing the main engine for a start sequence, but also when planning a longer stay in a harbor (finished with engine [FWE] status). Furthermore, it is worth a mention, that some information presented on this screen is context sensitive. This means for example, that “Turning Gear disengaged” has a red exclamation mark because the turning gear is engaged and the engine should be in a Standby mode (see Fig. 4). If the requested mode is FWE, the above screen will look different (Fig. 5).

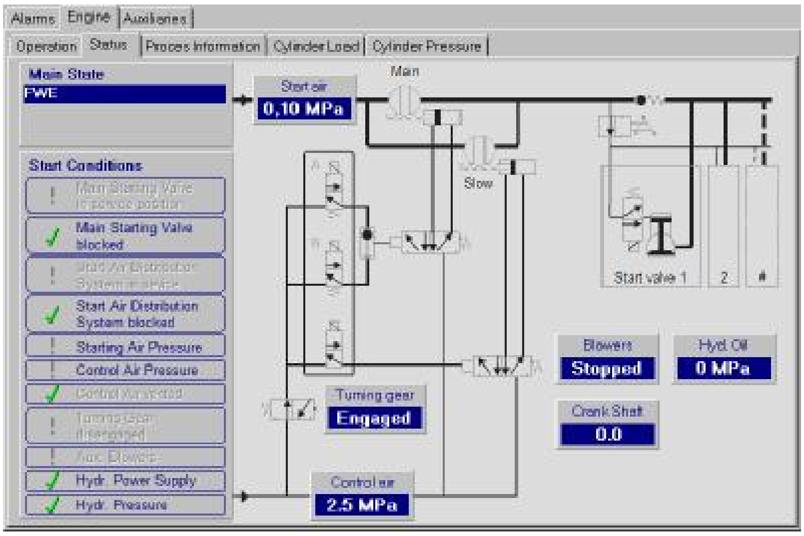

Fig. 5 The VER5 simulator MOP screen showing main engine state in FWE mode [8].

Therefore, the main advantage of the electronically controlled engine is the possibility to adjust on fly a number of injection, lubrication and exhaust valve settings (see Fig. 6).

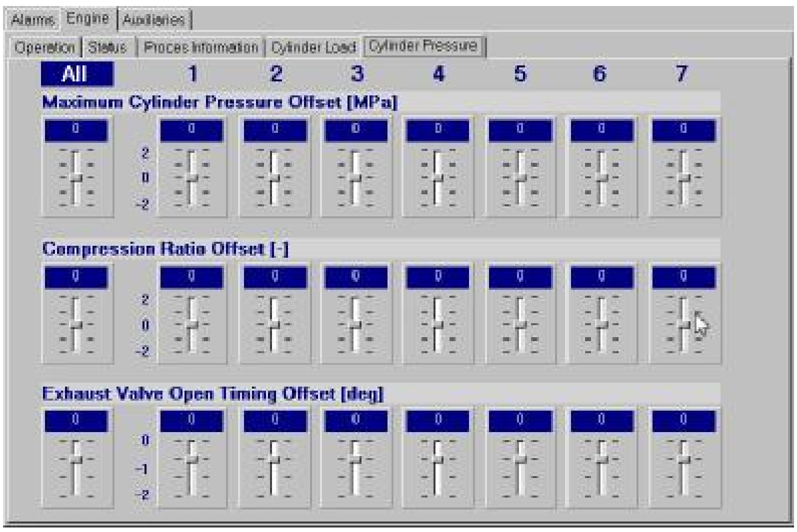

Fig. 6 The VER5 simulator MOP screen showing sliders for cylinder setting change.

This makes the control panel itself a powerful tool, but also it is a danger to the untrained. For instance, some engineers may wish to compensate the effect of worn piston rings and lowered compression pressure by a simple adjustment of the slider Compression Ratio Offset. This action removes the symptoms but not necessarily the cause of the problem. Similarly, when there is increased exhaust gas temperature caused by a poor atomization of an injector, it can be easily solved by a delayed opening of the exhaust valve. Because of this type of example, simulator training is especially useful, not only for the training of ab-initio cadets, but also for continuation of experienced engineers who have only just started to work with electronically controlled engines. The trainee can then try different settings (for example the change of the injection advance) using the simulator, and they can observe their influence on such elements as the combustion (see Fig. 7) before using these skill the actual engine type.

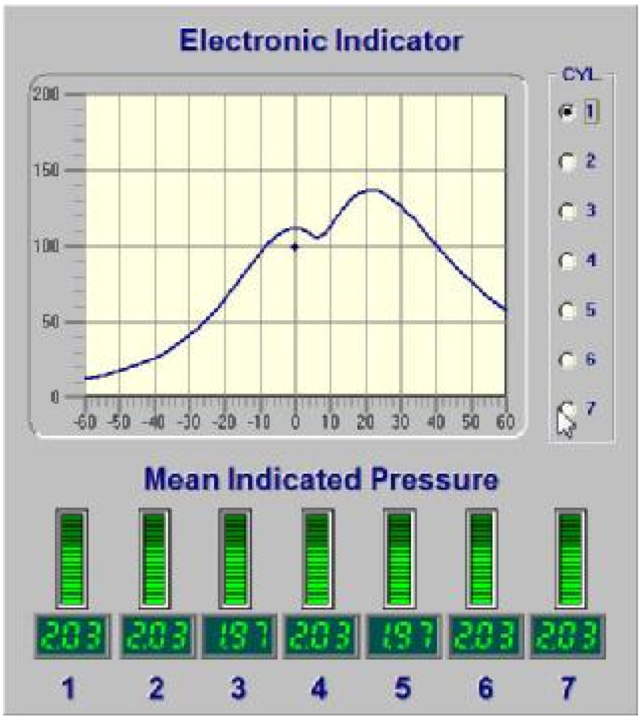

Fig. 7 The VER5 simulator panel showing the combustion pressure curves [8].

Of course, the electronically controlled engines have several new systems and controls specific for their construction for example a High Pressure System (HPS). Fig. 8 shows a typical screen with a simple schematic drawing of the hydraulic system which includes three engine-driven pumps and two electrically-driven start-up pumps.

Even if this system looks very simple at the first glance, it includes several advanced control settings for the hydraulic pumps. The influence of those settings can be easily tested in the simulator in order to prevent unexpected problems during the normal operation. The examples discussed above explain, why the simulator of the electronically controlled engine is a welcome addition to the actual system. Thus, simulation can be useful both for the cadet the experienced engineer new to these control systems.

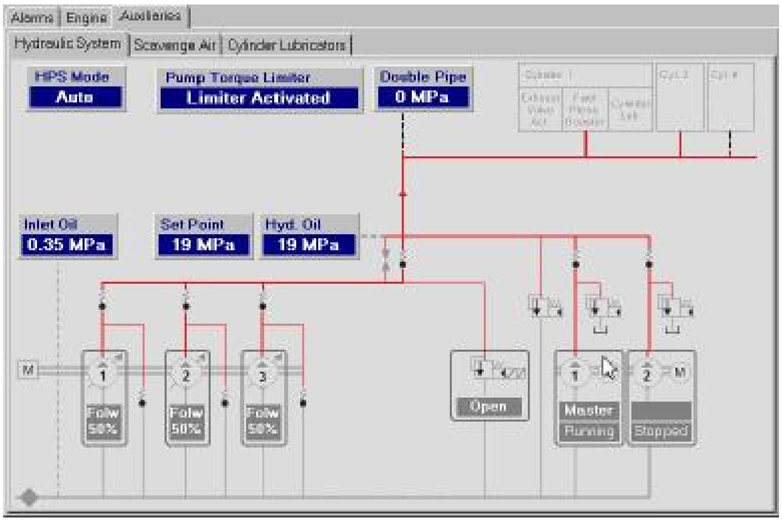

Fig. 8 The VER5 simulator screen showing the high pressure hydraulic system [8].

3. STCW Update

For many years the participants of ICERS Conferences used to repeat that STCW code [1] should be updated in order to take into consideration different types of the propulsion systems (low-speed diesel, medium-speed diesel, steam turbine, gas turbine, diesel electric etc.) [2, 3, 4]. A good example of what can be achieved is available in the latest version of DNV requirements for engine room simulators [6] - where the specification / requirements are different between propulsion system. However, the introduction of the electronically controlled engines requires changes in the convention itself. Tables A-III/1 and A-III/2 [1] should include in a column “Knowledge, understanding and proficiency” the subjects like:

- Understanding the fundamentals of the electronic control of the fuel injection, combustion and exhaust process.
- Operation, testing and maintenance of the engine electronic control system.
- Methods of compensating engine malfunctions with electronic control system settings.
- Methods of engine commissioning if the electronic control system is applied.

The last subject is very important because the electronic control of the main engine opens the wide possibility of test result manipulation during both factory tests and sea trials. For example, one of the main criteria of the engine acceptance tests for a of a new build vessel, or a repair, was the balance of the mean indication pressure, maximum pressure and exhaust gas temperature in all engine cylinders. It was necessary to equalize the compression ratio, fuel quantity in cylinders and atomization quality in order to pass such a test. In the past, a lot of mechanical work had to be done in order to achieve the satisfactory results. Nowadays, it is possible to attach a maintenance laptop to the electronic control system, change some settings like those shown at Fig. 6 and then save them unchecked within the computer interface. Even significant changes in an exhaust valve-timing, quantity of the fuel injected to the cylinders, or in a compression ratio can be hidden by the shipyard staff; this could mean that a ship engineer will see only equal settings (zero deviation) for all cylinders. Only an engineer who has full theoretical knowledge and has received sufficient practical or simulator training will be able spot such errors and potential cover-up.

The column named “Methods for demonstrating competence” in tables A-III/1 and A-III/2 [1] in the row dedicated for electronically controlled engines should include following items:

- Approved in-service experience.
- Approved training ship experience.
- Approved simulator training.

The proposed STCW extension should provide better quality of the modern engine operation and a lower risk of the serious engine breakdowns. This latest problem seems to be an important one at the current stage of the new engine developments.

4. Conclusion

New technology has many advantages without question and offer a brighter future for the end-user. However, like in many new solutions sometimes the positive aspects of development are accompanied by new unseen dangers, complexities and the possibility of that test data and settings can be manipulated. The application of appropriate simulator training can decrease the risk of the operation faults on one hand, but on the other it also increases the chance to use and experience the benefits of the systems in achieving typically increased engine reliability and lower fuel consumption.

STCW cannot stand still and ignore in this case, the introduction of the electronically controlled engines within the shipping industry. Therefore it is time for the convention to be updated to reflect this particular change, but also extended in many areas of requirements. Also it is worth to consideration that STCW should address the problems of the different industrial standards, in this case, these electronic control systems. For example: there are two main industrial standards for electronically controlled low-speed diesel engines available today, but at the same time there are many different gas turbine control systems available within the maritime industry with no standardization whatsoever. In summary, on one hand STCW should not be aligned to any specific commercial product, but on the other hand the convention should offer support and guidelines for the actual equipment available today, but most of all the day-to-day operational problems of ship engineer.

5. References

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