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The application of a steam engine room simulator to engineering education and training

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ABSTRACT: The author's studies on steam power plant simulators have shown that this type of simulator is necessary for the successful and effective training of engineering crewmembers for steam powered ships. The steam engine room simulators require new model courses and new assessment methods. Some operational skills, which are considered necessary in a steam engine room, can be trained and attained in a diesel plant simulator. However, the most important tasks, such as the main boiler, main turbine and steam system operations, have to be taught and learnt in the appropriate and dedicated steam engine room simulator.

INTRODUCTION

The first steam turbine powered ship was *Turbinia* and was built in 1897 [1]. The first reversible marine diesel engine was built in 1906 [2]. Initially, ship turbines were much more popular than diesel engines as a ship propulsion, especially in navy vessels. Today, most merchant ships are powered by diesel engines.

The difference between the engine room powered by a steam turbine and the engine room powered by a diesel engine is obvious for anybody who has seen both of them. Because of these differences, the parallel education of ship-engineering officers for both engine room types was a common standard until the last decade of the 20th Century. However, this practice has changed over the last few years and the steam turbine engine room theory and operation have disappeared from many training centres and merchant marine academies. This trend has generated increasing difficulties in finding well-prepared engineering officers for modern steam turbine ships.

DESIGN

The simulator called *Steam Engine Room* (SER) has been developed by the company Unitest. This simulator can be utilised as an example of steam engine room simulators that are applied for engineering training. The SER is a software package developed for a normal PC with a Windows XP operating system. The *heart* of the program is a diesel engine mathematical model, based on the physical structure of the modelled object. The computer model is based on actual plant data and will react naturally under almost any operating conditions.

The model is divided into several modules each dealing with one sub-system and comprises the following elements:

- Main engine (steam turbine);
- Steam and condensate system;
- Main boilers;
- Fuel system;
- Seawater system;
- Lubricating system;
- Power plant;
- Miscellaneous systems (eg bilge system, ballast system, fire fighting system, steering gear).

These systems can be initialised in many different conditions by loading an appropriate set-up so that no extensive setting of engine room controls is required.

In this article, the author describes in detail only steam engine room specific systems, because other systems (eg electrical power plant, bilge, ballast, fire fighting and steering gear) are almost identical, such as can be found in the diesel engine simulator called *Virtual Engine Room* developed by the author. Furthermore, they have been described in other papers [3][4].

MAIN TURBINE

The type of the main turbine modelled in the SER is one set, cross compound, with the astern element located at the exhaust end of the low-pressure turbine casing. It has the following parameters:

- Maximum rated power: 30,000 SHP at 91 rpm;
- Throttle steam condition: 60 bar, 513°C;
- Steam consumption: 90,000 kg/h;
- Condenser vacuum: 724 mmHg;
- Number of bleeds: 4;
- Number of drains: 4.

The main turbine is equipped with a double reduction, double helical reduction gear and a turning gear powered by an electric motor.

The turbine window shown in Figure 1 displays the general view and all the most important valves related with the turbine operation (both remotely and locally controlled). This window also includes the turning gear control panel and several hot-spots for quick switching between windows.

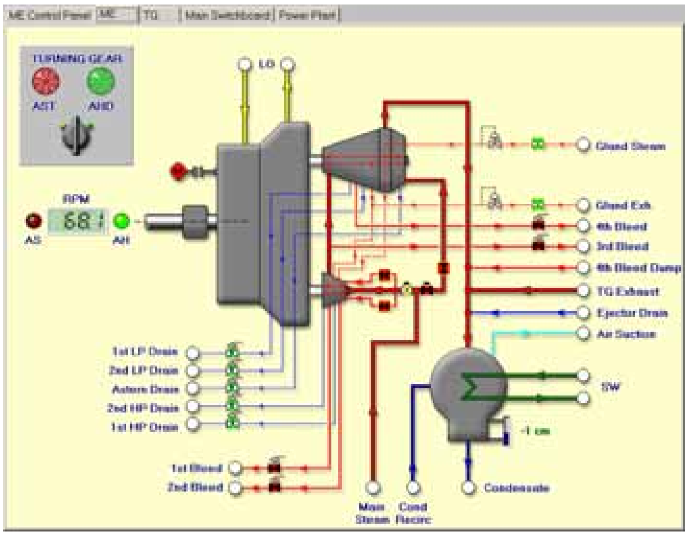

Figure 1: The main turbine diagram.

The main turbine control panel shown in Figure 2 includes all the controls and gauges necessary for turbine remote and emergency control. The main turbine remote control system includes manoeuvring from the bridge and the engine room.

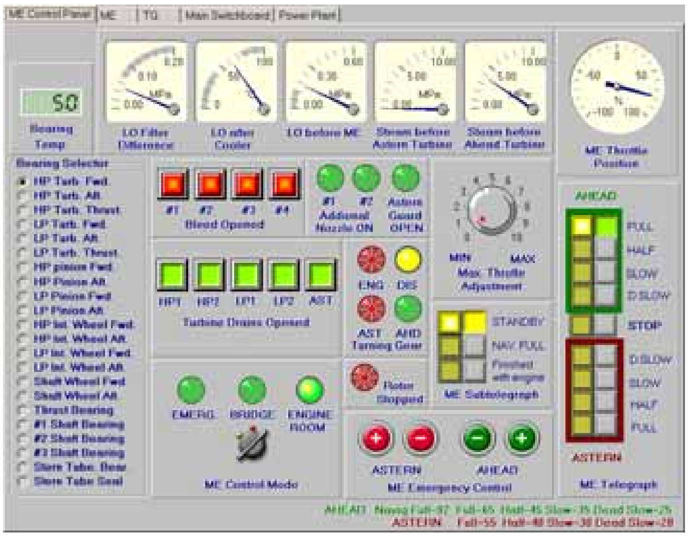

Figure 2: The main turbine control panel.

The main turbine operation is rather simple once the steam pressure and temperature have reached the proper levels. However, special attention has to be paid during the warm-up or cool-down periods. This is also necessary even when the turbine has stopped, yet the rotor is still spinning.

STEAM AND CONDENSATE SYSTEM

The steam and condensate system modelled in the SER represents a modern steam installation type with four feed water heaters (one of them being a deaeration tank), one main condenser and two additional condensers to be used for turbo generators in a harbour. Two feed water pumps are powered by the steam turbines, although one cold start feed pump is powered by an electric motor.

The steam and condensate system diagram shown in Figure 3 includes a mimic diagram with active controls (valve buttons), status indicators and selected gauges. The steam and condensate system status overview and local control is the main task of this window. The active hot-spots enable easy communication with other cooperating systems.

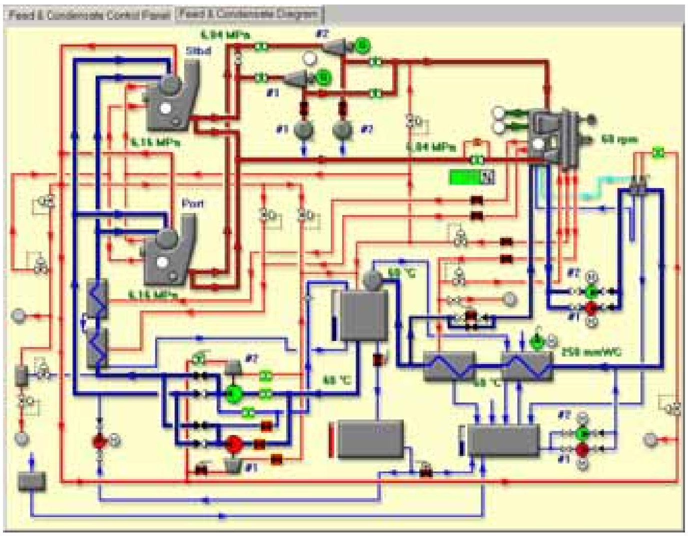

Figure 3: The steam and condensate diagram.

The steam and condensate system control panel includes all the controls and gauges that are necessary for operation of the feed water and condensate pumps. Good practice is always set one of the two supply fuel pumps to ON and the other one to STANDBY. In this case, if the operating pump should stop due to a fault, the other one will be able to take over the duty of the faulty pump.

The operation of the steam and condensate system is rather simple during the operation at sea, but requires special care when the engine room is prepared for the voyage.

MAIN BOILERS

The main boilers are fully integrated with the steam and condensate system described above, but because of their complexity, high steam output and specific operational problems, they create a separate subsystem in the SER (see Figure 4).

Two modern main boilers are two-membrane, two-drum, bend-tube, single-furnace and single-uptake type, with a superheater, a desuperheater, an economiser and a steam air heater. Each boiler has three burners and can deliver a maximum of 48,500 kg/h of superheated steam (61 bar and 513 °C) and 4,125 kg/h of desuperheated steam.

Steam boilers are the most sensitive and easily damaged power plant components and must be treated with great care. The boiler dynamic behaviour has been sped up in order to improve the simulator usability. As a consequence, it takes only around 15 minutes to start-up the boiler, but in the reality this process takes about four hours from the cold status and about one hour from the warm status (steam pressure 7 bar).

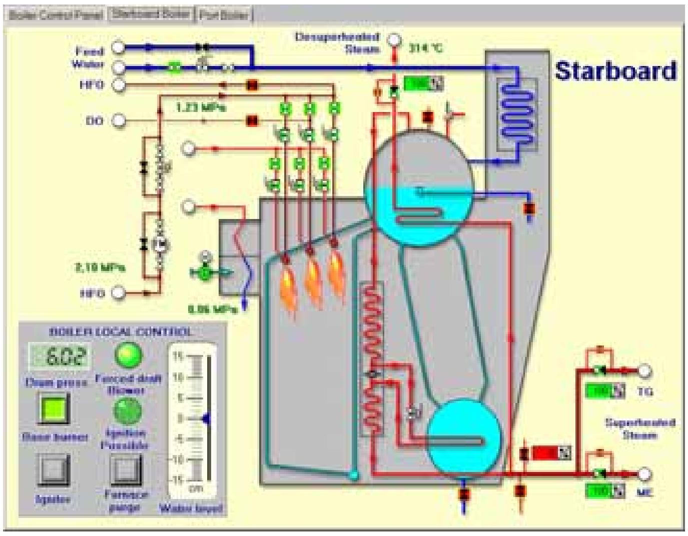

Figure 4: The main boiler diagram.

The main boiler control panel, shown in Figure 5, includes all the gauges and controls necessary for the main boiler's remote operation. All the knobs used for air/fuel ratio, superheated steam temperature and fuel oil pressure setting have a small toggle that enables the switching between manual and automated control methods.

Figure 5: The main boiler control panel.

The manual control of the above-mentioned settings is especially important when starting the boilers from the cold condition. Only the baseburner can be operated on diesel oil and ignited electrically. The two remaining burners have to be ignited from the baseburner only, and cannot be ignited from the other one.

FUEL SYSTEM

The fuel system modelled in the SER (see Figure 6) can run on diesel oil when heating steam is not available, and on heavy fuel oil during normal operations. The system does not include any fuel separators and is rather simple when compared to the fuel systems used in diesel engine power plants, so its operation is not very complicated.

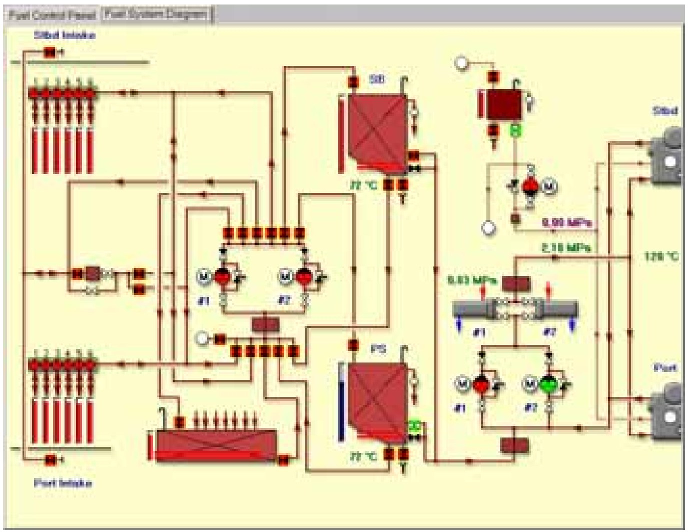

Figure 6: The fuel system diagram.

LUBRICATING SYSTEM

The lubricating system includes the lubricating oil storage tanks, main turbine or turbo generator sumps and a purifier. Only the purifier operation can be considered as a rather complicated task, which requires additional attention during training. On the other hand, each of the several lubricating system faults can cause a number of the serious damages in the whole power plant, so the emergency procedures should be trained carefully. The lubricating system diagram is displayed in Figure 7.

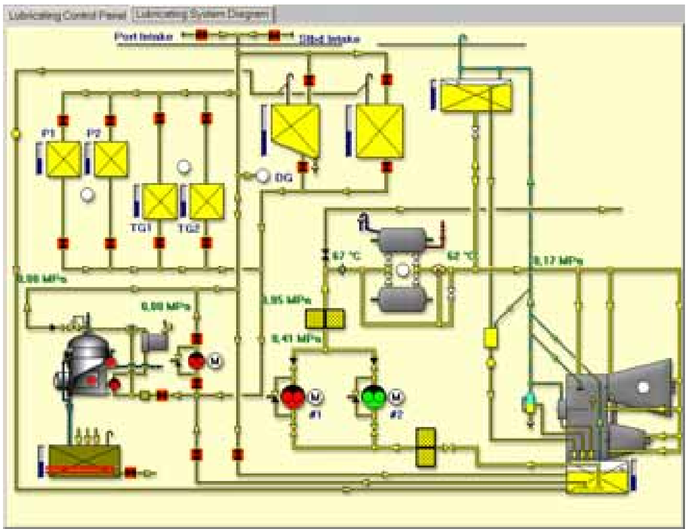

Figure 7: The lubricating system diagram.

SEAWATER SYSTEM

The seawater system plays a very important role in a steam power plant, mostly because of the main and auxiliary condenser cooling. This task requires high water flow and powerful main cooling pumps, which have to be operated and controlled very carefully. Figure 8 shows the seawater system.

FAULT SIMULATION

Several of the most typical and important steam engine room faults can be simulated on the SER. There are three possible states for each fault simulation, as follows:

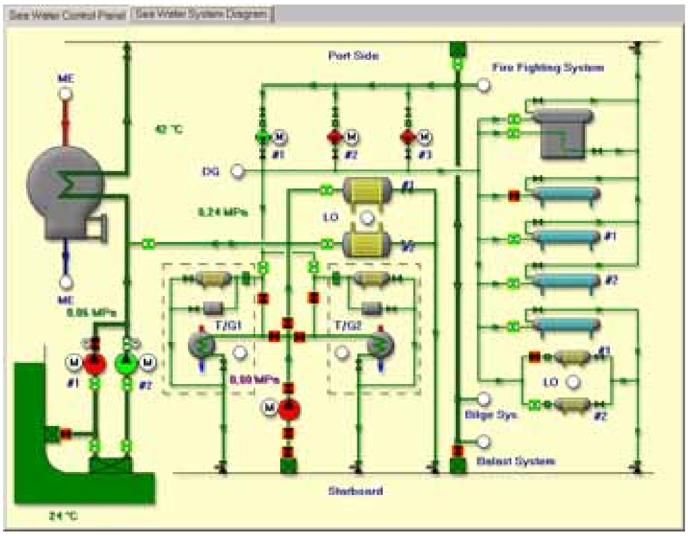

Figure 8: The seawater system's diagram.

- *No fault*: ie default technical state.
- *Stable fault*: the selected engine room component is out of order and will remain in this state until changed by selecting one of the two other states, ie *No fault* or *Unstable fault.* The stable faults are marked in red.
- *Unstable fault*: the state of an engine room component will sometimes be satisfactory, and sometimes out of order. This kind of fault is very difficult to identify, so it is a very interesting case to evaluate.

The faults introduced by an instructor cannot be *repaired* directly by a trainee. The trainee has to report them to an instructor, who will then remove them.

CONCLUSION

Training experience has shown that many of the operational skills necessary in a steam engine room can be trained in a diesel plant simulator [5][6]. Additionally, the most important tasks, such as the main boiler, main turbine and steam system operations, have to be taught and learnt in an appropriate, dedicated, steam engine room simulator. This simulator should be integrated with the appropriated training programme in order to gain the proper training results.

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