PREDICTIVE MAINTENANCE

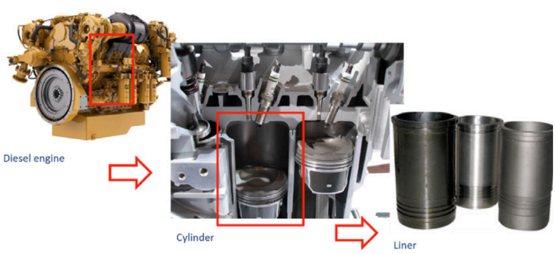
LIFE TIME PREDICTION FOR DIESEL ENGINES

a life prediction tool for diesel engine components

Diesel engines are an essential part of ship propulsion systems. Failures of these engines lead to downtime of the ship, which may yield economic or safety issues, and the need for costly maintenance activities. Therefore, ship operators like Loodswezen, Fugro and the Royal Netherlands Navy are looking for suitable maintenance policies that prevent these failures to occur, and at the same time do not lead to over maintenance. As the ships are operated in a variable manner and in different operational environments, defining such a policy and the required maintenance intervals is not trivial. In his PDEng project, Prabu Duplex designed a life prediction tool for diesel engine components, that enables to incorporate the typical variations in operating conditions in the service life assessment.

CRITICAL PART SELECTION

Ideally, the maintenance of any type of system would be fully condition-based: maintenance is only performed precisely at the moment the system actually requires maintenance. However, that would require that the service life of any component in a system can be exactly predicted. With ships consisting of close to 100 subsystems, each composed of hundreds of components, that is not feasible. The first challenge therefore, is to identify those systems and components that are critical for the ship availability. Application of FMEA/RCM and the Four Quadrant method showed that in this case the diesel engine, and within that system the cylinder liner and exhaust valves, are critical.



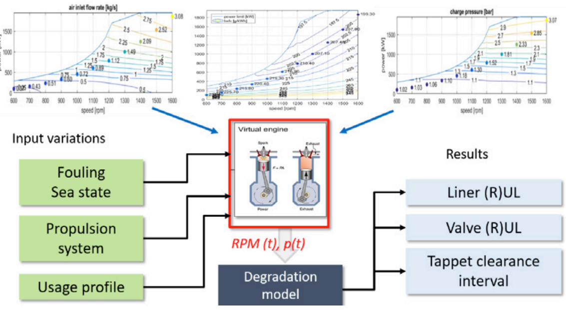
MODEL-BASED OR DATA-DRIVEN

The next challenge is to develop a method that could predict the life time of these components for a given usage profile. Basically two approaches are available for that. In the data-driven approach, big data analytics is used to derive relations from large data sets. However, in this case the amount and level of detail of the data associated to the selected components was too limited: accurate failure data was hardly available (as many parts are preventively replaced) and detailed historic

(operating) data of individual engines was hard to get. Therefore, this project focused on the model-based approach, in which a model describing the physical (failure) behavior of the system or parts is derived. Feeding such a model with a specific usage profile then yields a prediction of the component life time.

TOOL LAYOUT

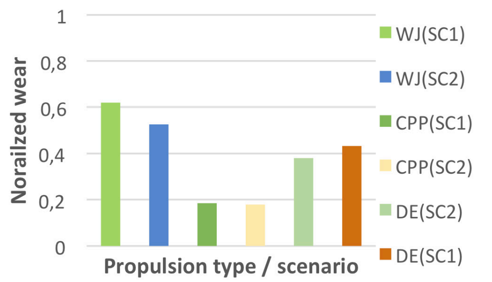
The tool that is developed is depicted below. The starting point of the tool is a definition of the usage profile for a specific engine. While almost any ship contains a diesel engine, various propulsion configurations exist: the diesel can be connected to a fixed or controllable pitch propeller, it can be driving a waterjet, but it can also operate as a generator to power an electric motor, which again can be connected to either a propeller or a thruster.

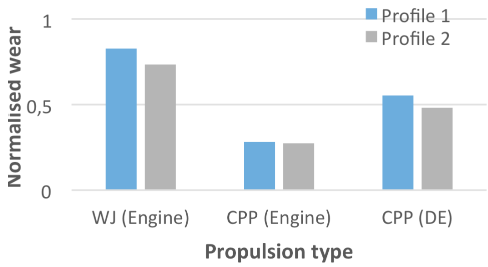


These configurations all have different ways of loading the diesel engine. And in addition, the operational conditions in terms of sea state or hull fouling, as well as the mission profile, also play a major role in engine loading. All these different ways of operating a diesel engine can be captured by the virtual engine (in the red box, developed at TU Delft), which simulates the thermodynamic process of a specific engine. The main outputs are the variation of rotational speed (RPM) and cylinder pressure (p) over time. The core of the tool is the degradation model, which contains the physical failure model (combination of wear and impact). Based on the variation in RPM and p, it calculates the (remaining) useful life (RUL) of both cylinder liner and exhaust valve.

IMPLEMENTATION AND APPLICATION

This tool has been implemented for a particular engine type (CAT 3516) in an Excel tool. Ship operators can specify their detailed usage profile and calculate the associated life time of liner and valves. Also alternative scenarios can be simulated, enabling to optimize the operation and maintenance process. The graphs below show the predicted relative valve and liner wear for three configurations (waterjet (WJ), controllable pitch propeller (CPP) and diesel-electric (DE)) and two scenarios / usage profiles (mission mix).





ACCURACY

The accuracy of the proposed tool heavily depends on a large set of model parameters, whose values are ideally derived from a validation case on a real engine. However, such a detailed data set is not yet available, meaning that several parameters are based on literature values. As a consequence, accurate predictions of the absolute time to failure cannot be done yet. However, since the tool can be used to do comparative studies and scenario analyses, it already provides large benefits and can be considered as a proof of principle.

Topsector Logistiek

FACTS

Researcher Prabu Duplex

University University of Twente & Netherlands Defence Academy

Supervisor Tiedo Tinga (t.tinga@utwente.nl)

Company Loodswezen, Fugro, Pon and Royal Netherlands Navy

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