Case Study

Marine

Flowmaster
Fluid thinking for systems engineers

SEMT Pielstick

SEMT Pielstick successfully apply Flowmaster to engine internal and external flows.

SEMT Pielstick is a French company, which designs and manufactures high-powered industrial diesel engines. It employs approximately 1,000 staff at its plant at St. Nazaire and has an annual turnover in the order of FF 1,300 million.

The range of products includes two families of engines; high speed and medium speed. The characteristics of the engines are detailed below:

There are four main market sectors for these engines:

- Railway Traction - diesel-electric locomotives.
- Civil Marine - passenger ships, ferries and high-speed vessels.
- Military Marine - submarines, frigates and supply vessels.
- Power Generation - basic and stand-by (nuclear and thermal).

SEMT Pielstick have used Flowmaster since 1993 and recently enhanced their analysis capability by adding the heat transfer option. They have built up a database of fluid properties that are applicable to their specific applications. These fluids include lubricating oils, fuel oils - diesel and heavy fuel oils and sea water. They have used the External Component Model facility to develop

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application specific components. These include an engine component (hydraulic models of water and oil circuits), filters (a large range of types, sizes and materials) and a three-way thermostatic valve.Flowmaster is used for two types of analysis - engine internal flows, and installation external flows.

	High Speed Engines (PA)	Medium Speed Engines (PC)
Speed Range	900 - 1500 rpm	400 - 600 rpm
Bore	200 mm / 280 mm	570 mm
Power	500 - 7,000 kW	7,500 - 23,000 kW

Figure 1. Characteristics of SEMT Pielstick Engines

Engine Internal Flows

The crankshaft is an essential element of an engine lubrication system. The lubricating oil circulates through the crankshaft in a complex network of drillings then supplies the main bearings, connecting rod bearings, pistons and finally the cylinder liners. The users built a Flowmaster model of the crankshaft. This consisted of one front section, 18 standard sections and one back section. The users then performed comparative studies on the distribution of oil within the engine. They also assessed how changes would affect the supply to the primary cylinders.

The cylinder block and liners forms the main part of the cooling system of a diesel engine. The cylinder liner temperature is controlled by the water circulation around them and has a direct influence on good operation and wear and tear of the engine. Circulation above the liners, through the cylinder heads, is by means of oblique passages. The purpose of the study was to determine the influence of casing of the passages and the possibility of alternating cased and non-cased liners on the same engine. The study showed that alternating liners does not significantly alter the flow rate in adjacent cylinders.

Installation External Flows in Power Generation Sector

A diesel-electric power station, rated at 71 MW, was being built on Rhodes in the Mediterranean Sea. The original design was over complicated and the installation used too much space. SEMT Pielstick presented their clients with an alternative design backed up by simulations which confirmed the improved solution under various operating con-ditions.

SEMT Pielstick simulated transient operation, particularly pump trip and valve closure, to size the surge suppression devices. The study showed that the surge suppressers were not useful under the operating conditions adopted. However, for safety reasons one accumulator was retained instead of the two initially specified.

It was important for SEMT Pielstick to analyse the exhaust system as back pressure has a considerable influence on engine performance, both fuel consumption and exhaust temperatures. SEMT Pielstick built a Flowmaster model which included bends, junctions, silencer and boiler. Analysis confirmed that back pressure remained within acceptable limits. They were also able to determine the required insulation thickness to maintain a safe external wall temperature on the exhaust. The use of Flowmaster on this system, costing several million French Francs, made it possible to optimise the design avoiding an initially restrictive solution while improving the flexibility.

Installation External Flows in Civil Marine Sector

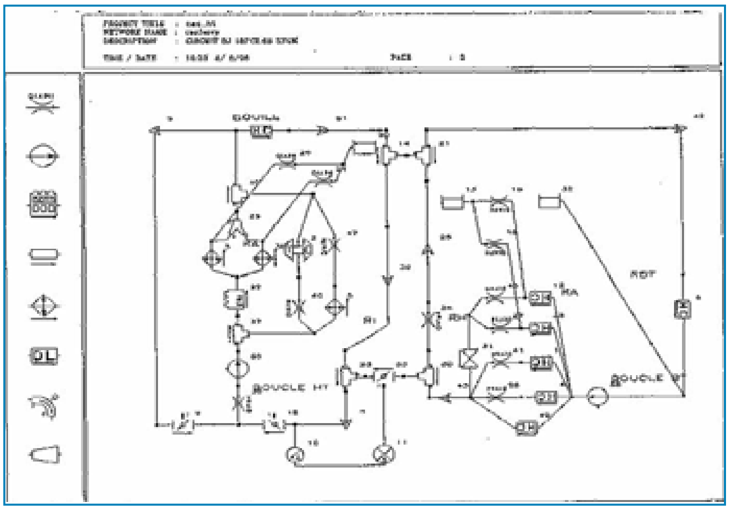
SEMT Pielstick have recently carried out a major engine installation project for the latest passenger ferry built at the Atlantique Shipyards for SNCM. The ship operates between Marseilles and Corsica during the tourist season and is used for cruises and seminars during the off-season. It was delivered in April 1996 and is 172m long, carries up to 2,600 passengers and cruises at 25 knots.

It is propelled by four 18-cylinder SEMT Pielstick PC2.6B (bore 400mm) giving a total power of 43 MW (2 engines to each propeller shaft). The engines are mounted on an elastic suspension system so that engine vibrations are not transmitted to the hull. In addition to the engines, their suspensions and couplings, SEMT Pielstick also supplied all ancillary systems including cooling, lubrication and final-stage fuel treatment.

The engine cooling system is necessarily complex. It must dissipate the energy produced by the engine that is not converted to mechanical power or rejected in the exhaust gas. The engine output is about 45% and the energy lost in the exhaust gas is about 30% of the energy input. This leaves about 25% of the energy input, up to 7 MW, to be dissipated by the cooling system into the environment. In this case, the sea.

The cooling system consists of three cooling loops:

- high temperature loop - engine, boiler, first stage air cooler
- low temperature loop - oil, propeller, reducer gear, second stage air cooler
- final sea water loop



Flowmaster Network Diagram - BJ 18PC2.6B SNCM

The first two loops, which are freshwater, include temperature control valves.

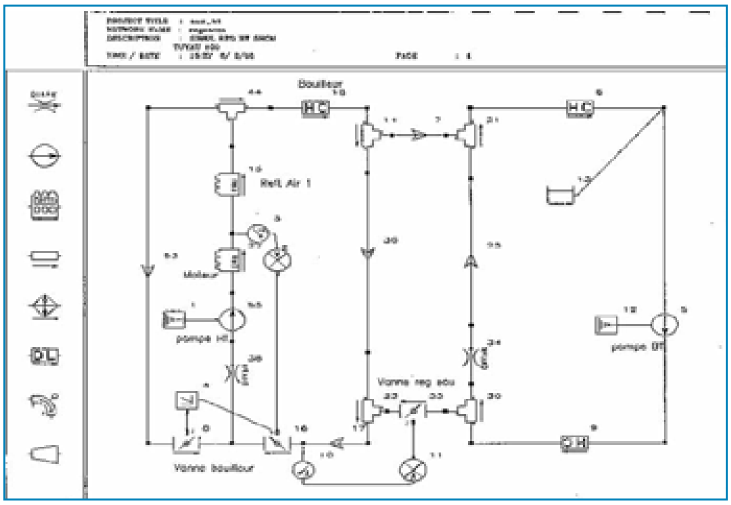
There are a number of constraints on the cooling system:

- the engine outlet water temperature in the high temperature loop, must be constant, regulated to 88° C, whatever the engine speed and load
- the engine must be effectively reheated during start-up and part load operation
- the maximum amount of energy should be recovered by the boiler from the cooling water for on-board use
- the boiler should be bypassed if the water temperature is too low (~ 95° C)
- cooling should take place if the boiler is out of service
- the low temperature loop should cool the whole of the engine environment including the reducer gear and propeller
- during part load operation the engine supercharge air should be reheated to reduce the corrosion risk caused by the condensation of sulphuric acid on the liners

Some problems were noted during tests immediately after launch. A transient thermal analysis was carried out to understand these problems. SEMT Pielstick simplified the cooling system model, from the hydraulic point of view, but extended it by adding heat exchangers and controllers to permit dynamic modelling.

In particular,

- the diesel engine is represented by a component developed by SEMT Pielstick which combines the hydraulic behaviour (discrete loss) and the thermal behaviour (ability to simulate an increase in engine with a resultant increase in thermal energy rejected to the cooling system)
- valves with PID controllers (as fitted on the ship)
- pumps with controllers to simulate the variation of speed related to the increase of load on the motor
- the low temperature loop was reduced to its simplest form.



Flowmaster Network Diagram - Transient Thermal Analysis

Flowmaster Network Diagram - Transient Thermal Analysis

Firstly, SEMT Pielstick obtained an explanation of a phenomena experienced on two of the four engines. The problem was that a valve did not control correctly but cycled between fully open or fully closed. In the "as-built" installation the temperature sensor was not positioned where the design specified. In this position, when the valve closed it sensed engine output temperature, so opened the valve. When the valve opened, it sensed cold water temperature, so closed the valve. This initial diagnosis was confirmed by the Flowmaster model.

After initial adjustments, operation was in accordance with estimates. However, there was a problem of temperature overshoot when taking on loads. The Flowmaster model reproduced this and explained why it occurs. When there is a rapid increase in load the temperature also rises rapidly. The reaction time of the valve, a geared motor valve, and the inertia of the control circuit causes a lag in response. The temperature then reaches the maximum allowed before being controlled.

This was corrected by reducing the operating temperature for the valve. The valve then opens sooner and reduces the temperature overshoot to an acceptable level. The Flowmaster model reproduced the onboard observations.

The cooling system operates as predicted which, considering the system complexity, is a success. Various problems were encountered with the implementation including mis-positioned sensors and poor filling. These seriously affected the development tests. However, all problems were overcome and the solutions verified with Flowmaster. The ship is now in service and operating successfully.

Flowmaster was used for two different tasks in this cooling system study:

- design optimisation - a detailed model was used for sizing calculations
- commissioning and fault diagnosis - a simplified model was used to gain an understanding of circuit operation, confirm modifications and refine adjustments.

SEMT Pielstick have successfully applied Flowmaster to engine internal flows and installation external flows. Flowmaster has proved to be an extremely valuable tool in both areas for design validation and optimisation.

SEMT Pielstick also found Flowmaster a powerful diagnostic tool during the commissioning phase of several projects.

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