Optimisation of pump- and cooling water systems[1]

Review of a report by Grontmij Carl Bro, APV and DESMI.

INTRODUCTION

This report aims to show the benefits of co-operation between the pump supplier, the heat exchange supplier and the system designer. It is shown that in combining the designer's knowledge with the experience of the two suppliers a higher efficiency is achieved and thus the cost and CO_2-emissions are reduced prominently.

METHOD

Analysis was made using a simple model cooling system for a bulk carrier, a typical seawater (SW) cooling system. Calculations are made when changing the different components of the system, and the operating conditions apply for all four cases tested. The cases are as follows:

- *Case no. 1*: Basic model design using existing pumps and coolers.
- *Case no. 2:* Same as case no. 1 but with a new optimised pump.
- *Case no. 3:* Calculation with a new cooler based on 2x50% instead of 2x65%* cooling capacity combined with a new optimized pump corresponding to the new coolers.
- *Case no. 4:* Calculations with optimised coolers in respect of low pressure drop combined with a new optimized pump corresponding to the new coolers.

* The way designers, shipyards and ship owners specify coolers has resulted in a doubled safety factor for the cooler. This case study tries to show the consequence of this common mistake.

All calculations and evaluations have been made using FluidFlow, which is "a powerful design and simulation tool for pipe systems". This facilitated quick and effective evaluations regarding for example pressure loss calculations, optimal pump selection and pump cavitation control etc..

CASE no. 1

Background

This case is based on an original design of a SW cooling water system from a preliminary specification stated with no specific knowledge of flow resistance for coolers, filters and elevation location of each component. This system was not optimised in the detailed production design when the system-related equipment and elevation locations were specified. In this way the "first, qualified guess" is used as the final specification for purchasing the pumps. A practice that is not uncommon, especially in "young" shipbuilding nations.

The coolers were selected with a cooling water heat transfer capacity (HTC) of 2x65% of the total heat transfer requirement, calculated as an estimated load factor based on the total amount of cooling consumed (mainly by the main engine and the auxiliary engines).

Results

For the given operating conditions the pump's mechanical power in the duty point is **29.09** kW corresponding to the following values.

Fuel consumption (ts/year/pump):	**57.70**
CO_2 emission (ts/year):	**179.6**
Running cost (USD/year):	**32,807.0**

These results will be used for comparison between the different cases.

CASE no. 2

Background

In this scenario the same cooler as specified in Case no. 1 is used. New pumps have been chosen that run at the specified system pressure. This means that no throttle valves or orifices are needed to keep the pump at the specified operation point.

Results

For the given operating conditions the pump's mechanical power in the duty point is **9.89** kW corresponding to the following values.

Fuel consumption (ts/year/pump):	**19.60**
CO_2 emission (ts/year):	**61.0**
Running cost (USD/year):	**12,545.0**

The savings compared with:

Case no.1:	**66%**

CASE no. 3

Background

In this scenario the total cooling capacity has been reduced from 2x65% to 2x50%. This way, by using the built in safety HTC margin of the cooler and not adding another 15% margin, the cooler is allowed to operate at a lower flow/pressure drop. This has a direct effect on the fuel consumption and CO_2 emission.

Results

For the given operating conditions the pump's mechanical power in the duty point is **6.80** kW corresponding to the following values.

Fuel consumption (ts/year/pump):	**13.48**
CO_2 emission (ts/year):	**42.0**
Running cost (USD/year):	**8,630.0**

The savings compared with:

Case no.1:	**77%**
Case no.2:	**31%**

CASE no. 4

Background

In cases 2 and 3 significant savings have been shown. In case no. 4 optimisation of the coolers due to pressure drop and comparing the yearly costs and CO_2 emissions is compared to the purchasing cost of the entire system. The purpose of this is to determine the optimum between initial installation costs and operational costs.

To do this several different scenarios were considered and evaluated. The most optimised SW cooling system regarding low yearly running costs and very low CO_2 emission gave the following results.

Results

For the given operating conditions the pump's mechanical power in the duty point is **2.69** kW corresponding to the following values.

Fuel consumption (ts/year/pump):	**5.33**
CO_2 emission (ts/year):	**16.1**
Running cost (USD/year):	**3,414.0**

The savings compared with:

Case no.1:	**91%**
Case no.2:	**73%**
Case no.3:	**60%**

Worth mentioning is that a cooler with a lower pressure drop is a larger (i.e. more expensive) cooler generating a higher initial installation cost but a lower operational cost.

CONCLUSION

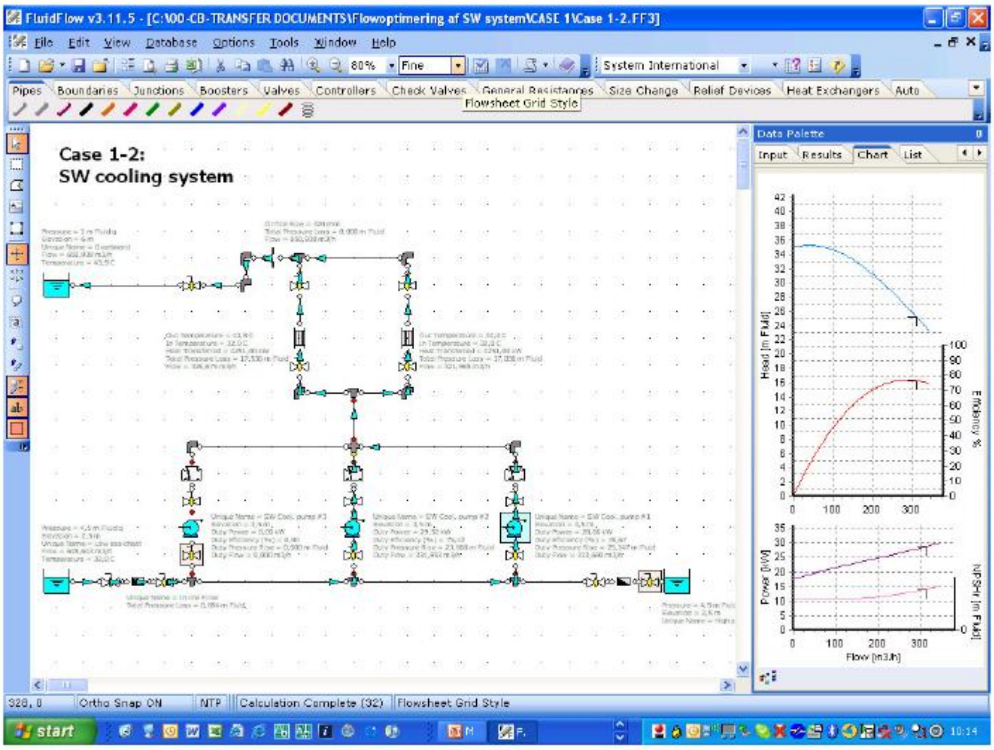
For cooling systems the pressure drop of the cooler is essential. The cooler has a significant impact on the overall system pressure, being that it is the single component of a sea water system causing the highest resistance. Reducing the pressure drop over the cooler allows for installation of smaller pumps which reduces the fuel consumption and the CO_2 emissions. This is a good investment since the overall costs, purchasing + running costs, are reduced as well as the environmental influence.

Letting the pump specification be open until the entire pipe system has been designed in detail with all the components well known, allows for the pump to be optimised to exactly fit the system pressure.

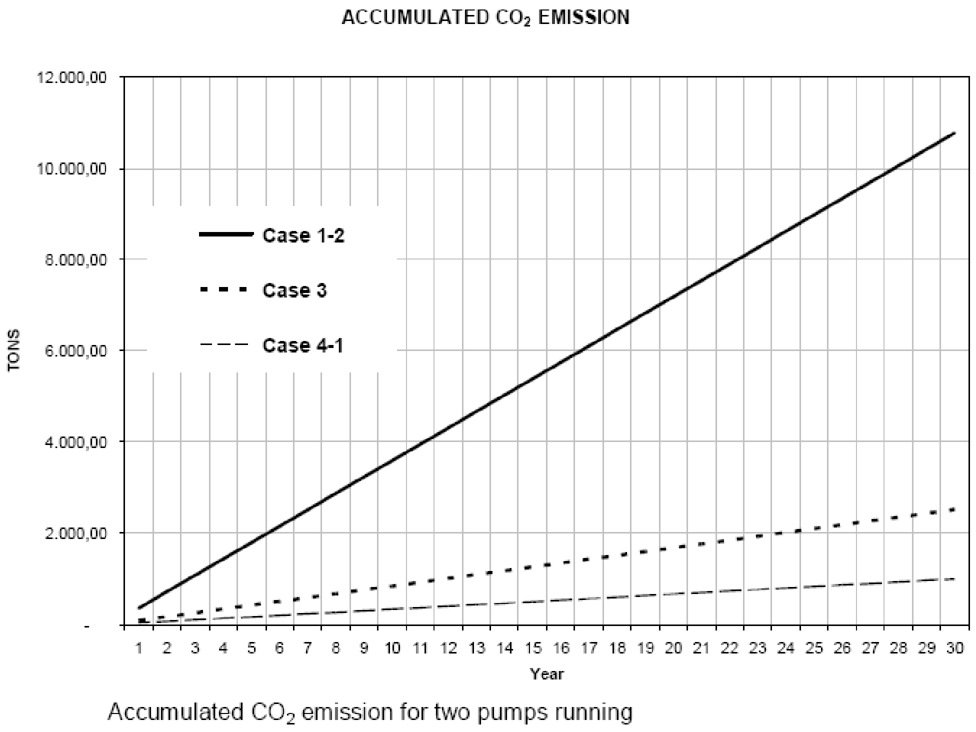
An extra benefit of low pressure is that causes less stress on all components. This, together with the fact that a low pressure drop on the sea water cooler side decreases the pressure drop on the fresh water side and allows for smaller pumps there, is a factor decreasing costs and resulting in shorter investment payback time that has not been included in this report.

REFERENCES

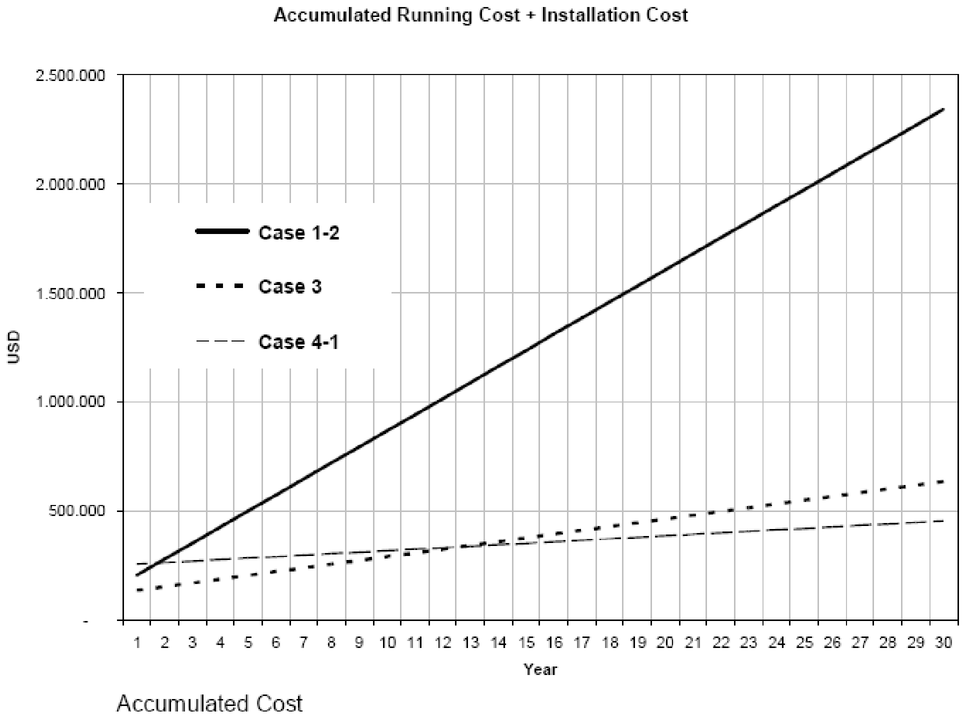
[1] Grontmij Carl Bro ,APV, DESMI; Optimisation of pump- and cooling water systems, 2008-09-11
http://www.desmi.com/download/optimisation%20of%20pump-%20and%20cooling%20water%20systems.pdf



A view of the FluidFlow, the software used for simulation and evaluation for this report.



A graph showing the accumulated CO_2 emission over time in the different scenarios.



A graph showing the accumulated cost in the different scenarios. This states that the initial cost is higher for the more efficient cooling systems but that the investment payback time is short.

Would you like to know more about FluidFlow? Please visit www.mflow.se or contact us at info@mflow.se or +46 (0)31-243930 for a demonstration.