Intermarine Shipyard tests Flownex SE for its naval piping systems

Software found to save time in the design phase

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There are various piping systems that convey many different fluids on board a vessel. Each fluid must reach its user at the right pressure and flow conditions. Accessories such as valves, bends, fittings and pipes induce pressure losses (as a result of factors such as pressure (p), flow rate (q) and pipe size (diameter, A)). The designer has to calculate these probable pressure losses in the pipeline in order to select (or verify) the size of the pump to be installed in the piping system to prevent a number of possible problems. Usually, these calculations to predict pressure losses are performed "manually" using the procedures described in the technical literature, such as the method of equivalent lengths, with the help of software such as Microsoft Excel or similar, and with the lengths and the fittings information being derived from one-line diagram (2D CAD software). The Shipyard wanted to test the capability of the 1-D computational fluid dynamics (CFD) software known as Flownex Simulation Environment (SE), provided by EnginSoft S.p.A., as a pipeline solver for its naval piping systems.

The results obtained with Flownex were compared with the "manual / classic" method described above and also with actual field data from on-board measurements.

CFD model

The testing activity focused on the "auxiliary seawater cooling system", in which we concentrated on different lines such as the suction and delivery lines of the pumps, and the inlet and outlet lines of the diesel generator. The Flownex model was designed with the following characteristics:

- ***Fluid*** - the fluid was customized to match the average seawater characteristics (such as density, kinematic viscosity, and temperature) Nodes and fittings - the pipelines were designed with their characteristic values using the software elements
- ***Pumps*** - these items were modeled by introducing the relevant performance curve (data provided by supplier) P=f(Q)

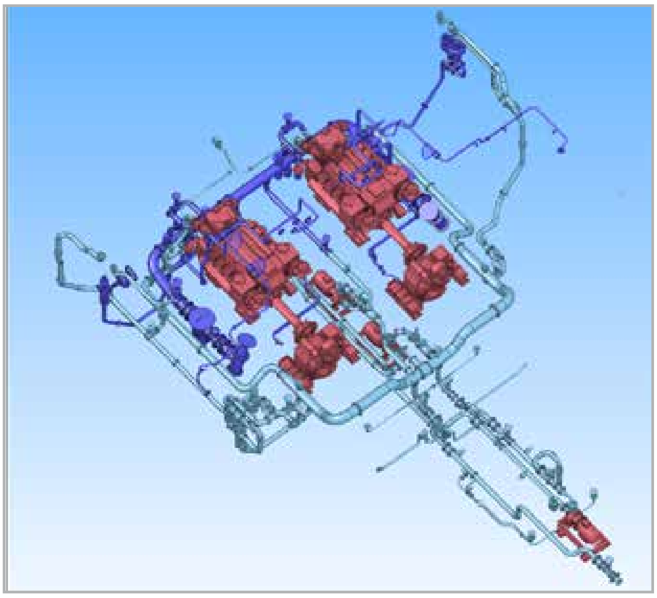

Fig. 1 - Excerpt of Auxiliary Piping System 3D Model (CADMATIC SW; pumps inlet and outlet)

Boundary conditions -> for each suction and delivery line, these were set with P (for the inlet) and Q (for the outlet).
Some special fittings, such as expansion joints that had no similar components already available in the Flownex library, were replaced with "basic pipe" elements of equivalent length that corresponded to their concentrated losses.

Numerical results

The pipelines were calculated at two different flow rates: the lower at approximately 39 m^3/h, corresponding to the operating point of the pump (for improved efficiency under design conditions), and the higher at approximately 112 m^3/h, corresponding to the flow rate when all the users are running the cooling system simultaneously (the worst potential condition, furthest from the design conditions).Lower flow rate case (39 m^3/h)
Notes:

- *) Boundary conditions may differ for intermediate or final lines due to a different result in previously calculated lines
- **) Negative values of pressure drops are related to a descending pipe, because of the gravitational effect.

The Flownex results showed a slight increase in pressure loss values (1) indicating a more conservative behavior in the software with

Pipeline	Manual / Excel P [bar]	Flownex P [bar]	Experimental Results P [bar]
Boundary Conditions	1,247	1,247	-
ΔS_{1-2} (39 m^3/h) Suction line losses	0,163	0,164	-
Pump differential (39 m^3/h)	3,4	3,4	-
ΔS_{3-4} (39 m^3/h) Delivery line losses	0,077	0,081	-
Node #81 Delivery Node pressure	**4,407**	**4,402**	**-**
Inlet and Outlet lines from the diesel generator (Fig. 3)			
Boundary Conditions	4,407*	4,416*	-
ΔS_{5-6} (45 m^3/h) Inlet line losses	0,807	0,838	-

Pipeline	Manual / Excel P [bar]	Flownex P [bar]	Experimental Results P [bar]
ΔS_{7-8} (10,8 m^3/h) Inlet line losses	0,129	0,282	-
ΔS_{9-10} (10,8 m^3/h) Inlet line losses	-0,095**	-0,074**	-
Genset concentrated losses	1,394	1,394	-
ΔS_{10-11} (45 m^3/h) Outlet line losses	-0,177**	0,473	-
Node #81 Outlet Node pressure	**2,349**	**1,504**	**-**

respect to the "manual" calculation. The same behavior is shown in (2), except for the Outlet line, because of the orifice device installed (these elements require further investigation, beyond the scope of this article).
Notes:

- Experimental results from on-board measurements

In this case (112 m³/h), interesting also due to the availability of field data measured on the suction line, it can be noted that both calculations (Excel with 0,671 bar, Flownex with 0,684 bar of pressure drop) have a conservative behavior related to the pressure gauge measurements (0,397 bar), thus predicting a higher pressure loss than the ones measured directly on board. No actual data is available for the delivery line, so we could only compare the "manual" calculations with the Flownex ones. The first returned a pressure drop of 0,546 bar, the second reported a pressure drop of 0,602 bar. In addition,, in this case, the tested software displayed more conservative behavior.

Conclusions

In summary, the study led to the following conclusions:

- The aim of the study, in terms of calculating the pressure loss in the pipeline for design purposes, was achieved.
- The software provides results that are comparable to the traditional method, leading to the same results in terms of pipe dimensions or pump size selection.

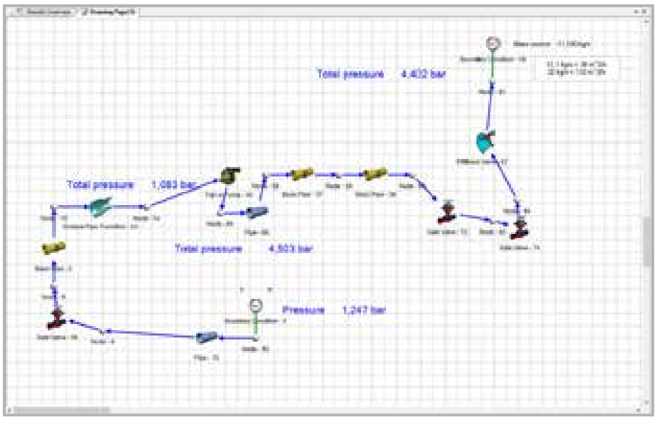

Fig. 2 - Suction and delivery lines of the pump (39 m3/h)

Pipeline	Manual / Excel P [bar]	Flownex P [bar]	Experimental Results P [bar]
Suction and Delivery lines of the pumps (Fig. 4)			
Boundary Conditions	1,247	1,247	-
ΔS_{1-2} (112 m³/h) Suction line losses	0,671	0,684	0,397
Pump differential (112 m³/h)	2,4	2,4	2,4
ΔS_{3-4} (112 m³/h) Delivery line losses	0,546	0,602	-
Node #81 Outlet Node pressure	**2,430**	**2,506**	**-**

Higher flow rate case (112 m³/h)

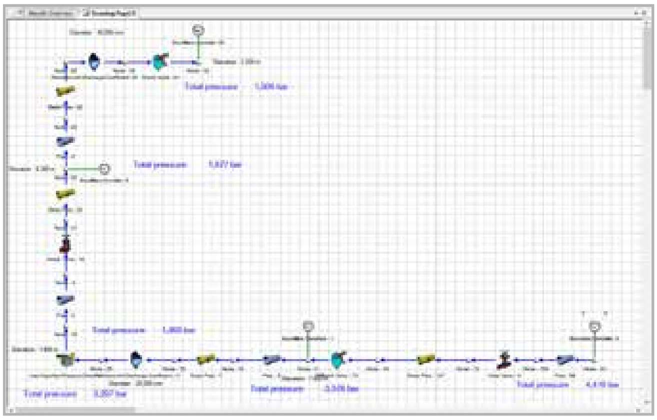

Fig. 3 - Inlet and outlet lines of the diesel generator

- The software can be a valid ally to save time during the design phase.
- Some fittings, such as restrictors (orifices) need to be better modeled to be successfully incorporated into the simulation.
- The comparison between the on-board measurements and Flownex could be extended to all systems in order to "calibrate/ ensure convergence" with the final software values.
- Further developments could include the use of Flownex SE software for all ship piping systems.

For more information
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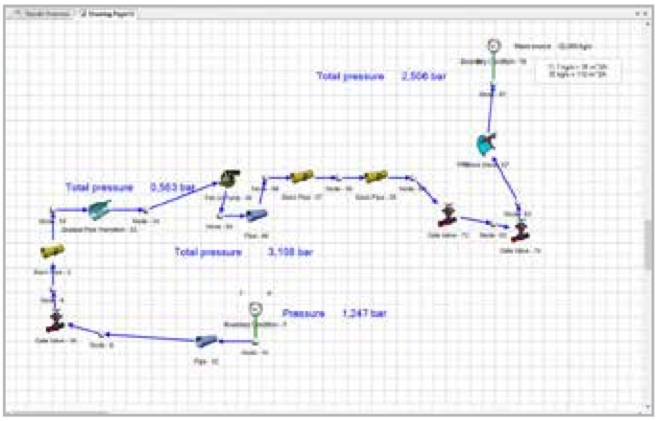

Fig. 4 - Suction and delivery lines of the pump (112 m3/h)

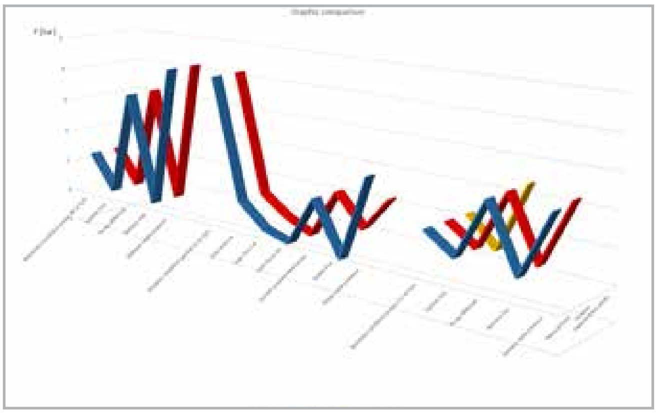

Fig. 5 - Graphic comparison of the pipelines