AFT Arrow™ Ensures Proper Fan Sizing in Nitrogen Closed Loop

CASE STUDY

General Facility

Fan Sizing

Applied Flow Technology

L&T Technology Services
Vadodara, India
Platinum Pipe Award Honorable Mention: Most Interesting Model

Sumit Sayankar, Senior Engineer with L&T Technology Services, was tasked with optimizing the fan hydraulics of a nitrogen closed loop in Frankfurt, Germany. The nitrogen loop is used to dry a slurry mixture, picking up process vapors and traces of solids in the process. These solids are removed via a bag filter, and the fluid is then cooled to condense out some components. The remaining stream is preheated before returning to the fan.

The fan to drive this loop had to meet supply pressure requirements under a variety of conditions, considering fan speed, auxiliary line draws, and the impact of the process fluid itself during evaluation.

The process fluid mixture was created from the built-in NIST REFPROP database, and its properties were verified against Aspen HYSYS.

Modeling the loop
The loop starts at the fan being evaluated with several speeds to consider. These speeds were entered as fan curves at specific RPMs according to the manufacturer's datasheet. Sayankar noted this saved significant time during sensitivity analysis.

From the fan, the process fluid passes through a series of heat exchangers for heating and cooling, considering the impact to fluid properties as a function of pressure and temperature automatically. Due to the complex geometry of the heat exchangers, each was modeled using resistance curves. These resistance curves fit to a measured pressure drop at the maximum flowrate, from which the software can determine pressure losses at other flowrates.

The fluid then proceeds through filters, dryers, and typical control and flow elements such as orifices and venturis. These components were similarly modeled using resistance curves based upon measured pressure drop data. The system also had a series of auxiliary lines originating from the main loop, which Sayankar could easily turn off and on at different stages in the analysis. The model could also test the operating range of each auxiliary's control valves.

The Visual Report (Figure 1) highlights the different temperatures seen in the system.

Process Fluid
In addition to fan speed and feed to the auxiliary lines, the system also considered the effect of the process fluid on the hydraulics. The system uses pure nitrogen gas during start-up and a 7-component mixture during operation. The mixture was created from the provided NIST REFPROP database, and its properties were verified against Aspen HYSYS. Sayankar noted generating accurate mixtures from within the software rather than manually specifying properties was very useful.

Using AFT's Analysis Tools
With the wide range of operating conditions to consider, Sayankar took advantage of some scenario specific tools available in AFT Arrow. He was able to use the Scenario Comparison tool to ensure each scenario's input isolated the intended variable, while Multi-Scenario Output (shown in Figure 2) could easily compare results across each test case. Sanyankar also used Design Alerts and the Visual Report to identify and mitigate areas of high pressure loss.

By testing the selected fan across many different operating speeds, conditions, and requirements, Sayankar was able to develop a robust system approach to his engineering design without a massive manhour investment to analyze the complicated network.

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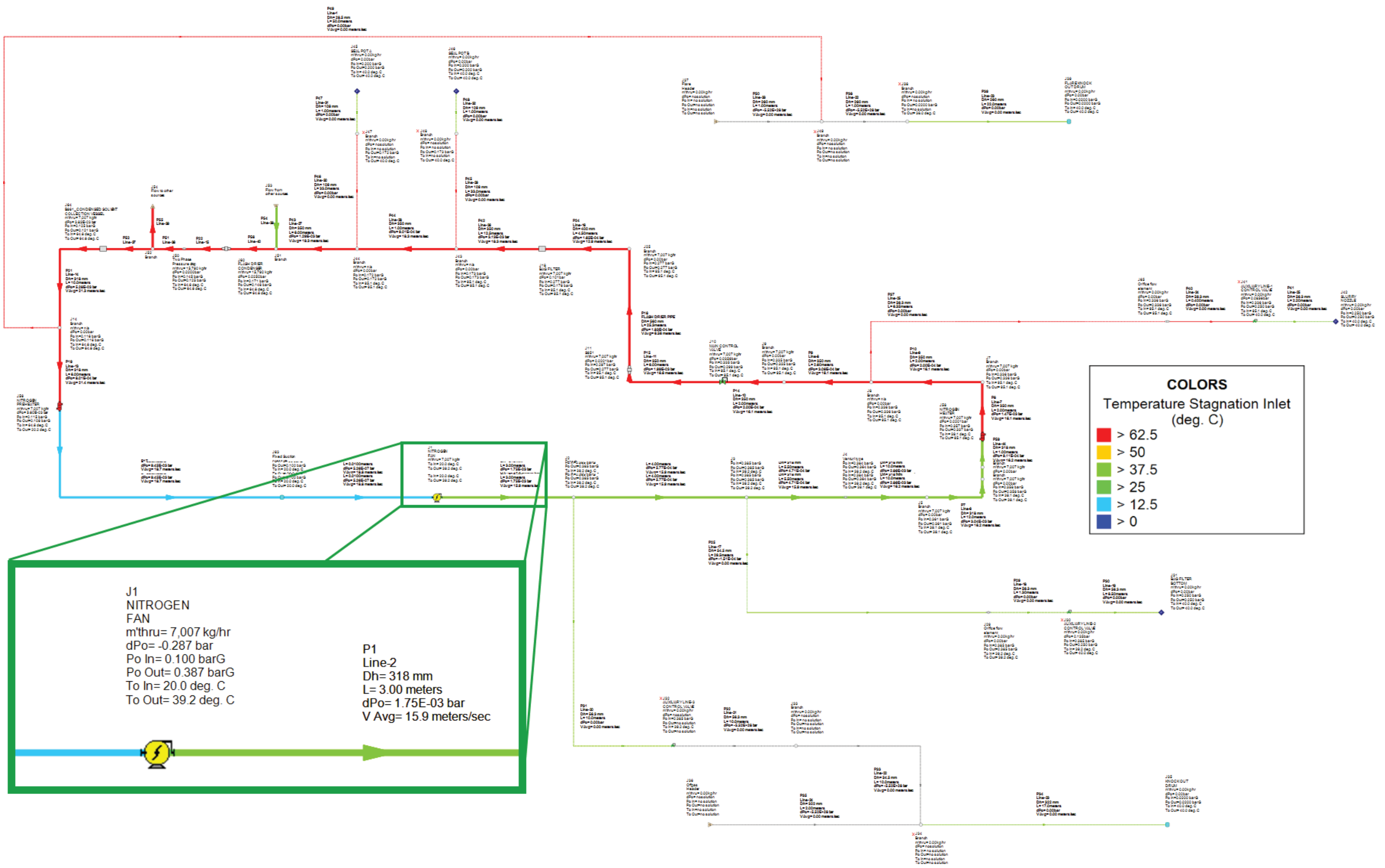

Figure 1: Visual Report view of the nitrogen loop, with inlet temperature color coded and a detailed view of the fan and pipe parameters reported.

All Junctions | Assigned Flow | Assigned Pressure | Branch | Compressor/Fan | Control Valve | General Component | Heat Exchanger | Tank

Compressor/Fan	Name	Mass Flow Rate Thru Jct (kg/hr)	T Static In (deg. C)	T Static Out (deg. C)	P Static In (barG)	P Static Out (barG)	dP Static Total (bar)
1 - Base Scenario/1. Start-up operation (with Nitrogen)/1.a) Maximum RPM	N/A	7,006.8	19.8233	39.6913	0.097651	0.384693	-2.8704E-01
1 - Base Scenario/1. Start-up operation (with Nitrogen)/1.b) Normal RPM	N/A	5,839.0	19.8776	35.2404	0.098370	0.316199	-2.1783E-01
1 - Base Scenario/1. Start-up operation (with Nitrogen)/1.c) Minimum RPM	N/A	3,503.4	19.9562	28.0009	0.099414	0.210033	-1.1062E-01
1 - Base Scenario/2. Normal operation (with process vapours)/2.a) Maximum RPM	NITROGEN FAN	7,006.8	19.8322	39.0345	0.097698	0.385230	-2.8753E-01
1 - Base Scenario/2. Normal operation (with process vapours)/2.b) Normal RPM	N/A	5,839.0	19.8835	34.7293	0.098402	0.316495	-2.1809E-01
1 - Base Scenario/2. Normal operation (with process vapours)/2.c) Minimum RPM	N/A	3,503.4	19.9581	27.7274	0.099425	0.210056	-1.1063E-01

Figure 2: Multi-Scenario output comparing fan performance at minimum, normal, and maximum speeds for both the start-up pure nitrogen and 7-component process fluid.