

Fluid Power Design

Fluid Power Design (FPD), based in Grantham, England is a company that generates engineering solutions. They design and manufacture their own systems and products and supply engineering services to other companies. FPD aims to provide added value. Reliability, engineering competence and professionalism are the basis of their service.

FPD is formed from two main departments, Nexus and Technical. The Nexus department has designed and developed a innovative method of coupling the air and electrical services on articulated vehicles. Supplying to major OEM's worldwide, FPD are the market leader for this product. The Technical department designs, builds and installs fluid power, mechanical and electrical systems that are tailored to solve specific engineering requirements.

Technical Department

The FPD design team uses Flowmaster, a sophisticated analytical computer modelling system. Flowmaster is capable of modelling a wide variety of applications and can emulate many types of fluids from gases to semi-solids. The computer model allows all types of fluid motion to be accurately assessed and tested without the need for long, expensive prototype programmes.

Flowmaster is capable of modelling a wide variety of applications and can emulate many types of fluids from gases to semi-solids.



System Analysis

Flowmaster is capable of producing a wide spread of analytical data. System pressure, flow and temperature can be calculated at any point in a circuit. The model can run both steady state and dynamic applications meaning digital, proportional and time-based systems can be accurately predicted.

System Enhancement and Performance

The luxury of generating a design solution from the drawing board is not always an available option. There are often many constraints that need to be considered before a solution can be reached. In many cases FPD are asked to solve a problem on an existing system. In these cases all system components are modelled, including the flexible hoses and end fittings. This information is firstly used to verify the current system behaviour. Once the results from the model are shown to be representative of the actual measured system characteristics, the components can be changed to allow system performance to be optimised and higher efficiencies reached. If additional services or applications are required, modifications and upgrades can be incorporated rapidly into the model. Feasibility of new sub-systems can be tested quickly and components can be resized easily to give optimum system performance and reliability.

System Design

To support the system modelling activities, FPD is capable of managing projects at a turnkey level. The design team's expertise extends beyond the design activities to building and installing complete systems. FPD have in-house electrical and electronic capacity that allows them to design, source and build their own control systems and panels. In addition they are able to supply MIG welding for general purpose fabrication and TIG-welded pipework to BSEN287-1:1992 to supplement their power-pack and installation activities.

System Upgrades and Modifications

FPD is capable of upgrading existing systems to give improved performance. Their role in projects can be tailored to suit specific needs, supplying as little or as much input as is required to fulfil the desired requirement. Typical examples of this type of project are:

- Water hydraulic system conversion to oil hydraulics.
- Increased system speed and force characteristics.
- 6 axis, time based vehicle simulator control system.
- Proportional cooling control system.
- Re-piping of systems for flow optimisation and balancing.
- Closed loop, force controlled hydraulic press.
- Closed loop, position controlled milling machine.

Testing and Commissioning

All systems can be tested and commissioned using pressure and flow measurement equipment. In addition, to ensure initial fluid cleanliness, all systems are flushed and oil analysis equipment can be used to ensure contamination levels are within NAS 1639 specifications.

A Typical Project

A recent project concerned a battery powered locomotive intended for a mine environment. The locomotive, a double bogie, six-axle machine with 12 wet-brake units, was intended to descend a 1:10 gradient with a gross train weight of 40 tonnes at a maximum speed of 13 km/hour and then bring the train to a halt. The problem was that after excessive use of the brakes the cooling fluid vented from the main tank leaving the system partially empty.

The Analysis

FPD built a model of the complete cooling system using Flowmaster's graphical user interface. The system comprised of a supply pump, reservoir, wet-brake units, filter assembly and radiator/heat ex-changer. The wet-brake units and reservoir were treated as thermal bridge components with given thermal heat input and output characteristics respectively. This allowed the wet-brake heat input rate and the header-tank thermal convection effects to be modelled. The filter assembly was modelled as a discrete loss assigning characteristics of pressure drop versus flow rate at known temperatures. Pipework and fittings were modelled as appropriate straight lengths of pipe, bends, T-junctions and pipe transitions.

Data acquisition for the model included:

- Thermal characteristics of the radiator including heat dissipation rate, thermodynamic effectiveness and pressures drops.
- Properties of the cooling fluid of dynamic and kinematic viscosity, specific heat capacity, thermal conductivity, vapour pressure and density at a range of temperatures.

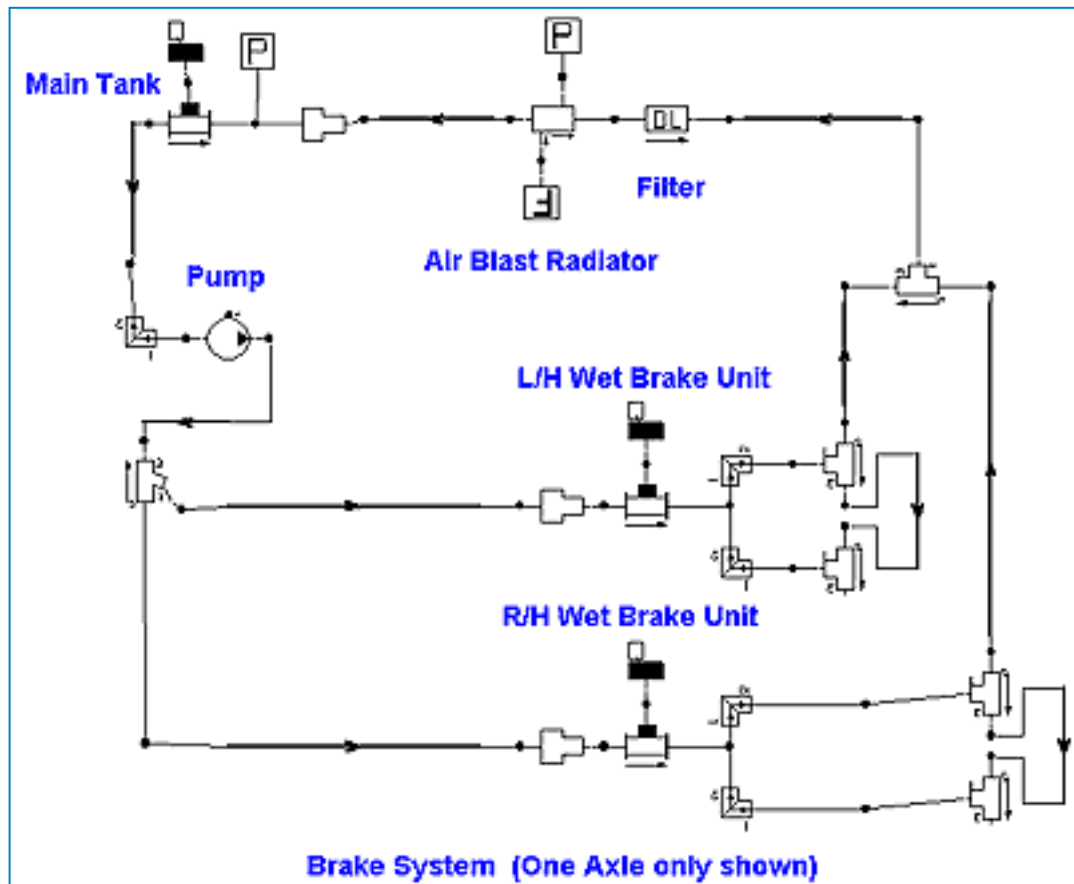
The model was run in heat transfer steady state mode to simulate stabilised temperature conditions throughout the system and model verification was achieved by comparing analysis results with test results at known conditions.

Analysis Results

The analysis showed two areas of concern. The first was a fluid flow rate imbalance between the left and right sides of the vehicle, the second was that excessive temperatures were being experienced in the wet-brake unit areas. The imbalance in fluid flow compounded the temperature problem in that the fluid temperature, in the side with the lower flow rate, was in excess of 100°C. From the fluid property data the maximum operating temperature of the cooling fluid was 100°C. At this temperature the water in the fluid will volatilise and will boil from the bulk fluid, resulting in release of gas into the system. The gas build up during a period of excessive braking will eventually work through to the reservoir causing the fluid and gas to vent from the system. Pressure in the system at the elevated temperatures were predicted to be within specified limits but at a condition simulating a cold start, the predicted pressures were approaching the system maximum.

Having determined the cause of the problem FPD had to determine an acceptable solution within a number of constraints. For example, the mine environment required a non-flammable cooling fluid and no higher specified fluid of this type was available. Further constraints were that no major design changes could be made

so increased brake unit size was unacceptable. However, a number of changes were possible. The system imbalance was corrected by changing the pipe sizes. A Flowmaster analysis confirmed the required sizes.



With the given constraints the only solution to the excessive temperatures was to reduce brake heat input by descending at a lower speed. Further Flowmaster analysis showed that system temperatures would be within limits with this reduced duty cycle. However, analysis at the low temperature operating point showed that the system would experience pressures greater than the design limits for the brake unit seals. The analysis showed that this was due to over-cooling the fluid, which led to a marked increase in fluid viscosity and hence pressure. Adding a thermostatic bypass to the air-blast radiator prevented this over-cooling and kept the system pressures within limits.

Conclusion

The analysis performed by FPD using the Flowmaster computational tool showed that the overall ability of the cooling system to cope with the rate of heat input was insufficient. With no major redesign being possible the only solution was to reduce the duty cycle by descending at a lower speed. This was confirmed by a Flowmaster analysis. Fluid Power Design have applied Flowmaster to high-pressure fluid engineering systems with considerable success. Flowmaster has proved to be an extremely valuable tool for design validation and optimisation. Fluid Power Design also found Flowmaster a powerful diagnostic tool for problem resolution in several projects.

www.fpd.uk.com