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Application Solution

Dynamic Simulation Example:

Compressor Motor Restart

Summary

This document describes how DYNSIM can be used to model a compressor trip and subsequent restart.

Business Value

Use DYNSIM's compression modeling to maintain high reliability of compression equipment, reducing equipment failure and production downtime.

INTRODUCTION

Large industrial compressors typically do not experience startup difficulties at low discharge pressure conditions. Compressor motors are started with the recycle valves opened and the suction valves throttled to maintain low discharge pressure until the motor reaches the design speed. However, if a compressor trips during normal operation, the compressor may have to be restarted at higher discharge pressures at settle out conditions. Horsepower and torque requirements for restart may exceed the capacity of the motor. The motor may fail to reach maximum rpm and trip off due to high winding temperatures. Another restart cannot be attempted until the motor has cooled, extending the time of lost production.

Dynamic simulation can be used to evaluate compressor motor startup scenarios including hot restarts. DYNSIM®, from SimSci-Esscor™, includes a compressor model that can simulate startup conditions as well as a motor torque curve varying as a function of speed. This document describes how DYNSIM can be used to model a compressor trip and subsequent restart.

DYNAMIC SIMULATION COMPRESSOR STARTUP BENEFITS SUMMARY

- Determine if compressor can restart at settle out pressure
- Determine suction throttle valve and recycle valve positions for startup
- Size motor based on torque requirements
- Avoid discharge flare
- Maintain high reliability of compression equipment

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DYNAMIC SIMULATION MODEL

Figure 1 illustrates the dynamic model of a two-stage compressor system. The model includes knockout drums, suction, interstage, discharge piping, intercooler, after cooler, and recycle valves. The motor drives a single shaft, which is speed locked to the compressor models.

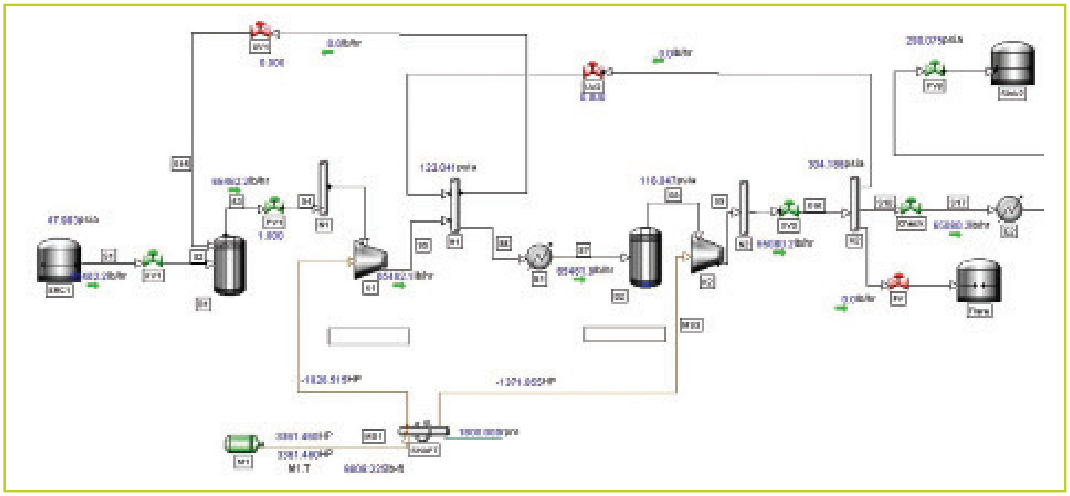

Figure 1: Two-Stage Compressor Model

The following assumptions were made in the development of this model:

- The motor includes a typical manufacturer's torque curve. There is a torque valley in the curve near 20% speed that is lower than the design torque at full speed.

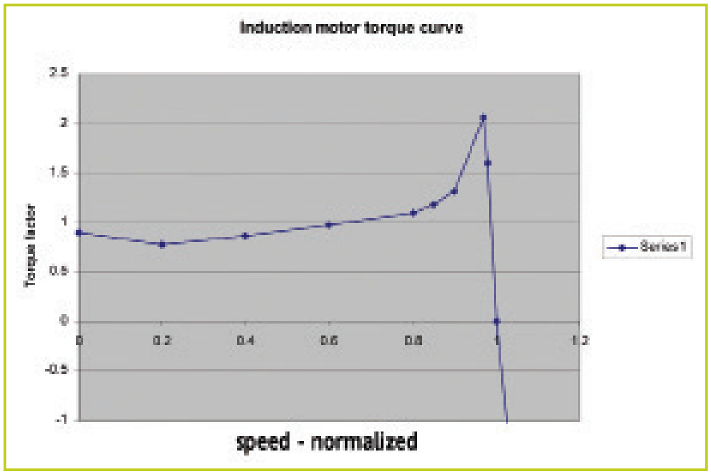

Figure 2: Motor Torque Curve

- The motor has a gearbox. The shaft compressor rotating inertia has to be adjusted by the gearbox ratio and entered into the DYNSIM shaft model.
- The compressor efficiency curves were extended far to the left such that the efficiency is approximately 30% at full speed and no flow. This is a hypothetical condition since the compressor would be in surge. Using DYNSIM multiple speed curves for head and efficiency from the compressor manufacturer is an improved way to model this compressor.
- The full speed efficiency curve was linearly prorated by shaft speed such that at half speed, the full speed efficiency at that volumetric flow was also reduced by half. The compressor vendor should confirm this relationship.

CASE EXECUTION AND RESULTS

A DYNSIM Scenario was created to conveniently run the simulation cases repeatedly while doing initial trial runs.

Case 1: Compressor startup at shutdown conditions

In Case 1, a scenario was developed to perform the following steps:

1) Load the shutdown case initial condition
2) Open the recycle valves
3) Throttle the suction throttle valve to 10% open
4) Wait 10 seconds
5) Start motor

Figure 3 demonstrates that the motor speed increases rapidly in approximately 17 seconds (blue line). Discharge pressure does not increase significantly with the recycle valves open (magenta line). Motor power and torque quickly subside as soon as the compressor is up to speed (red and green lines).

The transition to full load operation is not modeled. This transition includes closing the recycle valves and opening the suction throttle valve. This is an uneventful process as the motor has sufficient torque once it is fully accelerated.

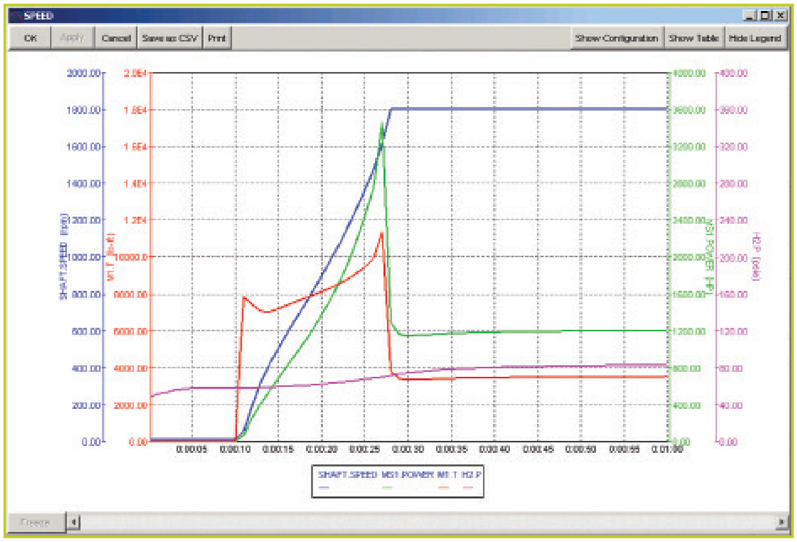

Figure 3: Motor Startup at Shutdown Conditions

Case 2: Compressor restart at settle out conditions

To model compressor motor restart, the compressor is tripped from normal operating conditions, and then restarted once the motor spins down.

In Case 2, a scenario was developed to perform the following steps:

1) Load the normal operating case initial condition
2) Wait 10 seconds
3) Simultaneously trip the motor and open the recycle valves
4) Wait for compressor speed to reduce
5) Restart motor

Figure 4 demonstrates that the motor speed drops to less than 100 rum around 45 seconds (blue line). The compressor pressure settles out around 200 psia (magenta line), and at this high pressure, the motor cannot restart and stalls around 500 rum indefinitely. To restart the motor, the discharge pressure must be reduced by opening a vent valve to the flare. The restart would cause the motor windings to overheat. The motor must be allowed to cool before another restart can be attempted.

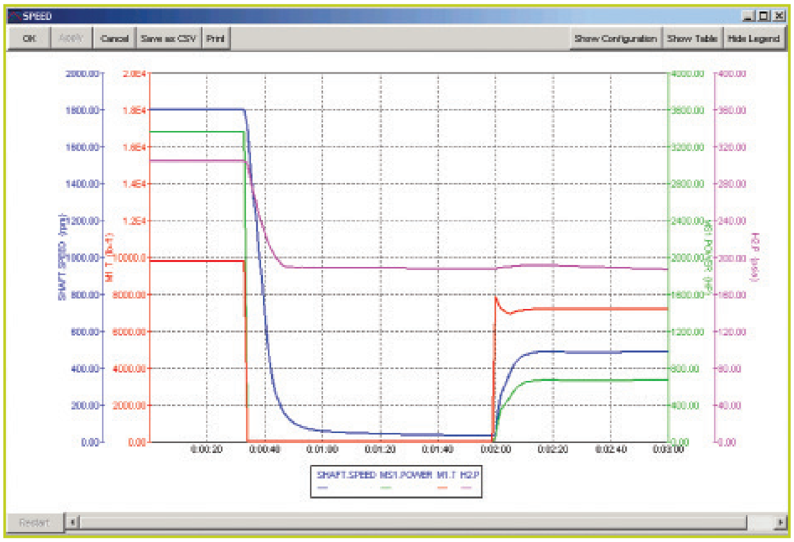

Figure 4: Motor Startup at Settle Out Conditions

Additional Study Work

The following are possible solutions to restart the motor after a trip:

- Adopt a restart procedure to vent to flare first. This may not be acceptable depending on local regulations
- Redesign the system with a larger motor
- Redesign with decreased discharge piping volume or increased suction piping volume to reduce settle out pressure

This model may also be extended to perform surge control analysis.

Additional Model Refinements

Some additional model modifications can be made for a more thorough analysis.

- Calibrate model to vendor data or live operating data
- Use multiple compressor curves at various speeds with data provided from manufacturer
- Include surge controllers on recycle valves

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