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Inprocess Application Overview

Design and Troubleshooting of Compressor Systems by using Dynamic Process Simulation

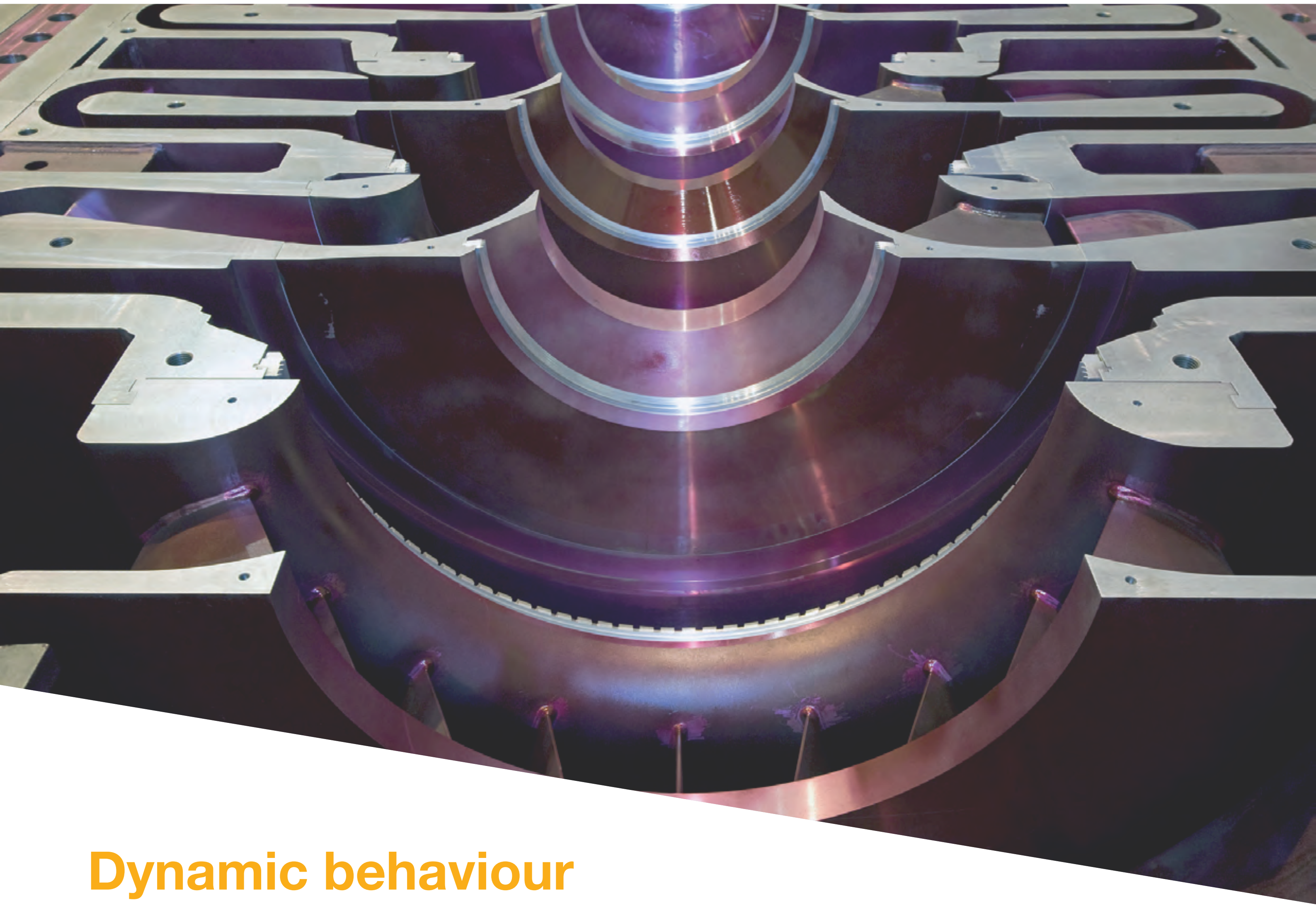
An Inprocess Application Overview by José María Nougués

Dynamic Simulation

The use of dynamic process simulation has been established in the last few years as a reliable and effective tool to analyse transient behaviour of process systems. Common Examples for applications are:

- Dynamic Models to support safety analyses
- Virtual Plant Models for Operator Training
- Dynamic Models to support the design of (Advanced) Process Control Systems
- Design and Operation of pipelines and compressor systems

Commercially available process simulation software tools (e.g. Honeywell UniSim, AspenTech HYSYS Dynamics, etc.) enable detailed dynamic plant models to be configured from standard model algorithm building blocks. Once built, these models are verified against plant or design data in order to validate the model predictions. The software tools allow the scaling of the level of detail of the dynamic model and, consequently, a major challenge of dynamic simulation is to select the right level of detail in order to predict realistic behaviour without having to collect and use vast amounts of plant and design data.



Dynamic behaviour of compressor systems

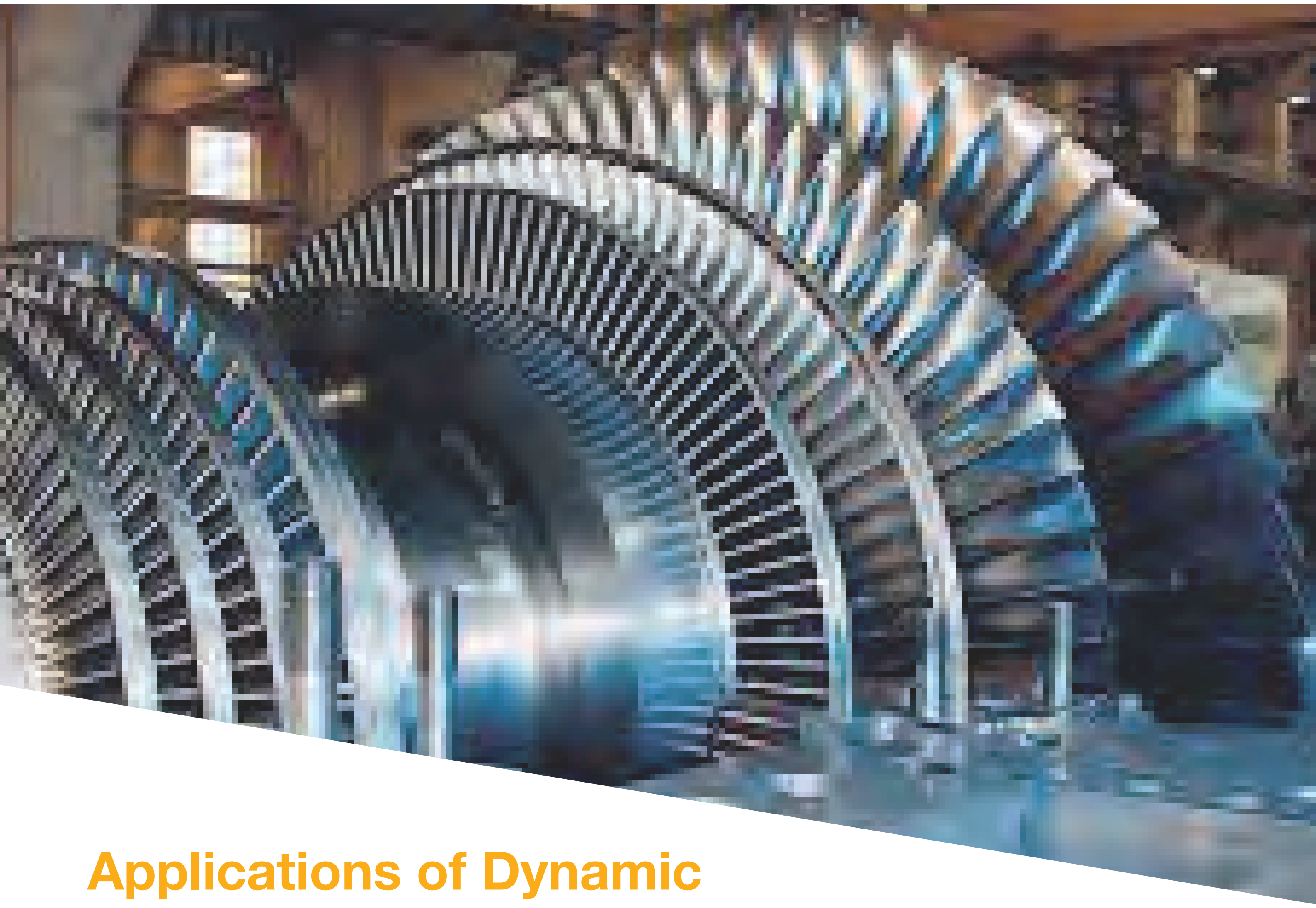
Centrifugal compressors systems show performance characteristics that mainly depend on the operating point imposed on them by the process units and the connection piping around the compressor.

Often, large compression systems have several compressors operating in parallel, with some of them in standby. Therefore, even in normal operation there are frequent start-up and shutdown operations while switching between compressors, e.g. to accommodate throughput changes. The transient analysis of these operations is critical to evaluate the dynamic behaviour of the compressor system and the associated control and safety systems.

Frequently, the most important analysis to be carried out for compressor systems is to understand if the compressor system could enter into surge[1] due to changes in the operating conditions, or due to shut down/start-up of other compressors in the system.

The protection of the compressor against surge is essential. Surge situations can be overcome by varying the number of compressors in use and/or changing the recycle rate, therefore moving the operating point in the performance map away from the surge line. This is accomplished by an integrated anti-surge system, which monitors the performance of the compressor stage and opens a recycle valve as the machine approaches surge conditions. Surge controllers are designed to prevent surge, and (for complex systems) the surge control strategy can be validated by dynamic modelling. Another aspect of the complexity of large compressor systems is the overlay of dynamic behaviour of the different compressors in the system with the dynamic behaviour of their respective drivers and the dynamic behaviour of the process connected to the compressor. Again, dynamic process simulation is an adequate tool to assess the influence of these transient effects on the compressor performance.

[1] Surge occurs when the pressure head demanded by the process system cannot be supported by the pressure head versus flow performance characteristics of the compressor at the current operating speed.



Applications of Dynamic Process Simulation of Compressors

Dynamic Process simulation has been proven a useful tool for a wide variety of analyses of compressor systems – during the design phase, as well as for trouble-shooting and revamping of existing compression systems. The list below gives a number of application examples.

1. Verification of the operating capability of the compression unit within the selected process scheme. Identification of potential problems and assessment of any required modifications especially related to the sizing of the ASCVs.
2. Analysis of compressor start-up – e.g. after a compressor trip (high discharge pressures). Verification of start-up procedure from hot stand-by.
3. Analysis of possible shut-down and emergency shutdown procedures and determination of the impact on the other compressors in the system.
4. Confirmation of the equipment design – including the designed protections and safety layers. Evaluate hot gas bypass and valve sizing.
5. Assessment of the designed anti-surge control (fitting the surge controller to the application),
6. Optimization of the current surge control line to minimise power consumption (i.e. optimisation of flow margin between surge and control lines according to defined criteria).
7. Assessment of the performance controller and the load sharing system
8. Analysis of the location of the non-return valves.
9. Determination of Settling-out-pressure, depressurization time estimation and blowdown valve sizing.
10. Testing and verification of compressor and driver integration with reference to transient behaviour during run down.

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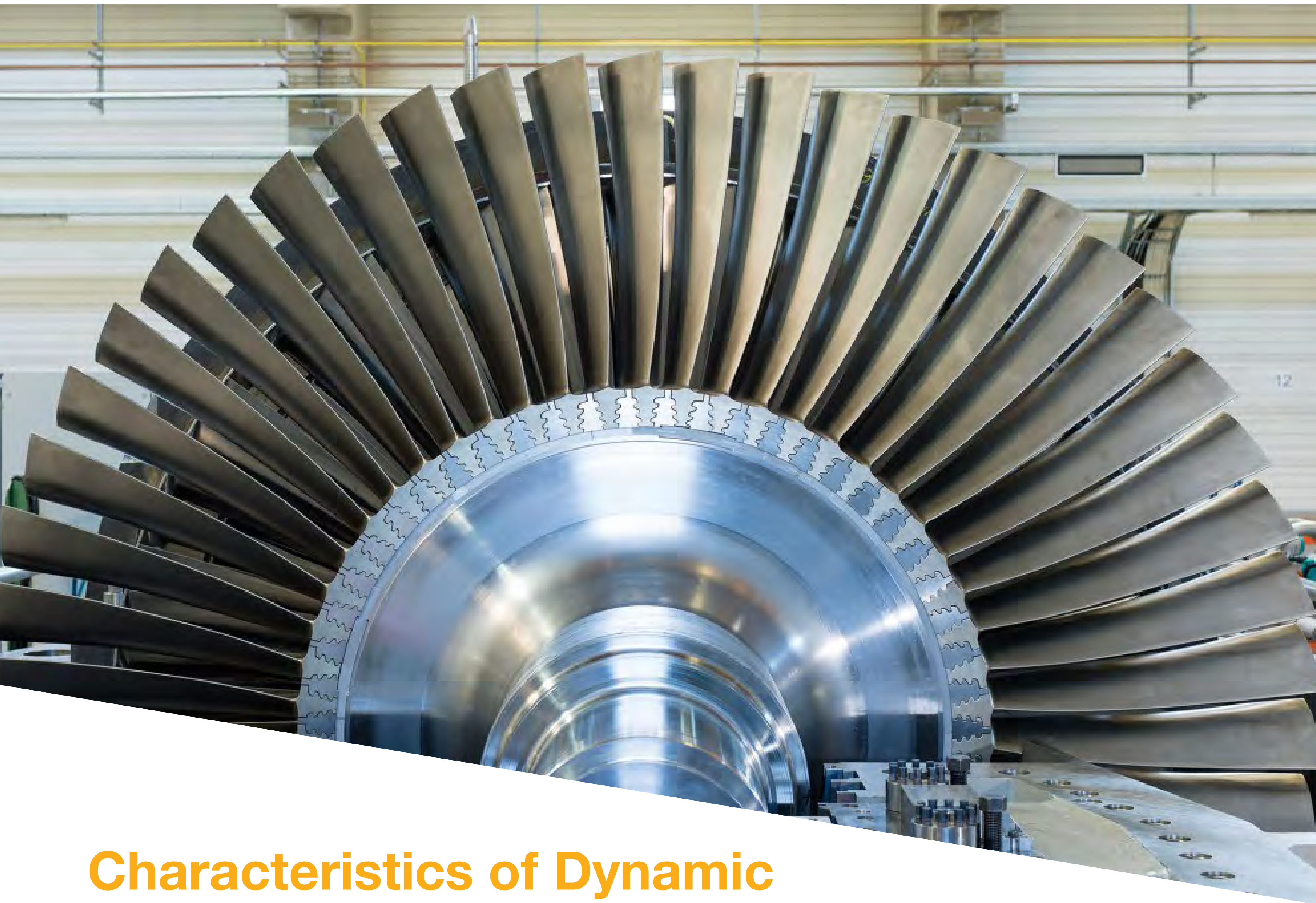

Characteristics of Dynamic Process Simulation of Compressors

Modern dynamic process simulation software tools are capable to represent complex compressor systems with sufficient degree of detail to support the type of analyses that are described above. Normally, in the process simulator the compressor unit is modelled using a global parameters model for the fluid side - calculating rigorously the process conditions by following the isentropic line from inlet to outlet pressure. Using the enthalpy at that point, as well as the specified efficiency, the simulator then determines the actual outlet enthalpy. For an irreversible process, the work determined for the mechanically reversible process is multiplied or divided by an efficiency to give the actual work. The compressor models are able to handle multiple compressors curves as a function of speed, as well as multiple compressor curves that describe the compressor performance as a function of inlet guide vain position. Other specification settings are also available - depending on the process simulation software. The following mechanical and operational details are normally also considered:

- Inertia and Friction loss;
- Possibility to link compressors or turbines that are located on the same shaft;
- Specification of surge and stonewall curves;
- The engine inertia and speed –torque curve for the electrical engine can be represented and dynamic properties included.

In addition, it is usually possible to customise the model in order to allow for any application specific needs – e.g. it is possible to include client-specific surge control algorithms or existing client-specific compressor models in the standard process simulation software.

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info@inprocessgroup.com
+34 933 308 205
www.inprocessgroup.com