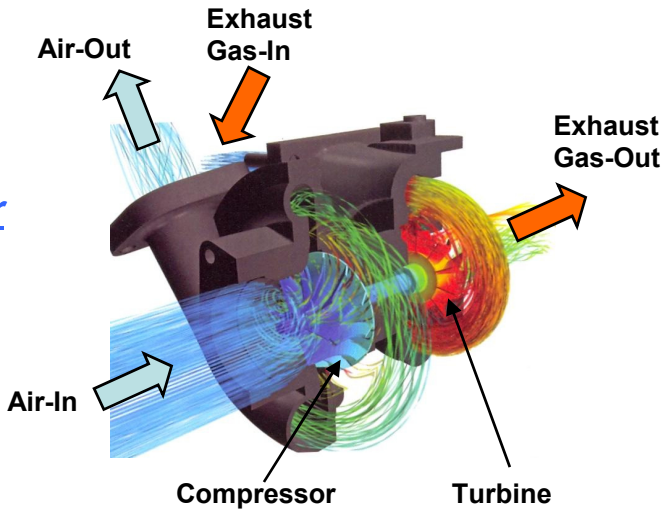
University of HUDDERSFIELD

Model-based Fault Detection for a Turbocharger

Motivation

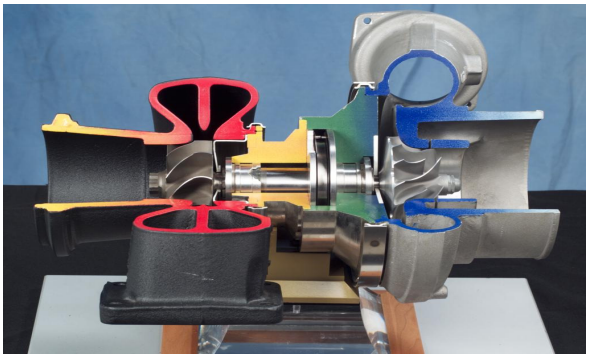
- Turbocharger is widely used on automotive, off highway, power generation and marine applications, etc
- Faults might happen under extreme conditions
- Inspecting periodically will cost plenty of time and money
- Parameters changing while faults happen can be used
- Model-based is an effective way for fault detection

Introduction of Turbocharger

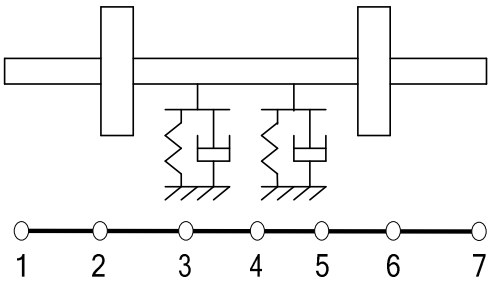


•A turbocharger comprises a turbine and a compressor linked by a shared axle. The turbine inlet receives exhaust gases causing the turbine wheel to rotate. This rotation drives the compressor compressing the ambient air and delivering it into cylinder
•Several types of faults might happen while a turbocharger is being used for a long period, such as rotor unbalance caused by impact damage, journal bearings abrasion, insufficient oil supply, failure from excessive exhaust temperatures, stable and stall, etc

Modelling of the core of a Turbocharger (Rotor-dynamics)



•The core of a turbocharger is a rotor supported by two journal bearings
•The journal bearing can be modelled into a spring-damping system
•Finite Element method is used to model the rotor including screws, turbine, compressor, journal bearing and shaft



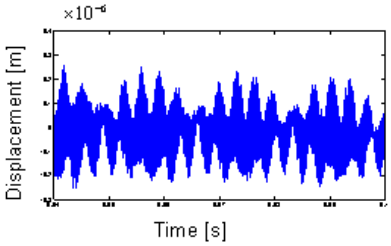
$$[M]\{\ddot{U}\}+[G]\{\dot{U}\}+[K]\{U\}=\{P(t)\}$$

Matrix differential equation for rotor motion is solved for simulating bending vibration for all seven nodes of the turbocharger on two planes

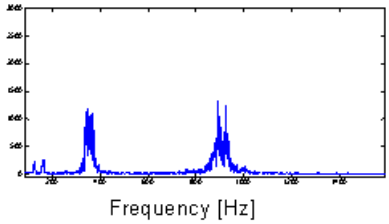
Through this model, the parameters of a turbocharger can be estimated as follows
•Natural frequency considering gyroscopic effect
•Rotor bending vibration in time domain and frequency domain while unbalance occurs

Simulation of Rotor Unbalance

Unbalance moment is exerted artificially on the turbine node and the bending vibration of journal bearings in time domain and frequency domain are simulated as follows



Bending vibration



Spectrum of bending vibration

Conclusion and Future work

- Rotor-dynamics theory is used for turbocharger modelling
- Data processing technique is implemented through the relevant software Matlab and Simulink
- Further research will focus on developing the whole model for a turbocharger in rotor-dynamics, thermo-dynamics and fluid-dynamics
- Fault detection and software-based fault source location

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