



CENTRIFUGAL COMPRESSOR TECHNOLOGY

C.S.T. is a design and maintenance engineering service company, established by a group of experienced engineers to support OEMs, Packagers, Main Contractors and End Users in the design, assembly and servicing of compression equipment.

- Half a century of experience at the leading edge of technology
- 360° know-how (marketing, design, project management, manufacturing, service, organization)
- Mix of experience and innovation
- Links with Technology Centers of Excellence
 - Universities of Florence, Modena, Rome, Pisa
 - Cineca (Consortium of 51 it. Univ.), No. 7 in the top 500 HPCs worldwide
 - EFRC Membership
 - ASME Membership



UP & MIDSTREAM

- Gas treatment
- Gas gathering
- Gas lift
- Associated gas reinjection
- Fuel gas boosting
- Pipeline
- Undrgrnd storage
- Boil off gas
- other



REFINERY

- Hydrocracking
- HDS
- Cat. reforming
- Lube Oil
- Ethylene

PETROCHEMICAL_

- L/HDPE, LAB, EVA
- Ammonia
- Nitric acid
- Urea
- Fertilizers



CLEAN FUELS

- CNG
- Mini & Micro LNG

AIR COMPRESSION

- Combustion
- Process
- Services

INDUSTRIAL GASES

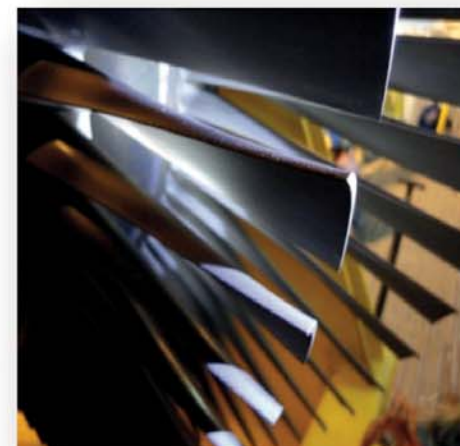
- Hydrogen
- Nitrogen
- Oxygen
- Air Separation



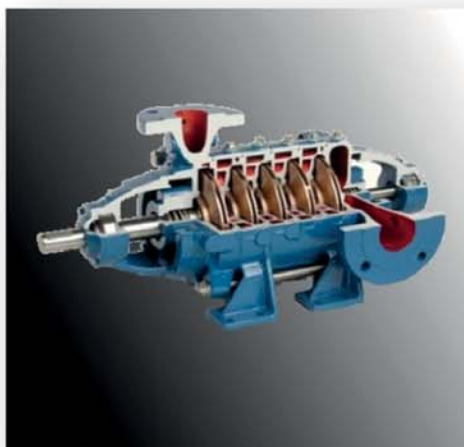
RECIPROCATING COMPRESSORS



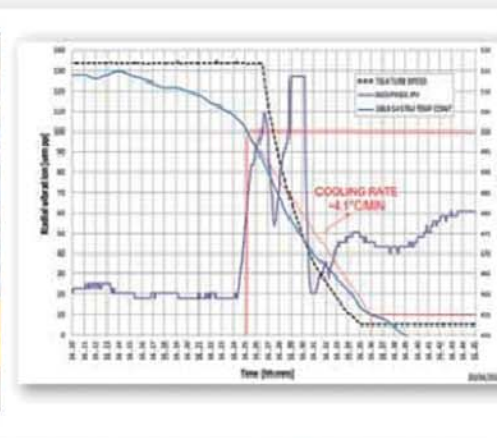
CENTRIFUGAL COMPRESSORS



STEAM TURBINES



PROCESS PUMPS

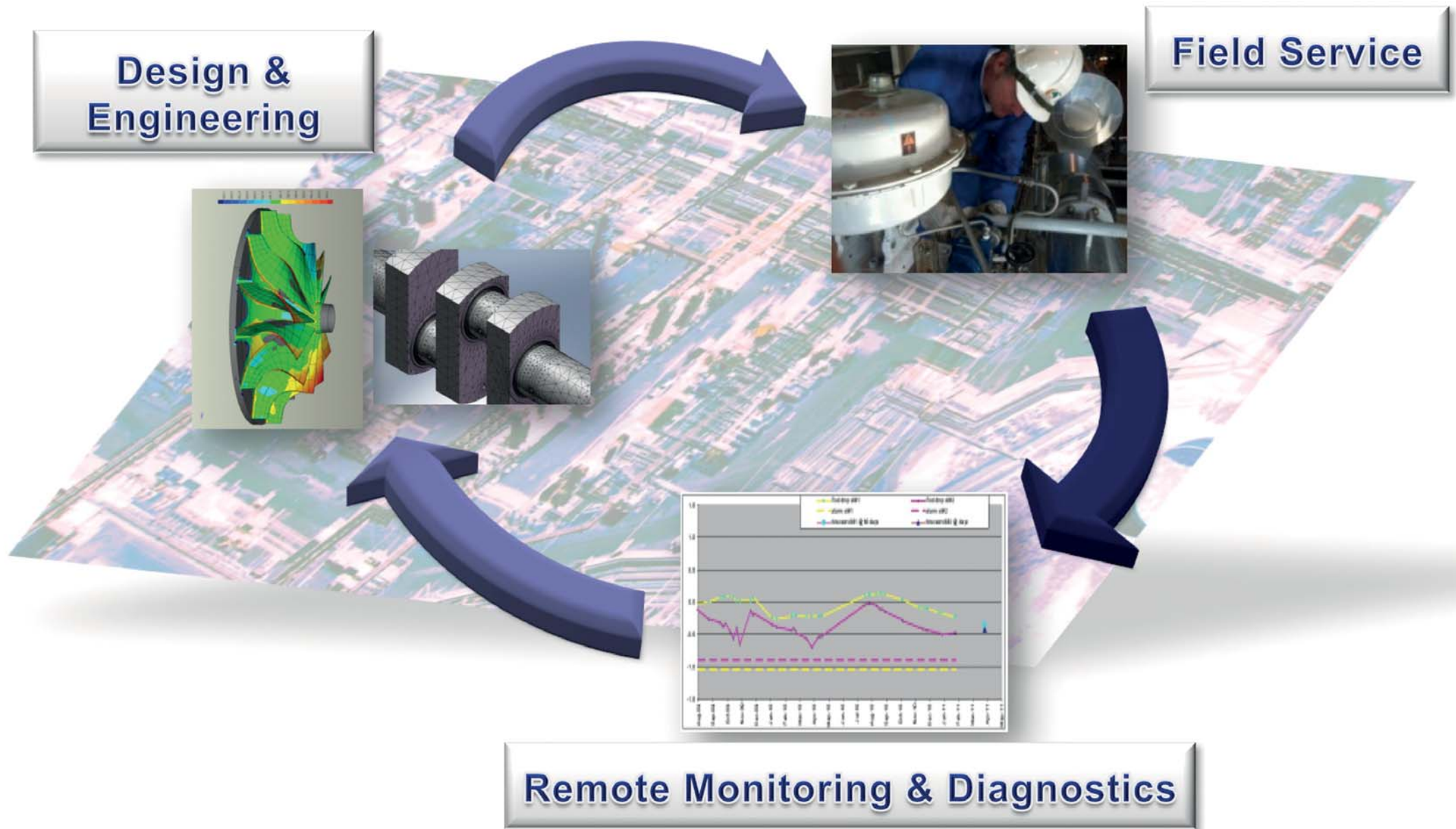


DIAGNOSTIC SYSTEMS

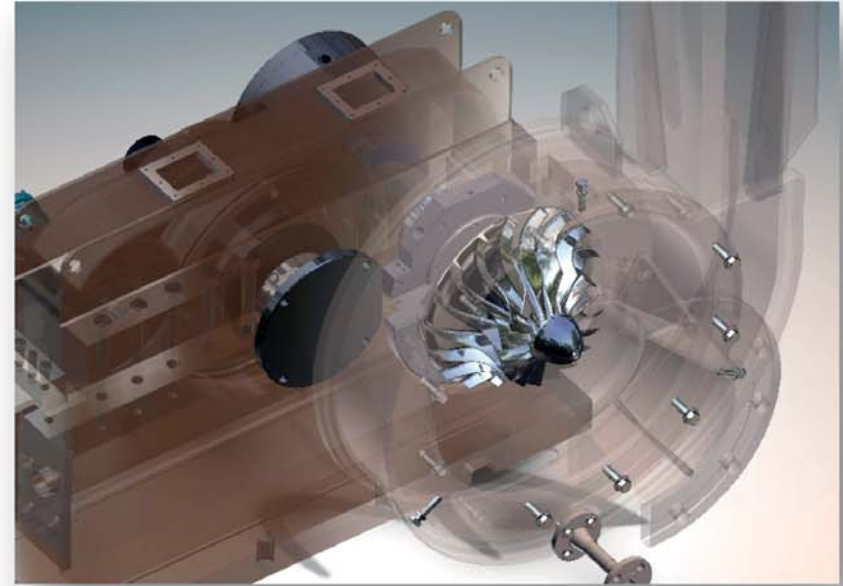
COMPANY WORK PHILOSOPHY

- Continuous improvement / innovation
- Total quality
- Cost consciousness
- Proactive behavior toward customers
- Coordination of Holonic Networks
- Long Term Partnering Agreements
- Cooperation with advanced technology centers
- Segregation of data of different customers

KNOWLEDGE LOOP



Centrifugal Compressor Technology

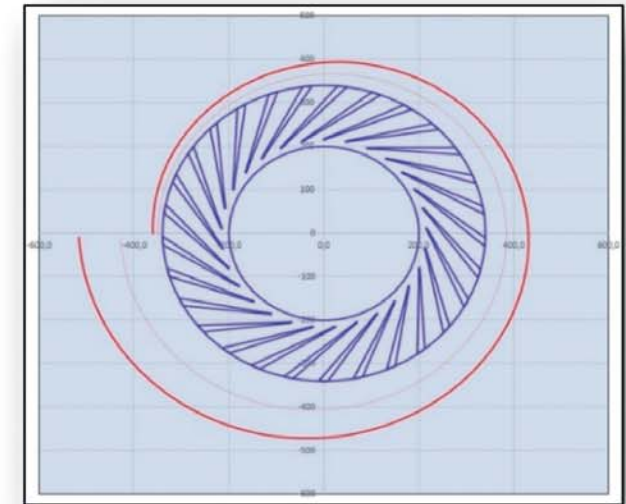


Leveraging the state of art know-how and technological edge of its engineering staff, CST has developed a structured approach to:

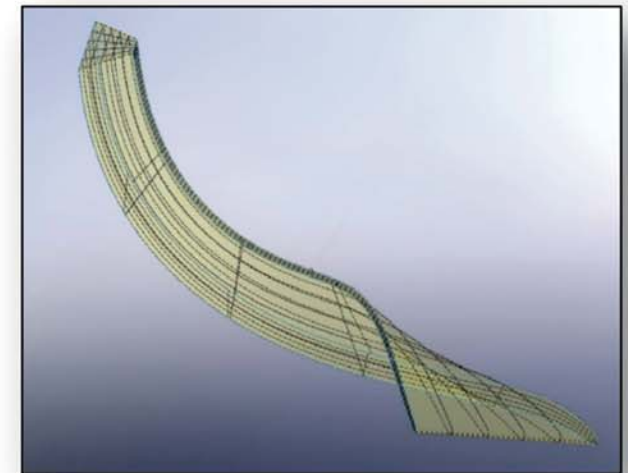
- ✓ aerodynamic & mechanical design
- ✓ rotordynamic and lateral analyses
- ✓ complete compressor stage simulation and performance assessment
- ✓ conversion, modification & upgrades
- ✓ troubleshooting

Centrifugal compressor design based on:

- ✓ standardized compression stages:
 - 3D and 2D impeller
 - vaneless and vaned (high/low solidity) diffuser
 - volute or return channel
- ✓ dimensionless flow and head coefficients and tip speed Mach number
- ✓ optimized geometries to maximize efficiency and flow rangeability



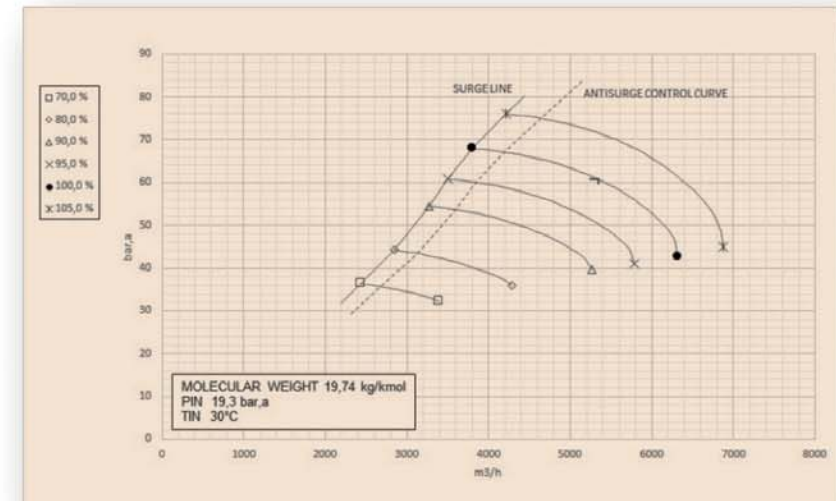
HIGH SOLIDITY VANED DIFFUSER & VOLUTE DESIGN



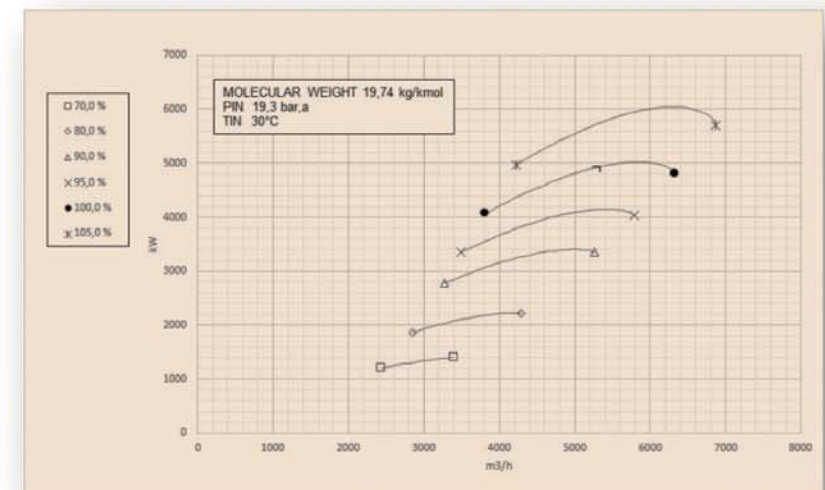
IMPELLER 3D BLADE PARAMETRIZATION

COMPRESSOR PERFORMANCE

- ✓ Overall compressor performance curves produced selecting best standard stages to fit the specific application
- ✓ Accurated prediction of surge and choke conditions
- ✓ Prediction of compressor behavior using capacity control systems (speed variation, IGV, suction throttling, etc.)
- ✓ Advanced equation of state to describe real gas properties



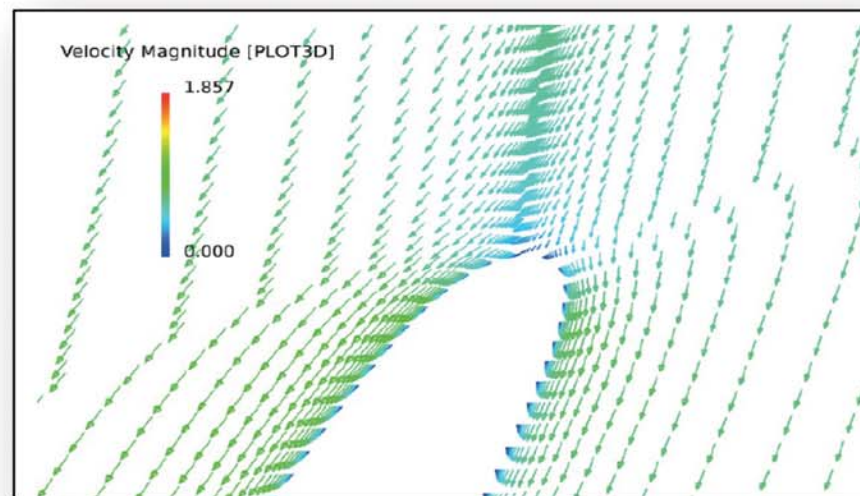
PRESSURE RISE VS FLOW RATE



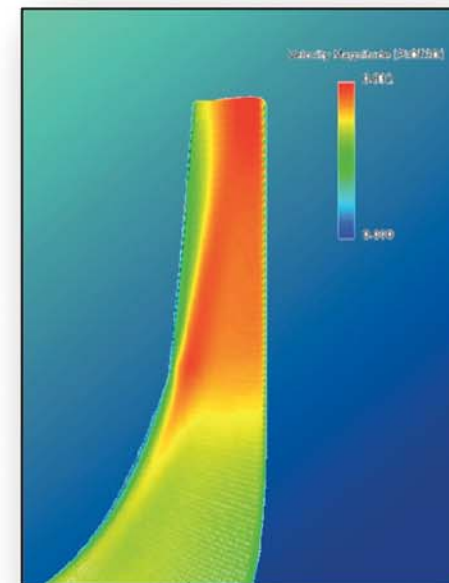
POWER VS FLOW RATE

3D model CFD simulations, at fluid boundary conditions, to obtain:

- ✓ accurate characterization of velocity fields
- ✓ pressure distribution
- ✓ loss sources
- ✓ design and off-design performance verification
- ✓ identification of critical points



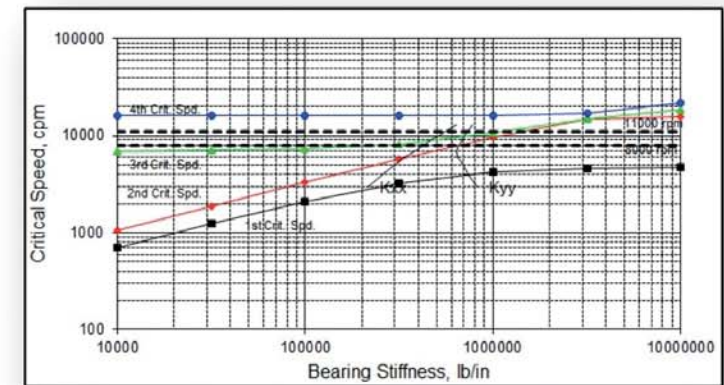
IMPELLER INLET VELOCITY FIELD



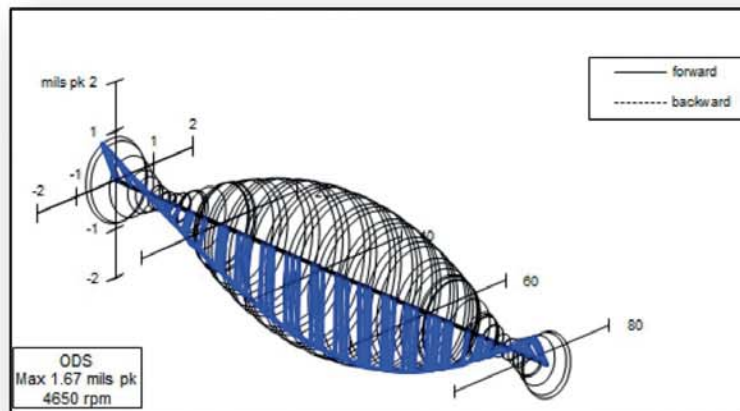
IMPELLER OUTLET VELOCITY FIELD

Rotordynamic verification, based on Lumped Parameters Models and/or Finite Element Analysis, includes calculation of:

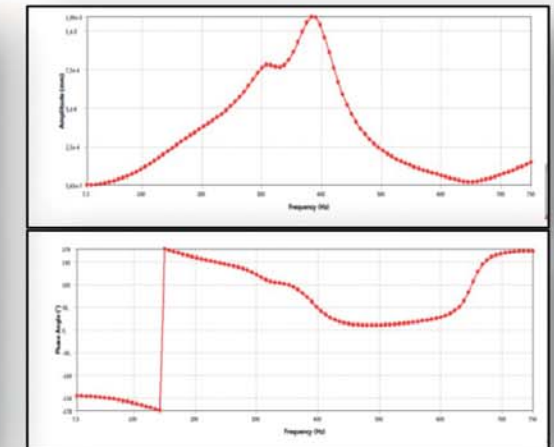
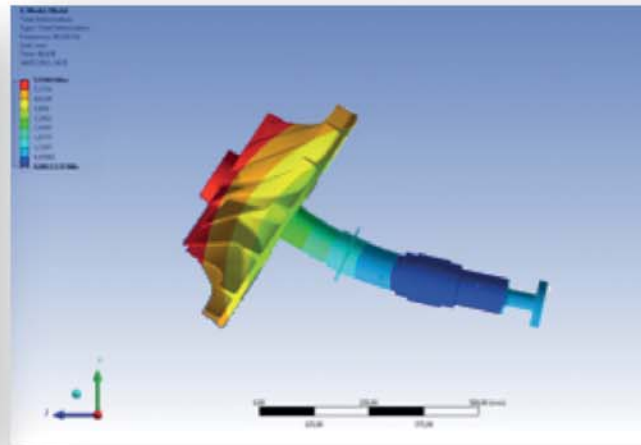
- ✓ lateral natural frequencies & mode shapes
- ✓ response to unbalance
- ✓ stability check
- ✓ torsional natural frequencies & mode shapes
- ✓ torsional forced response



CRITICAL SPEEDS



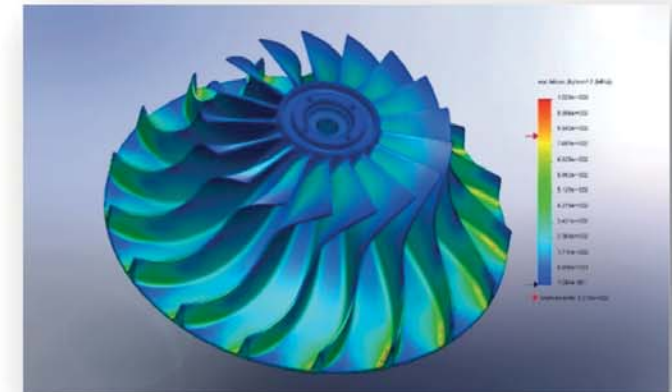
SHAFT MODE SHAPES



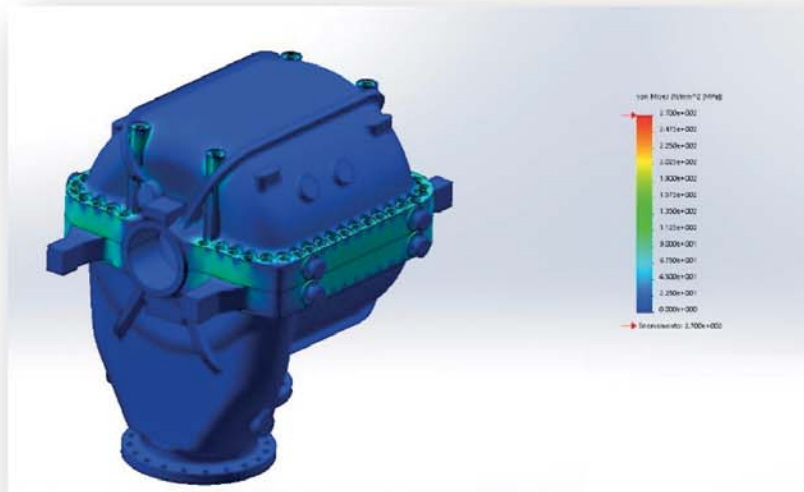
RESPONSE TO UNBALANCE

Finite Element Analysis for structural properties characterization and stress & strain calculation

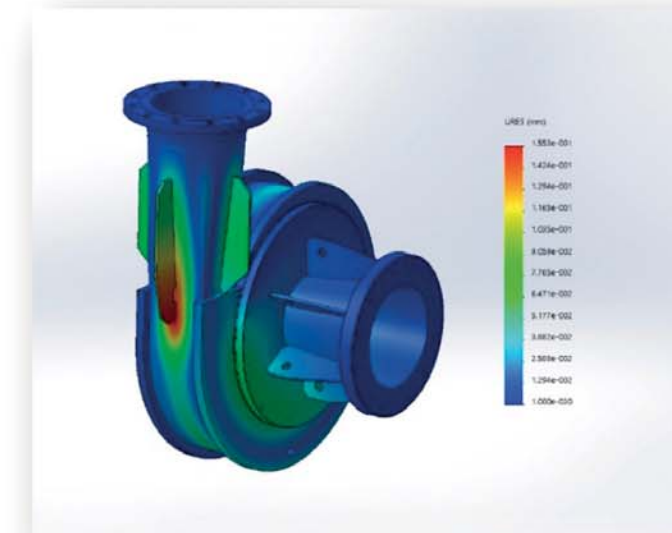
- ✓ Static FEA: detailed stress distribution to identify local stress levels in the worst operating conditions
- ✓ Impeller modal analysis: blades natural frequencies and mode shapes



IMPELLER FEA

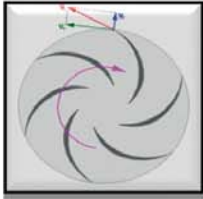


HORIZONTALLY SPLIT CASING FEA



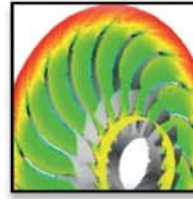
IGC CASING FEA

CST VALUE PROPOSITION



TENDER STAGE

- ✓ **Basic Project Outline**
- ✓ **Aerodynamic Design**
- ✓ **Performance Curves**
- ✓ **Mechanical Datasheet**
- ✓ **Gas Mixture Properties**
- ✓ **Efficiency Calculations at Off Design Conditions**



PROJECT EXEC

- ✓ **3D Modelling**
- ✓ **Rotordynamic, Structural & Fluid-dynamic Study**
- ✓ **Manufacturing Dwgs**
- ✓ **Control and Antisurge Systems**
- ✓ **Inspection/Testing Procedures and Support**
- ✓ **Dry gas Seal Systems Selection & Specification**
- ✓ **Key Component Supply**



FIELD SUPPORT

- ✓ **Field Supervision**
- ✓ **Troubleshooting & Failure Analysis**
- ✓ **Conversion, Modification & Upgrade**
- ✓ **Rehabilitation**
- ✓ **New operating Conditions**

Competence at work for Service and Innovation



www.cstfirenze.com

