



**EUROPEAN
FORUM
for
RECIPROCATING
COMPRESSORS**

***EFRC and
Joint Research in the EFRC***

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Chairman EFRC Working Group
R&D**

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- **Introduction to EFRC**
 - Organisation
 - Objectives
 - Members
 - Working groups and activities

 - **Working Group R&D**
 - How it works
 - Finished Projects
 - Actual Project
-

Introduction EFRC - Organisation

EFRC Working Group R&D



EUROPEAN FORUM
for RECIPROCATING
COMPRESSORS

EFRC has been founded in 1999 by:

- TU Dresden - Germany
- TNO Delft - The Netherlands
- Leobersdorfer Maschinenfabrik - Austria
- Neuman & Esser - Germany
- Burckhardt Compression - Switzerland
- Thomassen Compression Systems - The Netherlands
- Wärtsilä Compression Systems - Germany
- Hoerbiger Ventilwerke – Austria



**Burckhardt
Compression**

THOMASSEN
COMPRESSION
SYSTEMS



- To serve as a platform to facilitate exchange of information between vendors, operators and scientists working in the field of reciprocating compressors.

Introduction EFRC - Objectives

EFRC Working Group R&D



1. Knowledge transfer

- Conferences
- Internet
- Workshops
- Training and seminars

2. Perform joint research

- Pre-competitive
- Aiming at improving the performance of the recip

3. Improving the image of the reciprocating compressor

- Student workshops
 - Field surveys
-

Introduction EFRC - Board

EFRC Working Group R&D



EUROPEAN FORUM
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President: Dr. Rene Peters

- *TNO Energy*



Secretary: Dr. Peter Steinrück,

- *Hoerbiger Kompressortechnik Holding GmbH*



Treasurer: Dr. Leonhard Keller,

- *Burckhardt Compression AG*



Secretary support: Mildred Wengler

- *TU Dresden*

Introduction EFRC – Members

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- 41 members
- 14 manufacturers
- 5 operators
- 1 packager
- 15 component suppliers
- 4 technology institutes
- 2 media representative



Introduction – Working Groups and Activities

EFRC Working Group R&D



Pre-competitive R&D

- Peter Duineveld – Howden Thomassen Compressors
- Initiate and fund R&D projects sponsored by members

Standardisation

- Andre Eijk - TNO
- Work on improvement of API and ISO standards

Student promotion

- Siegmund Ciernack – RWE
- Organise bi-annual student workshop

Marketing and EFRC conference

- Martina Frenz - NEA
 - Organise bi-annual EFRC conference
 - Maintain website www.recip.org
-

Introduction EFRC – WG Student promotion

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- Site visit OEM's and operations with recip for international students
 - Participation from many EU countries
 - Presentations by EFRC members
 - Excursions to production sites
 - Exercise for students (incl. award!)
-
- 2002 Benelux and Germany
 - 2004 Poland
 - 2006 Italy and Switzerland
 - 2008 Austria
 - 2010 United Kingdom
 - 2012 France



Introduction EFRC – Conference & training

EFRC Working Group R&D



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- *International conference on reciprocating compressor development and operation.*
- *Strong international participation*
- *Papers by OEM's, operators and suppliers*
- *Training seminar for young engineers*

- *1999 Dresden*
- *2001 The Hague*
- *2003 Vienna*
- *2005 Antwerp*
- *2007 Prague*
- *2008 Dusseldorf: International Rotating Equipment Conference*
- *2010 Florence*
- *2012 Dusseldorf: International Rotating Equipment Conference*

- *2014 Vienna*

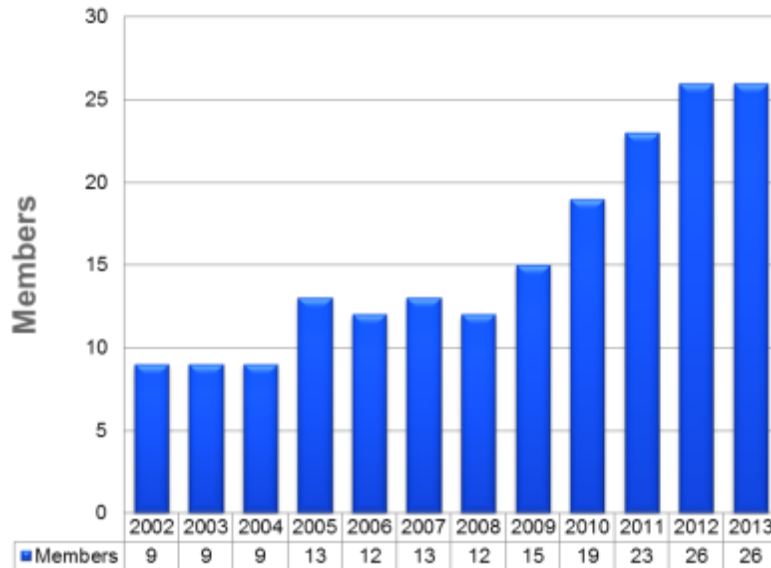


Working Group R&D

EFRC Working Group R&D



- **Combining forces of EFRC members to solve / investigate problems which are beyond the scope of a single player**
- **Basic research and precompetitive research carried out at research institutes or universities**
- **Scientific arm of the reciprocating compressor community**
- **(Support university graduates (diploma thesis, PhD thesis))**



Working Group R&D - How it works

EFRC Working Group R&D



**EFRC members can join the R&D Working Group
Annual budget funded by participating members**

Twice a year the EFRC Working Group has a meeting

- **Status of ongoing projects**
 - **Selection of ideas**
 - **New project proposals**
 - **Approval of projects**
 - **Financial status and membership fees**

 - **Results are owned by EFRC**
 - **Research results are disclosed to EFRC Working Group R&D members only**
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Working Group R&D – Finished Projects

EFRC Working Group R&D



Some examples of finished projects:

- **Simulation of Multi-stage Compressors**
 - **Failure diagnostics and failure identification (PhD)**
 - **Separator Efficiency in a Pulsating Flow**
 - **Effect of Solid Particles in the Gas Flow on Compressors**
 - **Rod load measurement**
 - **Study on Compression Equipment for H2 Refueling Stations**
 - **Effects of in-cylinder pulsations on valve dynamics (PhD)**
 - **Internal Flow and Valve Dynamics**
 - **Compressor Noise (analysis and measurement methods)**
 - **Effect of Cylinder Flange Misalignment on Allowable Nozzle Loads**
 - **Piston- & Piston Rod Cooling**
 - **EFRC guideline for vibrations in Recip. Compr. Systems (ISO)**
 - **Compressor Reliability Survey**
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Example project – Allowable vibration levels

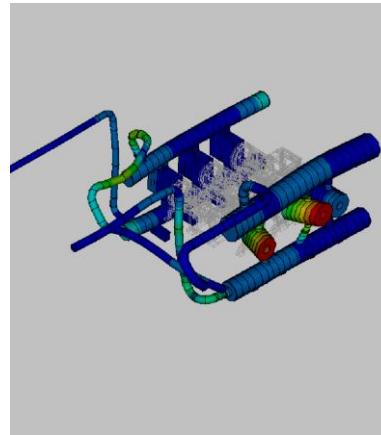
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Motivation:

- Vibrations are an important design criteria for installations
- Existing standards are considered to be not specific



Result:

- EFRC Guideline on vibrations
- Working towards ISO standard

Approach:

- Literature search
- Interviews with stakeholders
- International Workshop
- Report



Working Group R&D - Actual projects

EFRC Working Group R&D



Current Projects

- **TNO Compressor Foundation Analysis Tool**
- **VKA Study on cylinder lubrication**
- **TUD Temperature reduction of piston rod**
- **TUW Heat transfer and internal flow in reciprocating compressors**
- **TNO Guidelines and rules how to avoid liquid**
- **TUD Survey of gas solubility in lubricants in high pressure conditions**
- **TUD Survey on valve systems for piston expansion machines**

New projects for 2013:

- **TNO Guidelines for anchor bolts of reciprocating compressors**
 - **TNO Non-conventional material as construction material**
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Study on cylinder lubrication

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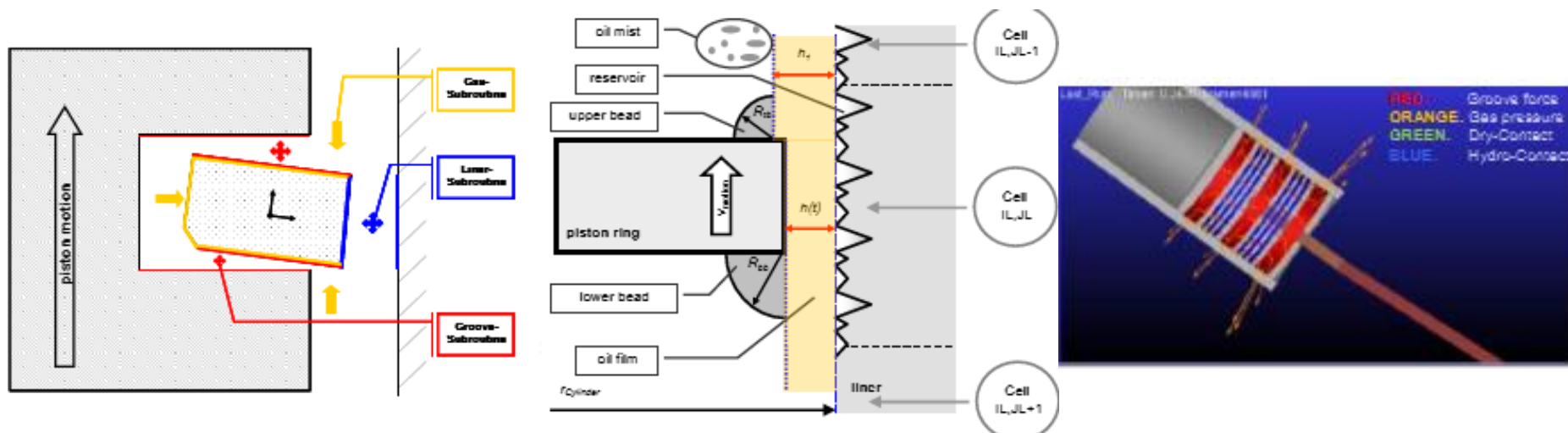


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Goal: Understanding cylinder lubrication in reciprocating compressors with main focus on minimal required oil-demand and setup of a tool to simulate & predict minimum oil demand, friction and wear.

Results:

- Deeper understanding of the wear mechanisms in lubricated compressors
- Equations for the minimum need of oil supply
- MBS piston ring models



Heat transfer and internal flow in a cylinder

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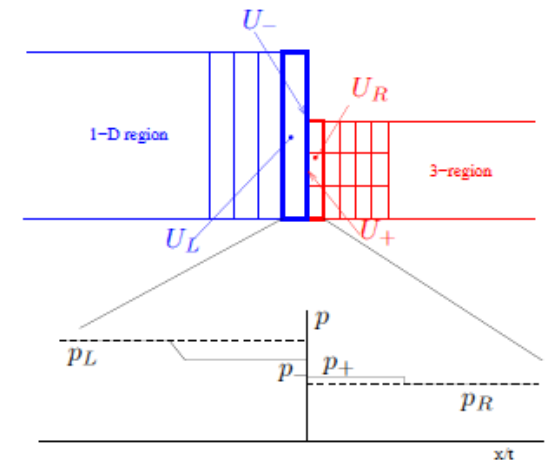
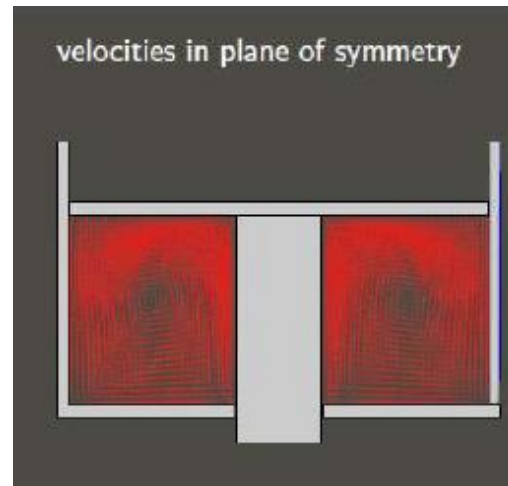
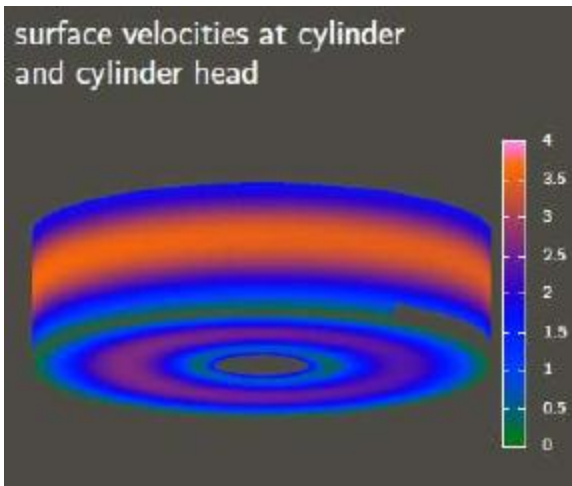


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Goal Develop easy to use software tool for prediction of heat transfer and internal flow inside the cylinder

Results:

- 3D Finite volume Euler code supplemented with solver for boundary layer equations for heat transfer with GUI.
- Coupling of valve cage to valve model



Guidelines and rules how to avoid liquid

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Goal: To develop “Engineering Guidelines how to avoid liquid problems in Reciprocating compressor systems”

Results:

- **The results of the project can be used how to design the compressor system and how to avoid severe liquid problems to ensure a safe and reliable system for the long term.**
 - **Further on some guidelines will be given on specifications of the measuring equipment which can be used to develop a liquid sensor device.**
 - **Literature survey and interviews**
 - **Internet survey sent out to 500 relevant industry addresses**
 - **International workshop to discuss and develop guideline**
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Guidelines for anchor bolts

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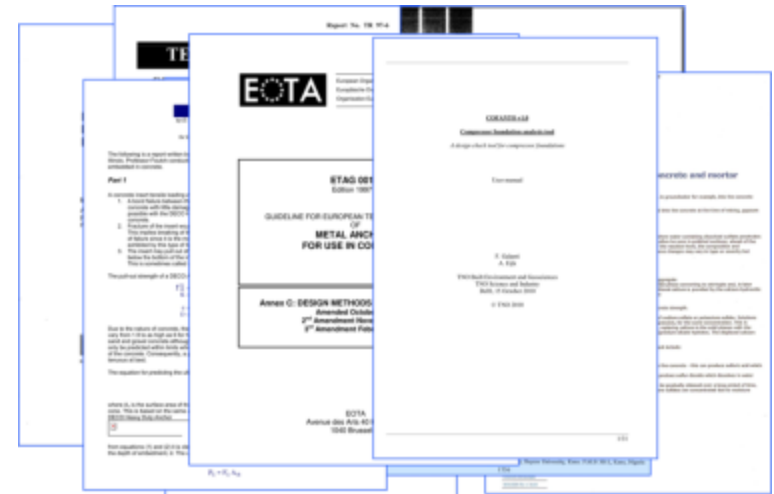
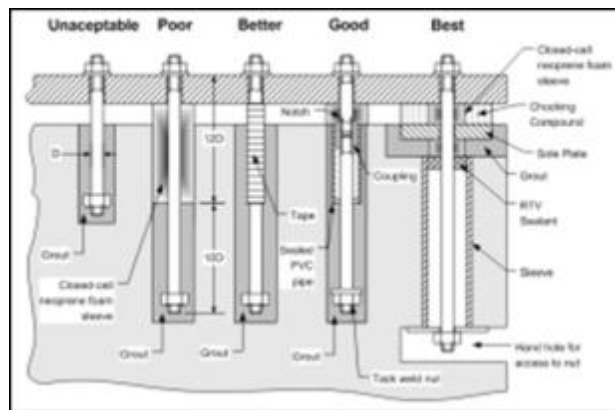


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Goal: Have a clear, easy to use and globally accepted set of guidelines which covers all aspects on how a reciprocating compressor should be anchored to the concrete foundation

Results:

- Survey on existing procedures used by OEM's, operators and packagers
- Survey on existing guidelines
- First draft guideline + report
- Proposal for next steps to include missing material



Survey of gas solubility in lubricants in high pressure conditions

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Goal: To understand influence of gas solubility on lubrication in high pressure cylinders

Results:

- Knowledge about mixtures data of compressed gasses with lubricants.
 - Report of survey providing lubricant compressed gas properties information and data and of a survey on lubricant compressed gas properties prediction methods
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Non-conventional material as construction mat.

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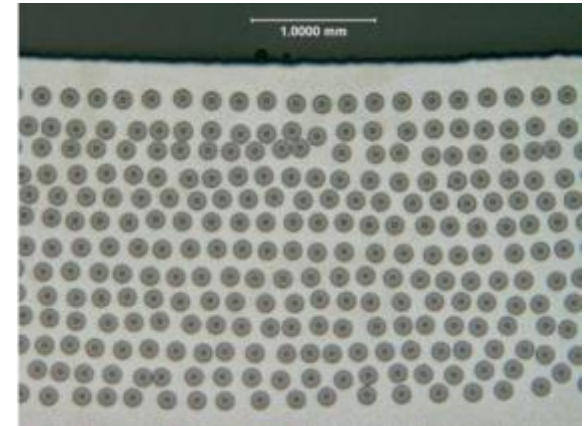
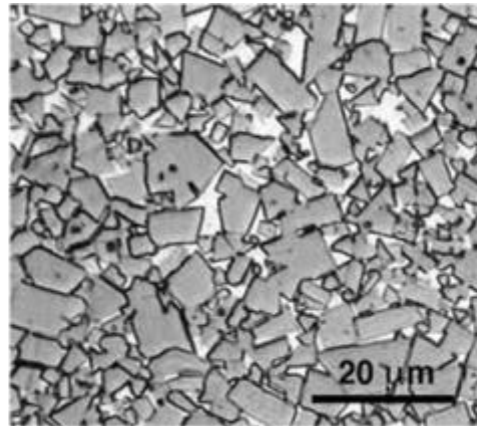


Goal: Find suitable non-conventional material for crosshead and piston

Project not started yet. Discussion about scope, public funding, etc

Results:

- **Select suitable materials**
- **Material testing**
- **Concept designs of parts**
- **Prototype design**



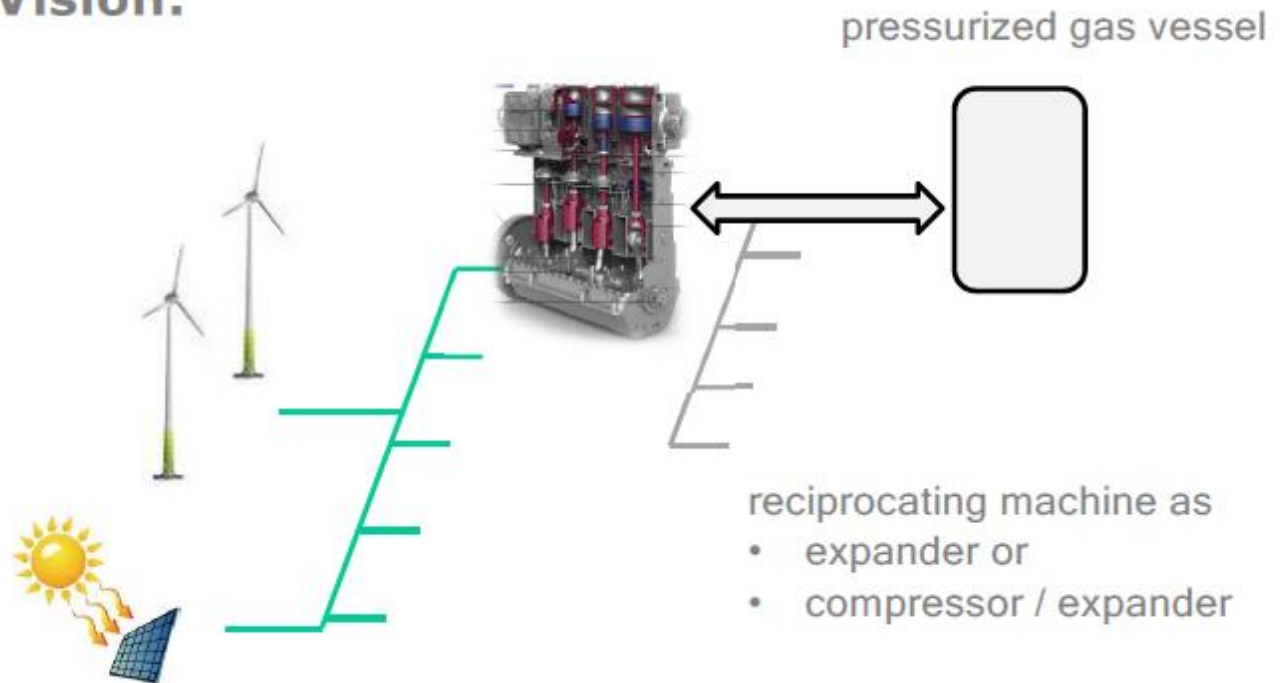
Survey valve systems for piston expansion mach.

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- Goal:**
- Survey on potential expander operations
 - Provide design and specification criteria
 - Survey on existing and applicable methods to provide controlled valve drives

Vision:



Compressor Foundation Analysis Tool

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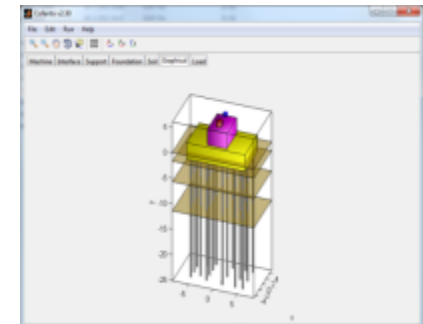
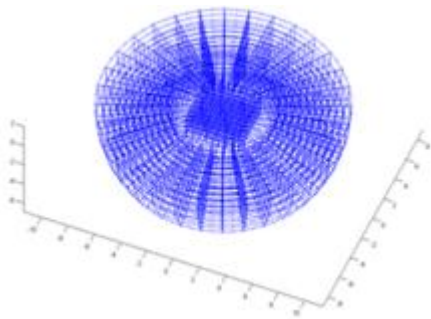


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Goal: Development of a quick assessment tool for checking the design of compressor foundations with respect to interaction effects.

Results:

- Program with GUI
- Design of a foundation can easily be checked
- No detailed analysis required



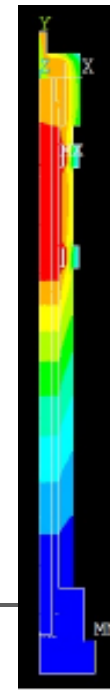
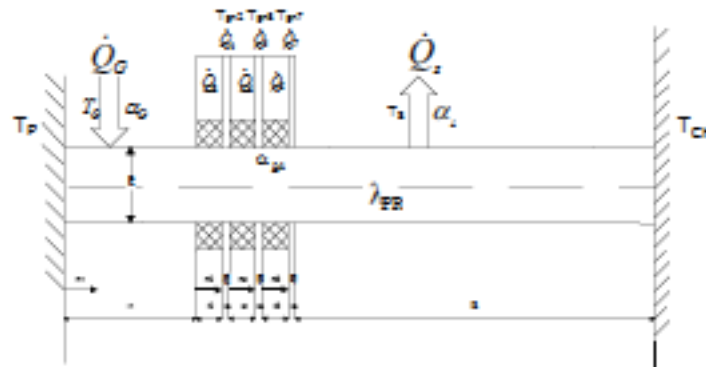
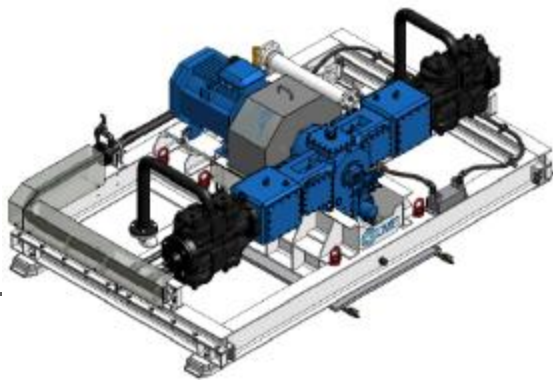
Temperature reduction of piston rod

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Goal: Verification and explanation of the temperature reduction in the piston rod area in order to increase the lifetime of the stuffing box internals. Temperature reduction by internal cooling of piston rod. Design criteria for other compressor models.

Results:

- Functionality of a piston rod cooling has been proved
- Decrease of temperature of the piston rod
- Determination of the internal heat transfer coefficient inside



End of presentation

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Join the EFRC Working Group R&D!

**Get access to results of projects
Initiate new projects**