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International Conference on
SCREW MACHINES 2024
3-5 September DORTMUND, GERMANY

Programme
Book of Abstracts

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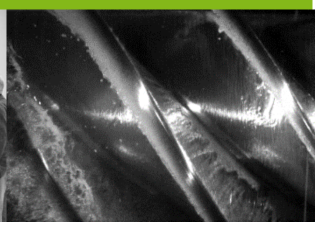

FOREWORD

Dear Members of the Screw Machine Community,

My team and I are thrilled to welcome you to the International Conference on Screw Machines (ICSM) 2024 at TU Dortmund University. This year's conference is especially significant as we celebrate 40 years since Professor Knut Kauder founded this event. His pioneering work at the Chair of Fluidics laid the foundation for what has become a key forum for advancing screw machine technology.

For the ICSM 2024, we have introduced several updates to enhance the conference experience. The conference cycle was shortened to two years, allowing us to respond more rapidly to developments in the field. We are also excited to offer a lab tour as a social evening event, providing a unique opportunity to connect with peers in a more informal setting. Additionally, we have introduced the option for technical presentations without the need to submit a full paper, encouraging broader participation and discussion. We are also pleased to continue the Science Update session. Introduced in 2022, this dynamic and interactive format is designed to foster open discussions and collaborative exchanges among participants. The ICSM Science Update provides a unique platform for presenting emerging ideas, ongoing research, and projects that are still in development.

We hope this conference continues to be a vital platform for sharing the latest research and innovations in screw machines. We look forward to the lively discussions, exciting insights, and collaborations that will emerge from this year's event.

Thank you for your continued support.

Sincerely,

Andreas Brümmer
Chair of Fluidics
TU Dortmund University

TUESDAY 3 September 2024

18:00	SOCIAL EVENT & LABORATORY TOURS Emil-Figge-Straße 71b, 44227 Dortmund	

WEDNESDAY 4 September 2024

09:00	CONFERENCE REGISTRATION	
10:00	OPENING SESSION Room H.001 p. 4	
12:00	LUNCH BREAK	
13:30	ARCHIMEDES – FOR 5955 Room 1.001 p. 5	DESIGN Room 2.008 p. 6
14:45	COFFEE BREAK	
15:15	SIMULATION Room 1.001 p. 7	OPERATION Room 2.008 p. 8
18:00	CONFERENCE DINNER – sponsored by Aerzener Maschinenfabrik GmbH Storckshof, Ostenbergstr. 111, 44227 Dortmund	

THURSDAY 5 September 2024

08:30	LIQUID INJECTION I Room 1.001 p. 9	ACOUSTICS Room 2.008 p. 10
09:45	COFFEE BREAK	
10:15	STEAMSCREW Room 1.001 p. 11	VACUUM TECHNOLOGY I Room 2.008 p. 12
11:30	LUNCH BREAK	
13:00	LIQUID INJECTION III Room 1.001 p. 13	VACUUM TECHNOLOGY II Room 2.008 p. 14

14:00	SCIENCE UPDATE SESSION (presentation only) ROOM H.001 p. 15
16:00	CLOSING SESSION ROOM H.001
16:30	END OF CONFERENCE

WEDNESDAY 4 September 2024

OPENING SESSION
Room H.001
Chaired by A. Brümmer

10:00 **Welcome address**
S. Stumpf, managing director of the Department of Mechanical Engineering
A. Brümmer, general chair & head of Chair of Fluidics
TU Dortmund University, DE

10:30 **Accurate Thermophysical Property Measurement of Refrigerants and their Mixtures with Oil – Is this Important for Practice?**
M. Richter, head of Chair of Applied Thermodynamics
Chemnitz University of Technology, DE

p. 18

11:15 **High performance computing of screw machines – State of the art and future possibilities**
M. Möller, Associate Professor of Numerical Analysis
Delft University of Technology, NE

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WEDNESDAY 4 September 2024

ARCHIMEDES – FOR 5955
Room 1.001
Chaired by A. Brümmer

13:30 **Influence of fluid properties and model parameters with regard to stratified gas-liquid gap flows**

L. Burchardt[1] et al.[1,2,3]
[1] TU Dortmund University, DE
[2] RWTH Aachen University, DE
[3] Ruhr University Bochum, DE

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13:55 **High-resolution simulations of gas-liquid Couette-type sealing gap flows**

J. Vorspohl[1] et al.[1,2]
[1] RWTH Aachen University, DE
[2] TU Dortmund University, DE

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14:20 **Astigmatism Quantification for Depth Localization of Bubbles and Tracer across Curved Surfaces**

H. Lange[1] et al.[1,2]
[1] Karlsruhe Institute of Technology (KIT), DE
[2] TU Dortmund University, DE

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WEDNESDAY 4 September 2024

DESIGN
Room 2.008
Chaired by M. Geissendorf

13:30 **On Rotor Profiling of Internally Geared Screw Machines**
H. Lacevic et al.
City, University of London, UK
p. 26

13:55 **Designing novel rotor profiles of twin screw compressors using generative deep learning**
R. Nakka, S. A Ponnusami and A. Kovacevic
City, University of London, UK
p. 27

14:20 **Design and Improvement of Curved Envelope Meshing Pair Profile of Single Screw Compressors**
W. Lei et al.
Xi'an Jiaotong University, CN
p. 28

WEDNESDAY 4 September 2024

SIMULATION Room 1.001 Chaired by F. Nal	
15:15	**Yet another structured mesh generator for screw machines simulation** Y. Ji and M. Möller Delft University of Technology, NE p. 30
15:40	**Simulation analysis of the internal flow field in single screw compressor using local re-meshing method** W. Wu et al. Xi'an Jiaotong University, CN p. 31
16:05	**CFD Analysis and Optimization of Oil Ports in Twin-Screw Compressors using Taguchi Method** A. Buyukbayraktar et al. Dalgakıran Compressor, TR p. 32
16:30	**Stability and Convergence for Preconditioned Successive Over Relaxation and Incomplete LU Decomposition Iterative Linear Solvers used in an Oil-Injected Screw Compressor** D. Ziviani[1] et al.[1,2] [1] Purdue University, US [2] Hitachi Global Air Power (HGAP), US p. 33

WEDNESDAY 4 September 2024

OPERATION
Room 2.008
Chaired by P. Hartwich

15:15 **A Bayesian-inference approach to quantify degradation parameters in a water-cooled variable speed screw compressor chiller**
A. J. Hoess et al.
Purdue University, US
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15:40 **MoS_2 Coatings in unsynchronized, dry-running Screw Compressors: Experimental Insights on Operational Efficiency and Durability**
M. Geissendorf et al.
TU Dortmund University, DE
p. 37

16:05 **Test rig setup for particle wear analysis in screw pumps**
P. Moor, M. Kuhr and P. Pelz
TU Darmstadt University, DE
p. 38

16:20 **Economic Assessment of Multi-Stage Screw Compressors: A Comprehensive Lifecycle Cost Analysis**
A. Kumar[1,2], A. Kovacevic[1] and N. Stosic[1]
[1] City, University of London, UK
[2] Kirloskar Pneumatic Company Limited, IN
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THURSDAY 5 September 2024

LIQUID INJECTION I
Room 1.001
Chaired by L. Burchardt

08:30 **Influence of Screw Parameters and Fluid Injection on the Performance of Screw Compressors**

A. Kumar[1,2], A. Kovacevic[1] and N. Stosic[1]
[1] City, University of London, UK
[2] Kirloskar Pneumatic Company Limited, IN

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08:55 **Optimization of Specific Power Consumption in Single-Stage Oil-Injected Screw Air Compressors: Experimental and Computational Approaches**

D. A Soylu et al.
Dalgakıran Compressor, TR

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09:20 **OilMixProp 1.0: Package for Thermophysical Properties of Oils, Common Fluids, and Their Mixtures**

X. Yang and M. Richter
Chemnitz University of Technology, DE

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THURSDAY 5 September 2024

ACOUSTICS
Room 2.008
Chaired by D. Aurich

08:30 **Experimental investigation and modelling of the noise and vibration in screw compressors**

J. F. Willie and R. B. Ganatra
Compressors and Vacuum Pumps Systems Engineering GmbH, DE

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08:55 **Investigation of Pressure Pulsations and Vibrations for an Internally Geared Screw Compressor**

J. Zhu[1] et al.[1,2]
[1] Carrier Global Corp, US
[2] City, University of London, UK

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09:20 **1D and Quasi-3D Simulation-Based Optimization of Discharge Noise Attenuation in Twin-Screw Machines Using GT-SUITE**

M. Luzzi[1], N. Framke[1] and G. Ramchandran[2]
[1] Gamma Technologies GmbH, DE
[2] Gamma Technologies LCC, US

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STEAMSCREW
Room 1.001
Chaired by M. Heselmann

10:15 **Thermodynamic simulation of a water-injected twin-screw steam compressor**
M. Grieb and A. Brümmer
TU Dortmund University, DE

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10:40 **Performance Analysis of a Water-Injected Twin-Screw Compressor in a High-Temperature R718 Heat Pump**
S. Höckenkamp[1] et al.[1,2]
[1] Fraunhofer IEG, DE
[2] TU Dortmund University, DE

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11:05 **Experimental investigation of the operating behavior and efficiency of twin-screw compressors with water injection and complete evaporation**
T. Kraschewski
Aerzener Maschinenfabrik GmbH, DE

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THURSDAY 5 September 2024

VACCUM TECHNOLOGY I
Room 2.008
Chaired by S. Brock

10:15 **CFD simulation of rotary positive displacement vacuum pumps: Possibilities and Challenges**
J. Hesse and A. Spille
CFX Berlin Software GmbH, DE
p. 56

10:40 **Combined Rotor Rack Generation for Twin Screw Vacuum Pump Rotor Profile Design**
Y. Lu and A. Kovacevic
City, University of London, UK
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11:05 **Design of toothed belt driven screw vacuum pumps**
R. Müller, A. Hellmig and T. Dreifert
Leybold GmbH, DE
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THURSDAY 5 September 2024

LIQUID INJECTION II
Room 1.001
Chaired by M. Grieb

13:00 **One-dimensional investigations of the periodic liquid-injection in twin-screw compressors**
M. Heseslmann, T. Monden and A. Brümmer
TU Dortmund University, DE
p. 60

13:25 **Screw Compressors for High Temperature Heat Pump Duty**
M. Sundström and Y. M. Muñoz-Muñoz
Svenska Rotor Maskiner International AB, SE
p. 61

THURSDAY 5 September 2024

VACUUM TECHNOLOGY II
Room 2.008
Chaired by T. Fehlau

13:00 **Investigations to reduce rarefied gap flows within positive displacement vacuum pumps by utilising surface structures**
S. Brock et al.
TU Dortmund University, DE
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13:25 **A Novel Approach for Measuring and Comparing Vacuum Pump Efficiency: Pumping Efficiency (PE)**
K. Nadler, R. Müller and T. Dreifert
Leybold GmbH, DE
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THURSDAY 5 September 2024

14:00	SCIENCE UPDATE SESSION Room H.001 Chaired by A. Brümmer

Design and Optimisation of Internally Geared Screw Compressors
H. Lacevic, M. Read and A. Kovacevic
City, University of London, UK

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Tool development for producing structures on vacuum pump rotors
J. Saelzer
TU Dortmund University, DE

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Impact of manufacturing clearances on leakages of screw-spindle compressors
T. Mösch
TU Dresden University, DE

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Raman Spectroscopy Analysis of MoS_2 and Doped MoS_2 Coatings on Screw Rotors
S. Nicolai and J. Debus
TU Dortmund University, DE

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Advanced Additive Manufacturing of Compressors with Internal Cooling: Case Studies of Linear and Screw Compressors
D. Ziviani and E. A. Groll
Purdue University, US

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The Tipping Point in Uncertainty
J. Sauls (retired)
Trane, US

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OPENING SESSION

Accurate Thermophysical Property Measurement of Refrigerants and their Mixtures with Oil - Is this Important for Practice?

M. Richter

Department of Applied Thermodynamics, Chemnitz University of Technology, Chemnitz, Germany

The efficient design of energy systems for heating and cooling requires reliable technologies, as the global demand is constantly increasing. Accurate knowledge of the thermophysical properties of the involved working fluids, i.e., refrigerants and their mixtures with oil, is essential for optimizing and controlling future energy consumption. Properties such as density, speed of sound, vapor-liquid equilibrium, and viscosity are used to adjust friction losses, sizing, and capacity of the associated apparatus. When designing refrigeration machines, the thermophysical properties of the refrigerants are typically calculated by considering only pure fluids, while the oils lubricating the compressors are often ignored. This can lead to discrepancies between the theoretical and real behaviors of the machines. In our research, we tackle this issue by measuring and modeling oil-refrigerant mixtures. The goal is to advance the understanding of machine components such as rotary positive displacement machines and heat exchangers, thus unlocking unprecedented optimization possibilities.

High performance computing of screw machines – State of the art and future possibilities

M. Möller

Institute of Applied Mathematics – Numerical Analysis, Delft University of Technology, Delft, The Netherlands

The computer-aided design of screw machine is a non-trivial task due to the complex physical processes taking place and the machines' complicated shapes. While simplified chamber models allow for the quick (pre-)design and analysis, full-fledged CFD simulations are computationally demanding both in terms of the required computer hardware and the time-to-solution. In fact, despite massive progress of high-performance computing (HPC) hardware and CFD algorithms and software over the last two decades, fully resolved simulations of the fluid dynamical processes at all relevant scales, so-called direct numerical simulation, is out of reach with today's tools.

In this talk, we will give an overview of the state of the art in high-performance CFD analysis of screw machines but also discuss the limitations of traditional approaches. We will then shed some light on less conventional approaches, such as the lattice Boltzmann method and the combination of CFD and AI, and discuss if and how they might be able to overcome the limitations of the traditional tools that are typically based on the Navier-Stokes equations. Next to discussing alternative methodological approaches we will also look into future computing technologies, in particular, quantum and neuromorphic computing that follow different paradigms than today's CPU- and GPU-based HPC systems.

ARCHIMEDES – FOR 5595

Influence of fluid properties and model parameters with regard to stratified gas-liquid gap flows

L. Burchardt[1], J. Vorspohl[2], F. Sabozin[3], M. Meinke[2], W. Schröder[2] and A. Brümmer[1]

[1] Chair of Fluidics, TU Dortmund University, Dortmund, Germany

[2] Institute of Aerodynamics, RWTH Aachen University, Aachen, Germany

[3] Chair of Thermodynamics, Ruhr University Bochum, Bochum, Germany

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In rotary positive displacement machines - like twin-screw compressors - clearance flows have a big impact on the quality of the energy conversion. To partially seal the gap connections and thereby reduce internal losses, an auxiliary fluid, e.g. oil, is often injected into these machines. If a chamber model method is used to simulate the thermodynamic operating behavior of such a wet-running twin-screw machine, two-phase mass flows rates through the gaps must be calculated as accurately as possible in order to achieve a high simulation accuracy. This paper presents an extended model for simulating such two-phase gap flows. The model allows the simulation of a gap flow, taking into account the possible outgassing of a gas (e.g. refrigerant) from a liquid phase (e.g. oil) along the gap. The model is used to analyse the sensitivity of various fluid properties (e.g. solubility, density, viscosity) or boundary conditions (e.g. pressure ratio, quality at the inlet of the gap) in relation to the simulated gap mass flow rate.

High-resolution simulations of gas-liquid Couette-type sealing gap flows

J. Vorspohl[1], L. Burchardt[2], A. Brümmer[2], M. Meinke[1], W. Schröder[1]

[1] Institute of Aerodynamics, RWTH Aachen University, Aachen, Germany

[2] Chair of Fluidics, TU Dortmund University, Dortmund, Germany

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The two-phase flow in sealing gaps of twin-screw compressors is investigated using highly resolved coupled multiphase simulations. Oil-injected rotary-type positive displacement compressors (RPDC) such as twin-screw machines are used for the compression of refrigerants in HVAC (Heating, Ventilation, and Air Conditioning) systems. The efficiency of such machines is largely determined by the inevitable two-phase surge and gap flows. The simulation of flows in such compressors is still a challenge due to the complexity of the two-phase flow in the narrow gaps (< 0.3mm) with organic working fluids and moving boundaries. Due to the rotation of the screws relative to the housing, gaps are present between the rotors and the end plates of the housing and between the tips of the rotors and the cylindrical housing walls. Oil injection can increase the efficiency of screw compressors or expanders by more than 10%, since oil enhances the sealing of the gaps where leakage occurs. On the other hand, additional momentum losses are caused by the two-phase gap flows. The oil injection, however, increases the hydraulic losses which depend on the geometry of the gap, the liquid, and the kinematics of the established multiphase flow in the gap. In this work, a highly efficient, high-resolution numerical method is used for the simulation of the gas-liquid multiphase flow in the screw compressor gap between the rotor tip and the stationary housing. The Lattice-Boltzmann method (LBM) defines the basis of the method used in this work, forming an in-house developed framework in which each fluid phase is solved by a separate solution algorithm. To capture the motion of the liquid-gas phase boundary, a level-set method is used. In the present work, a generic gap flow is considered. A Couette-type flow configuration, where the sealant flow in the gap is driven by the moving inner wall, is investigated. The Reynolds number based on the height of the channel is $Re = 20000$. Finally, we discuss the impact of bubble-laden sealing gaps on the momentum losses of the system.

Astigmatism Quantification for Depth Localization of Bubbles and Tracers across Curved Surfaces

H. Lange[1], C. Sax[1], A. Brümmer[2] and J. Kriegseis[1]

[1] Institute of Fluid Mechanics, Karlsruhe Institute of Technology (KIT), Karlsruhe, Germany

[2] Chair of Fluidics, TU Dortmund University, Dortmund, Germany

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The present combined theoretical/experimental study addresses the impact of astigmatism on the two-phase flow diagnostics across the curved surfaces of liquid test-rig containments. In the present context, the target application is the two phase leakage flow diagnostics across the annular housing gaps of oil-injected rotary positive displacement compressors (RPDC). Earlier studies by the authors identified the Defocusing Particle Tracking Velocimetry (DPTV) and Interferometric Particle Imaging (IPI) as particularly promising combination of flow measurement techniques to investigate the liquid and disperse gas phases inside the annular housing gap of RPDCs. The test-rig-specific influence of astigmatism on the resulting optical transfer function for a quantitative evaluation of the recorded defocused particle images (PI) is first compared to the theoretically derived circular PI diameter upon pure defocusing and subsequently tested for both classes of PIs, i.e. DPTV and IPI. To mimic the optical configuration of optically accessible lateral surfaces of typical RPDC test rigs, a circular beaker glass (CBG) of comparable diameter is chosen for the experimental campaign. The results are discussed and future efforts for advanced PI-evaluation strategies are outlined on the grounds of the drawn conclusions.

DESIGN

On Rotor Profiling of Internally Geared Screw Machines

H. Lacevic, A. Kovacevic, N. Stosic and M. Read

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The internally geared screw machine represents a novel type of positive displacement compressor which consists of an inner and outer rotor. Both rotors rotate in the same direction but are each centered on offset parallel axes. The rotor profiles are designed to create multiple continuous contact points between the rotors, forming several separate working chambers whose volumes vary from minimum to maximum and back to minimum during a single rotation of the outer rotor. For a gas or two-phase working fluid, adjusting the discharge port geometry allows internal compression to occur before discharge. Previous research has focused on using the well-known rotor profiling method, which employs a circular pin to generate the inner and outer rotor profiles. Although the rack method for rotor profile generation has been described and investigated for conventional screw machine rotor profiles, it has never been applied to internally geared screw machine profile generation. This paper provides an initial description and application of the rack method for generating internally geared screw machine profiles. Potential benefits of using the rack method compared to conventional methods for rotor profile generation in internally geared machines are discussed. Additionally, the limitations of using the rack method for internal gearing are presented and illustrated through various examples and applications.

Designing novel rotor profiles of twin screw compressors using generative deep learning

(presentation only)

R. Nakka, A. Kovacevic and S. Ponnusami

City, University of London, Centre for Compressor Technology, London, United Kingdom

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Twin screw compressors efficiency depends on the profile of its rotors. The traditional approach is to define a profile as a set of curves either on the rotor or rack and produce associate profiles of other rotors using gearing theory and Willis conditions. In recent times, artificial intelligence (AI) in general, and deep learning in particular, has shown a potential to be used in defining new shapes of rotors due to the availability of large data and increasing computing capabilities. Among various deep learning methods, generative methods are successfully applied in various domains either for data augmentation or inverse design. Generative modelling learns the mapping from a known distribution to the underlying unknown distribution of training set examples. In this direction, the current research is focused on applying state-of-the-art generative deep learning methods, especially generative adversarial networks (GAN) in rotor profile design based on rack generation.

A training data set containing about 60,000 rack profiles of the demonstrator class of profiles is used to train a GAN network. These training set samples guide the GAN learning process in an adversarial competitive environment. GAN models are trained with Wasserstein distance and gradient penalty loss, using open source deep learning framework PyTorch. A trained GAN model takes a vector from high-dimensional space with values sampled from a normal distribution and produces a new valid rack profile which is then used to derive a pair of rotor profiles based on the analytical relations conforming to meshing conditions. The idea of using rack profiles instead of generating a pair of the main and gate rotors directly is to reduce the complexity of the model training process. The architecture of the generator and critic networks and loss functions are modified to produce smooth rack profiles, which is a critical requirement for manufacturability. It is observed that the trained GAN is able to produce thousands of different and novel rack profiles in a matter of seconds.

Design and Improvement of Curved Envelope Meshing Pair Profile of Single Screw Compressor

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In recent years, the wear problem of the wheel tooth in the single screw compressor (SSC) had been solved due to the development and application of various envelope profiles. Among these profiles, the curved envelope profile shows performance advantages, which displays great application potential in the fields of high-temperature heat pump, steam compression, etc. However, SSC with curved envelop profile still faces the problem of incomplete design method, large leakage clearance, difficult processing and meshing pair interference under extreme conditions. Therefore, aiming at solving these problems, a coupling profile design method for the curved envelope meshing pair of the SSC was presented and studied. The profile equation of curved envelop meshing pair of a SSC with an ellipse profile as the characteristic line was established. The method of using standard tooth width was proposed for the quick geometric design of the SSC. The coupling profile design of the star wheel tooth angle and the groove bottom angle with variable diameter circular arc was invented. The equation of the transition arc surface of the bottom angle of the groove and the angle of the star wheel tooth was derived. It provided a theoretical basis for the design and improvement of meshing pair with curved envelop profile.

SIMULATION

Yet another structured mesh generator for screw machines simulation

Y. Ji and M. Möller

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High-quality structured mesh generation is essential for the numerical simulation and design optimization of screw machines, particularly rotary twin-screw compressors used in high-pressure gas production. Existing meshing techniques often struggle to accurately capture their intricate geometries, limiting their application potential. This paper proposes a novel Isogeometric Analysis (IGA)-based mesh generation approach specifically tailored for twin-screw compressors. Our method leverages high-order B-spline parameterizations derived from boundary representations to enable efficient and precise mesh generation. A novel boundary correspondence technique using Schwarz-Christoffel mapping is introduced to further enhance mesh quality and preserve critical profile features. Additionally, we integrate elliptic grid generation techniques within the IGA framework, combined with a block-diagonal Jacobian-preconditioned Anderson acceleration algorithm, to efficiently solve the associated nonlinear systems. This approach, built upon the open source Geometry + Simulation Modules (G+Smo) library, demonstrates its effectiveness in generating high-quality structured meshes that meet stringent requirements for screw machine simulations, providing a viable alternative for design optimization.

Simulation analysis of the internal flow field in single screw compressor using local re-meshing method

W. Wu, P. Zhang, Q. Wang, L. Huang, Y. Sun and T. Feng

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The single screw compressor (SSC) is considered an excellent competitor to the twin screw compressor due to its symmetrical structure and balanced gas forces on the screw rotor. To enhance the performance of SSC, it is crucial to have a thorough understanding of the internal flow field, particularly in the leakage channels. Nevertheless, the vertical relationship between the star wheel axis and the screw axis leads to mesh distortion, which presents technical challenges for mesh division in CFD simulations. In this paper, the method of local re-meshing is employed to simulate the comprehensive flow field using the Forte software. The mesh is regenerated near the motion boundary, while the mesh in the remaining areas remains unchanged. The pressure and temperature distribution of the internal flow field of the compressor are obtained, as well as its variation during operation. The results indicate a noticeable pressure gradient change in the leakage gap. The pressure and temperature of gas gradually increase along the axis direction of the screw, reaching the maximum value in the exhaust channel. The research can provide support for the future optimization design of the SSC

CFD Analysis and Optimization of Oil Ports in Twin-Screw Compressors using Taguchi Method

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Twin-screw compressors are important equipment widely used in industrial applications. In order to enhance and optimize the performance of these compressors, careful analysis of oil injection parameters is necessary. The aim of this study is to optimize the oil injection ports to be used in a twin-screw compressor through CFD analysis. In this study, CFD analysis of the oil injection ports of a twin-screw compressor is conducted using Ansys Forte software. This analysis, structured with surface meshing, allows for a detailed examination of the internal flow of the compressor, enabling evaluation of the effects of oil injection on performance. Specifically, the effects of oil injection parameters, such as the number, positions, and diameters of injection ports, on performance are investigated. Additionally, the impact of changes in operating conditions, such as pressure ratio and male-female rotor speed, on performance is evaluated.

The outputs of these analyses form the objective function through Taguchi tabulation method optimization. The objective function aims to achieve the average minimum temperature in the compression chamber, thereby providing enhanced cooling. Thus, the goal is to determine the most suitable combination of oil injection parameters and maximize compressor performance. This study represents a significant step in the design and optimization of oil injection systems for twin-screw compressors. The obtained results contribute to the more efficient and reliable operation of such compressors in industrial applications.

Stability and Convergence for Preconditioned Successive Over Relaxation and Incomplete LU Decomposition Iterative Linear Solvers used in an Oil-Injected Screw Compressor

D. Ziviani[1], M. S. Barrubeeah[1], A. Saravana[1], S. Bhaduri[1], D. Low[2] and E. A. Groll[1]

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[2] Hitachi Global Air Power (HGAP), Michigan City, United States of America

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Discretized Partial Differential Equations (PDEs) for numerical modelling of fluid mechanics systems involves several different iterative linear solvers. In this work, a transient 3D CFD model of an oil-injected screw compressor has been developed utilizing two different numerical approaches, i.e. a structured grid and a cut-cell grid. The numerical models have been validated utilizing experimental measurements. Presence of turbulent boundary layer and shear flow topology in the rotating fluid domains required implementing k-ω Shear Stress Transport (SST) turbulence model along with the physics needed to capture multifluid interfaces.In CONVERGE CFD, Semi Implicit Pressure Linked Equation (SIMPLE) algorithm was used for initial model development and pressure-velocity coupling in a collocated grid model, eliminating checkerboard numerical oscillations with the Rhie-Chow interpolation scheme. These model parameters and pressure velocity coupling algorithms are kept unchanged while comparing preconditioned Successive Over Relaxation (SOR) and Incomplete Lower and Upper triangular (ILU) decomposition. These two solvers yielded to different numerical instabilities and rate of convergence, affecting the simulation clock time.

OPERATION

A Bayesian-inference approach to quantify degradation parameters in a water-cooled variable speed screw compressor chiller

A. J. Hoess, J. Ma, E. A. Groll, J. E. Braun and D. Ziviani

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Variable-speed screw chillers can provide effective capacity modulations in commercial buildings to reduce energy consumption, match the load requirements, and contribute to lower equivalent carbon emissions. However, variable-speed operation can also yield to degradation phenomena inside the compressor. Assessing the real-time health status of chillers and detecting anomalies are important aspects to ensure long-term operation and improve reliability. To this end, an automated accelerated life test (ALT) procedure was developed and applied to a 513 kW (145.9 RT) water-cooled variable-speed screw chiller in a laboratory test facility to experimental assess performance degradation over time. After every 1,000 operating hours of ALT, steady-state performance tests at 30%, 50%, 75% and 100% load were conducted according to AHRI Standard 550/590. Additional operating conditions were included while conducting the tests to provide a more complete assessment of the degradation trends compared to the initially measured baseline. The experimental data set was then used to quantify the performance degradation based on the impact on the screw compressor operation. A Bayesian-inference identification approach has been developed to identify changes of sensitive parameters that statistically provide evidence for the likelihood of a performance degradation of the compressor. The information was used to implement the parameters in a dynamic model which was used to perform studies to predict the degradations of a chiller. The outcomes of this study help to improve the maintenance schedule of a compressor and even the whole chiller so that the system can be operated more economically and unplanned downtime can be minimized.

MoS_2 Coatings in unsynchronized, dry-running Screw Compressors: Experimental Insights on Operational Efficiency and Durability

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The discourse on unsynchronized, oil-free screw compressors versus their conventional, oil-lubricated counterparts encapsulates a pivotal shift towards more efficient and environmentally friendly industrial machinery. By forgoing gears and lubricants, these innovative compressors streamline manufacturing and assembly, while also eliminating the risk of lubricant contamination in the process gas. In this configuration, the torque generated on the gate rotor by the gas pressure is directly conveyed to the main rotor through the interfacing surfaces of the rotors.

In the development of compressor technology, a significant improvement is the application of a molybdenum disulfide (MoS_2) coating on the primary rotor. This application utilizes the properties of molybdenum disulfide, which is effective in reducing friction and wear under various operational conditions. By applying this coating, there is an anticipated increase in the wear resistance of the rotor, effectively reducing frictional losses during its operation. This reduction in friction is expected to improve the mechanical efficiency of the compressor and extend its operational lifespan.

The investigation of contact interactions utilizes a custom-designed test rig, through which effective parameters are analyzed to facilitate conclusions regarding losses and the durability of the coating. Additionally, the geometry within the contact area is tactilely measured, enabling the quantitative determination of wear. Various layer thicknesses, surface roughness levels, and loads are examined in this context.

Test rig setup for particle wear analysis in screw pumps

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For many applications multi-screw pumps can be operated with minimal wear rates, thus offering long service life. Pump manufacturers are however met with increasing demand for pumps in applications with particle-laden fluids, which often lead to high wear rates. Thus, the need for design guidelines and models for the estimation of the life expectancy arises. The scientific literature does not offer such models or published systematic studies. In this work the authors present a test rig setup for the systematic analysis of wear in operation with particle-laden fluids in multi-screw pumps. The setup is designed with repeatability of the test environment and reliability aspects in mind and draws inspiration from food and chemical processing industries.

Economic Assessment of Multi-Stage Screw Compressors: A Comprehensive Lifecycle Cost Analysis

(presentation only)

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Screw compressors play a pivotal role in diverse industrial applications, offering efficient solutions for gas compression. This contribution centers on the economic evaluation of multi-stage screw compressors, specifically scrutinizing the performance and associated costs of single-stage and two-stage configurations. Leveraging the SCORG modeling and analysis tool, an extensive investigation is undertaken to unravel the economic implications of these compressor types. Commencing with an overview of screw compressors, this study accentuates the advantages inherent in multi-stage configurations. Notably, two-stage compressors exhibit promise in augmenting performance and efficiency compared to their single-stage counterparts. The intricate interplay of design considerations, operational efficiency, and construction costs lays the groundwork for a comprehensive analysis. A meticulous examination of an industrial screw compressor is conducted, utilizing SCORG for the modeling and analysis of its performance characteristics. Moving beyond operational efficiency, the analysis delves into the economic aspects associated with the construction of both single-stage and two-stage screw compressors. The integration of insights from a comprehensive database and the incorporation of data from extensive experimental trials contribute to a holistic lifecycle cost analysis. Throughout the research, emphasis is placed on key economic factors that influence decision-making processes for stakeholders in the industry. The comparison of construction costs, operational efficiency, and long-term maintenance expenses offers a nuanced understanding of the economic landscape surrounding multi-stage screw compressors. In conclusion, this study contributes invaluable insights to the field of screw compressor economics. The advantages of two-stage screw compressors are not only evident in superior performance but also in economic feasibility. Stakeholders stand to benefit from a more informed decision-making process, aligning their choices with both operational and economic considerations. As

industries persist in the pursuit of efficient and cost-effective compression solutions, this research serves as a comprehensive guide, paving the way for optimized applications of multi-stage screw compressors

LIQUID INJECTION I

Influence of Screw Parameters and Fluid Injection on the Performance of Screw Compressors

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Screw compressors are widely used in industrial and commercial applications due to their high efficiency, reliability, and durability. However, there is still room for improvement in terms of energy efficiency and performance. To address this, the current study investigates the impact of screw rotor geometrical parameters: wrap angle, relative length, and built-in volume ratio and fluid injection methods (oil, and water injection) on the performance of screw compressors. The research offers a detailed analysis of these parameters, with a focus on the empirical validation of water injection's influence through experimental testing on an industrial screw compressor. The findings reveal that water injection reduces specific power consumption by 4.78 % compared to oil injection, highlighting its potential for improving compressor efficiency. This work contributes valuable insights into optimizing screw compressor design for enhanced performance and energy efficiency.

Optimization of Specific Power Consumption in Single-Stage Oil-Injected Screw Air Compressors: Experimental and Computational Approaches

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Oil-injected screw air compressors are widely used equipment in industry to meet the demand for compressed air. Optimization of specific power consumption plays a critical role in enhancing the performance of these compressors. In the study, a comprehensive experimental and computational approach has been adopted to analyze the performance of a single-stage oil-injected screw compressor.

Important parameters such as pressure, temperature, torque, and oil flow rate are measured on the test setup. The main focus of the study is to determine the appropriate oil flow rate and oil temperature for optimizing specific power consumption for different operating speeds. In this context, the power consumption is calculated based on the measured speed and torque values while controlling the oil flow rate and oil temperature for different operating speeds in the experimental setup. A sonic nozzle flow meter device is used to measure the free air delivery with high accuracy. The obtained experimental data are used to determine the optimum oil flow rate and oil temperature.

In the study, a comprehensive computational fluid dynamics (CFD) analysis is conducted specifically for the screw model. The CFD-based modeling is validated with experimental results. This step not only enhances the reliability of experimental data but also allows testing different models in a computer environment, leading to savings in energy consumption costs and reduction of carbon dioxide footprint.

As a result, this study constitutes an important step towards improving the performance and energy efficiency of oil-injected screw air compressors. The validation of obtained data and testing of different models contribute to the development of more efficient and environmentally friendly systems in industrial applications.

OilMixProp 1.0: Package for Thermophysical Properties of Oils, Common Fluids, and Their Mixtures

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This work presents the first version of OilMixProp (short for oil mixture properties), which could be the first software package capable of calculating all the core thermophysical properties of fluids involving user-defined oils. Properties needed in thermodynamic cycle analysis are all included: density, phase equilibria, heat capacity, entropy, enthalpy, speed of sound, viscosity, and thermal conductivity. Approximately 632 pure fluids are available, and users can define their oil by determining its fluid constants using embedded fitting tools. Analogous to refpropm (Matlab interface of REFPROP 10.0), a function OilPropm is developed as the only interface for calculating thermophysical properties. Various input combinations (e.g., temperature and pressure, pressure and enthalpy, temperature and vapor fraction, etc.) are available to cater to the needs of thermodynamic cycle analysis. Sophisticated outputs are designed to deliver either complete information (phases and properties in each phase) or selected information about a fluid at the given condition. The package is written in Matlab and will be converted to other languages (e.g., C++) in the future.

ACOUSTICS

Experimental Investigation and modelling of the noise and vibration in screw compressors

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This article presents work on the extension of torsional models' development for screw compressors. These compressors are common in industry and their vibration behavior and signature are very important. When neglected in the design, it can lead to torsional or structural resonance or lateral vibration in the machine during operation and in the worst case to catastrophic failure of the machine. The screw compressors presented here are used for bulk transport on trucks. They are designed and built by CVS Engineering GmbH. Measurements in the lab and field test showed that the torque peak in the drive shaft can fluctuate and show large values than normal when the first torsional mode is excited by 1 × the input speed. They also show that the nature of the excitation and hence the response of the machine depends on the drive and the excitation amplitude, which depends strongly on the prop-shaft angle. To predict this behavior, detailed free and forced torsional models are developed and validated with measurements. The latter enables the validation of the torque peaks obtained in measurement. The drive train configuration (branched or unbranched) is taken into account and a method that can handle both setups, the Holzer method, is used.

Investigation of Pressure Pulsation and Vibration of the Internally Geared Screw Compressor

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The Internally Geared Screw Machine (IGSM) is a relatively novel and promising type of positive displacement compressor concept that takes inspiration from classic gerotor pumps. The IGSM uses two rotors rotating in the same direction about parallel axes while maintaining continuous contact between both rotors which isolates several working chambers. By using ported end plate, the IGSM can determine the timing of the fluid entering and exiting the working chamber. There are several key advantages to the IGSM over traditional twin-screw compressors including reduction of the rotor to casting leakage, elimination of the blow hole area, reduction in sliding velocity at the point of contact, and a uniform circumferential rotor temperature profile. Although there is some research regarding the geometric profiling and chamber modeling of this type of machine, there is no research currently available on the pressure pulsation and vibration characteristics of the IGSM. The purpose of this paper is to provide an initial look into the pressure pulsation and vibration characteristics of the IGSM and how they differ from that of a traditional twin-screw machine. By explicating the key differences between the IGSM and the industry standard twin-screw compressor, this paper aims to better understand an important yet underdeveloped area of IGSM design.

1D and Quasi-3D Simulation-Based Optimization of Discharge Noise Attenuation in Twin-Screw Machines Using GT-SUITE (presentation only)

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Screw compressors are an established and reliable type of machinery both for air compression and Heating, Ventilation, Air Conditioning & Refrigeration (HVAC&R) applications. However, they can suffer from noise and vibrations during operation, mostly generated by the fluid pulsations inside the machine and the compressor discharge. Considering the growing interest towards heat pump systems in the current energy market in both housing and commercial buildings, the reduction of noise for such machines has become increasingly important to make this solution more appealing to the public. One common practice is to apply an attenuation system at the machine discharge to damp noise, but the design needs often to be tailored and specific, easily evolving into an expensive task. This study shows the potential of simulation in tackling such a problem, by designing and numerically optimizing the discharge attenuator of a screw compressor using a quasi-3D flow approach coupled with a state-of-the-art 1D flow solver. The workflow followed references past work where the compressor geometry including chamber volumes, port and leakage areas are generated and the 1D machine simulation validated, followed by thermodynamic simulations and noise suppression system optimization. The model architecture is demonstrated to be capable of applying leakage correlations and facilitates easy comparisons against leakage flows from experimental and simulation data using literature and commercial benchmarks. The standalone compressor model has been run with different working fluids to meet evolving standards in HVAC&R, and also looks at future challenging market perspectives such as the supply chain for hydrogen mobility where such machines could play a relevant role. The model built is proven to run effectively with air and compared against relevant references in the field. The proven simulation environment allows simulations including oil-flooded and dry-running operating points to represent practical working conditions of such machines with higher fidelity. From the baseline compressor, the design of 3D noise attenuation systems such as mufflers have been demonstrated and then optimized using the built-

in capabilities of GT-SUITE to achieve maximum noise reduction while not excessively compromising performance.

STEAMSCREW

Thermodynamic simulation of a water-injected twin-screw steam compressor

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Decarbonisation of industrial heating and process steam generation is crucial for the mitigation of advancing climate change. High-temperature heat pumps can meet these demands while effectively integrating with renewable energy sources, outperforming traditional heating and boiling systems, especially when operating with natural refrigerants. Since compressor efficiency is critical for the effectiveness of heat pump systems, particular care is required in compressor design and specification. Detailed thermodynamic simulations of the compressor system are indispensable in this process. The compression of fluids with a negative saturation vapour curve leads to challenging temperature increases during compression, with substantial superheating of the working fluid. In this context, a promising approach is the injection of liquid working fluid into the compressing chambers for internal cooling. This introduces new complexity to compressor simulations for heat-pump applications. In this work, a novel two-phase approach for multi-chamber simulations of positive displacement compressors is presented. Initially, an isentropic reference process for vapour compression with internal liquid injection is introduced and efficiency ratings are derived. Furthermore, the simulation process is described in detail, and comprehensive thermodynamic simulations of a water-injected twin-screw steam compressor are carried out.

Performance Analysis of a Water-Injected Twin-Screw Compressor in a High-Temperature R718 Heat Pump

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High-temperature heat pumps with twin-screw compressors and water (R718) as the working fluid show promising potential for providing industrial heat and process steam at temperature levels of up to 200 °C. This paper presents a simulation approach for a two-layered simulation structure of a water-based high-temperature heat pump system including a twin-screw compressor with water injection. The heat pump process with two-phase steam compression is investigated with respect to various aspects. In addition to controlling the compressor outlet temperature, the evaporation of the injected liquid leads to an increase in the displaced mass flow rate on the sink side of the heat pump. This effect is analyzed in detail for various system operating points using a thermodynamic simulation framework for the R718-based heat pump cycle and a comprehensive compressor model. The main target of the presented paper is the analysis of system performance and the detailed investigation of the interdependencies. Performance of the twin-screw compressor is determined by means of two-phase chamber model simulations. In the chamber model method thermodynamic properties of both injected liquid and steam are calculated based on the conservation equations of mass and energy for the compression process. Adequate sub-models for internal leakage and heat and mass transfer between vapor and liquid phase are applied. Integral results of the compressor simulations are embedded in the heat pump system simulation using a characteristic map. In conclusion, this paper contributes to the understanding of advanced compression technologies in the field of high-temperature heat pumps, offering a detailed examination of a water-injected steam compressor's applicability and efficiency in a practical system setting.

Experimental investigation of the operating behavior and efficiency of twin-screw compressors with water injection and complete evaporation

(presentation only)

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As part of the "SteamScrew" project, AERZEN is investigating the operating behavior and efficiency of twin-screw compressors with completely evaporated water injection. The outlet temperature of the compressor is therefore always above the pressure-dependent boiling temperature of water. To make the experimental setup as simple as possible, air was used as the conveying medium so that the compressor could draw in ambient air and blow it out into the environment. To determine the volume flow, an orifice measurement was installed on the suction side in accordance with ISO/TR15377. As the compressor has a directly flange-mounted asynchronous motor with gearbox, the power consumption could only be measured electrically. The main rotor tip speed could only be varied in the range of 43-68 m/s due to the design. Injection at low speeds and without atomization led to irregular fluctuations in outlet temperature and pressure and thus to unstable operating behavior of the compressor. During the measurements it was found that the intake volume flow of the compressor remained unchanged at high speeds regardless of the water injection. At low speed, however, the intake volume flow was measurably reduced (-5%) when water was injected. The power consumption remained almost unchanged at all operating points. However, if the additional water vapor content on the pressure side is considered, the reduction in the intake volume flow was compensated.

VACUUM TECHNOLOGY I

CFD simulation of rotary displacement vacuum pumps: Possibilities and Challenges

(presentation only)

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Rotary displacement machines such as screw compressors, scroll compressors, rotary vane pumps or roots blowers are used not only for compressing process gases but also as vacuum pumps for generating negative pressures. In this context, some adjustments are made:

- Due to the low mass flows, efficient cooling of the housing and rotors is necessary.
- The clearances (radial, axial and profile clearances) are often significantly smaller.
- Vacuum pumps are often designed in a multi-stage configuration to achieve lower pressures.
- Screw vacuum pumps, in contrast to screw compressors, have angular profiles and often variable and smaller pitches.

These adaptations also lead to increased demands on flow simulations, making simpler methods like overset meshes or remeshing difficult to use. Instead, contour-adapted hexahedral/prismatic grids are required. This presentation explains how the grid generation, implementation of chamber deformations and adapting the vacuum pump to these requirements are addressed for a multi-stage rotary piston vacuum pump and a screw vacuum pump. It also discusses the limits of the continuum approach and explores the possibility of extending the application range into slip flow with a Knudsen number <0.1 using a slip boundary condition for velocities and temperatures.

Combined Rotor Rack Generation for Twin Screw Vacuum Pump Rotor Profile Design

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Rotor profile design is a critical factor influencing the efficiency and functionality of twin screw vacuum pumps. This paper delves into a specific aspect of rotor profile design: the method of rack generation. The paper unveils an algorithm for rack generation tailored explicitly for twin screw vacuum pump applications. The utilization of straight lines to form the rack ensures the generation of involute profiles on the rotors, facilitating beneficial rotor contact and torque transfer. Additionally, rack-generated rotors are typically easier to manufacture. It elucidates the rack generation process and compares geometrical parameters, such as displacement, and leakage area, across three rack generated rotor profiles. Furthermore, chamber modelling is employed for the development of rotor profiles, augmenting the efficacy and reliability of the rack generation process. By focusing on rack generation, this paper offers valuable insights into rotor profile design, contributing to a deeper understanding of the methodologies driving innovation in twin screw vacuum pump technology.

Design of toothed belt driven screw vacuum pumps

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Most screw vacuum pumps use oil-lubricated gears for timing of the rotors. An alternative is a toothed belt to drive and synchronise the screw rotors. In combination with grease-lubricated bearings this drive concept allows the design of completely oil-free pumps. However, belts are less accurate in terms of timing, hence the design of efficient pumps is challenging. In this paper, the development of a new series of belt driven dry screw vacuum pumps is discussed. It covers the overall pump concept including cooling system, material selection and noise damping. Particular attention is paid to the design of the screw rotors with respect to the properties of the belt drive. It is shown that the disadvantage of the inaccurate timing and the need for wide rotor to rotor clearance can be overcome with a high number of wraps. Furthermore, it gives insight to applications and practical field experience.

LIQUID INJECTION II

One-dimensional investigations of the periodic liquid-injection in twin-screw compressors

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The injection of liquid fluid (mostly oil) in twin-screw machines brings several advantages like sealing the gaps, at least partially, and absorbs some of the compression heat. To predict the machine behavior, it is essential to consider the injection process, because it determines the amount of liquid within the working chambers. This in turn determine the absorption of compression heat, the degree of sealing the gaps and the hydraulic losses. Therefore, in this study the transient liquid injection is investigated using a one-dimensional method of characteristics within the injection nozzle. The theoretical results are compared with the actual liquid mass flow rate of an oil-injected twin-screw compressor.

Screw Compressors for High Temperature Heat Pump Duty (presentation only)

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Ever since SRM [1] introduced the screw compressor in 1930:ies there have been new applications for this compressor in different sectors in industry. It is one of the most common machines used to compress gases and now is totally dominating the refrigeration and heat pump markets for the heat power range between approximately 100 to 2000 kW.

This presentation introduces the different challenges faced particularly in the use of the screw compressor in applications for high temperature heat pumps (sink temperature above 100 deg C). In this context, the injection of liquid during compression is discussed and comparison is done against test data and simulation results.

Different compressor layouts and working media are discussed together with injection of oil and / or liquid working media during gas compression, and its effects on compressor performance as well as plant COP for the heat pump case.

A particular focus is given to the still ongoing heat pump project Interheat [2] with Butane / Steam cascade system, supplying steam at up to 160°C, and some system simulation examples are taken from this still ongoing project.

References

[1] https://rotor.se/

[2] https://interheat.dk/

VACUUM TECHNOLOGY II

Investigations to reduce rarefied gap flows within positive displacement vacuum pumps by utilising surface structures

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The ultimate pressure and efficiency of positive displacement vacuum pumps is limited by the backflow through the gaps within the machines. These gap flows are typically reduced by decreasing the gap height, which is limited for reasons of operational safety. Therefore, this study concentrates on the reduction of rarefied gap flows by means of suitable surface structures whose dimensions are small compared to the gap height without simultaneously reducing the minimum gap height. For this purpose, a method is presented to efficiently calculate the impact of the surface structure on these gap flows. Based on this method, design parameters for the choice of a suitable surface structure are discussed. Furthermore, a possible transfer for the application on the rotors is shown including a proposal for the machining process.

A Novel Approach for Measuring and Comparing Vacuum Pump Efficiency: Pumping Efficiency (PE)

(presentation only)

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Vacuum pumps play a crucial role in many industrial and consumer applications, yet there is currently no established standard for characterizing their energy efficiency and CO2 footprint. The lack of a simple and meaningful definition for vacuum pump energy efficiency is due to the complex field of applications that vacuum pumps operate in. Addressing this gap, the Atlas Copco Group - a leading supplier of vacuum equipment - has undertaken internal discussions to initiate international standardization for energy efficiency of vacuum pumps. In pursuit of Science Based Targets and the values of sustainability, we propose a novel approach for measuring and comparing vacuum pump efficiency called Pumping Efficiency (PE). PE provides a comprehensive, standardized, and transparent means to assess the energy performance of vacuum pumps across applications and conditions. In this conference presentation, we will share our PE proposal and discuss our concepts and methodology, with the goal of gaining momentum for timely standardization of energy efficiency for vacuum pumps. We believe that this work has significant potential for advancing sustainable and efficient use of vacuum pumps and contributing to global emissions reduction targets.

SCIENCE UPDATE

Design and Optimisation of Internally Geared Screw Compressors

(presentation only)

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The internally geared screw machine represents a novel type of positive displacement compressor which consists of an inner and outer rotor. Both rotors rotate in the same direction but are centred on offset parallel axes. The rotor profiles are designed to create multiple continuous contact points between the rotors, forming several separate working chambers whose volumes vary from minimum to maximum and back to minimum during a single rotation of the outer rotor. For gas or two-phase working fluids, adjusting the discharge port geometry allows internal compression to occur before discharge.

Previous research has primarily focused on using a circular pin to generate the inner and outer rotor profiles and implementing geometrical model, leading to a well-understood geometry of these machines. Recently, a one-dimensional chamber model has been implemented for internally geared screw machines, offering a quick and convenient method for performance prediction. To compare the performance of internally geared screw machines with conventional twin screw machines, it is crucial to provide an optimal design for specific applications.

This study presents an initial multivariable geometry optimization of the internally geared screw machine for air compression from 1 to 8 bar. The number of lobes, outer rotor diameter, and wrap angle were optimized using the existing quasi one-dimensional chamber model within in-house performance prediction software.

Tool development for producing structures on vacuum pump rotors

(presentation only)

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By applying surface structures perpendicular to the leakage flow on moving parts in vacuum pumps, flow losses can be reduced. Planing and turning with structured tools are ideal for the productive manufacture of such structures. However, burr formation is a major challenge here. The work presented here uses analytical and numerical simulations as well as real experimental chip formation analyses to develop burr-inhibiting tools for this machining task.

Impact of manufacturing clearances on leakages of screw-spindle compressors

(presentation only)

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Synchronized screw-spindle compressors are state of the art in vacuum technologies and have lately been investigated for water as a refrigerant as well. Thermal and mechanical rotor and housing deformation during operation are usually accounted for in the initial manufacturing clearances. Another clearance is the twist angle clearance to ensure that the synchronization is done by gears or electronically not by the screw rotors. The calculation of internal leakage areas usually assumes constant clearances over the entire rotor length. However, as this presentation reveals, the discrepancy to this assumption may be significant especially for conical rotors.

Raman Spectroscopy Analysis of MoS_2 and Doped MoS_2 Coatings on Screw Rotors

(presentation only)

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This study employs Raman spectroscopy to investigate the structural and chemical properties of screw rotors coated with molybdenum disulfide (MoS_2) and doped molybdenum disulfide. These coatings are utilized in industrial applications due to their favorable tribological characteristics and chemical stability. The Raman analysis focuses on the vibrational modes of the MoS_2 layers, providing insights into the crystallinity, coating quality, and chemical structures. The findings contribute to a deeper understanding of the interactions between the dopants and the MoS_2 matrix and their effects on the tribological performance of the coatings. This research aims at optimizing the coating processes and improving the functional performance of screw rotors in various applications.

Advanced Additive Manufacturing of Compressors with Internal Cooling: Case Studies of Linear and Screw Compressors

(presentation only)

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Positive displacement compressors are the core components in a wide range of HVAC&R systems ranging from residential to industrial applications. To develop the next-generation compression technologies, additive manufacturing and machine learning can broaden the design space and enable new concepts. In this presentation, recent advancements in additive manufacturing and numerical techniques applied to compressor development will be discussed. A linear compressor for residential heat pumps and a twin-screw compressor for high temperature heat pump applications will be used as case studies.

The Tipping Point in Uncertainty

(presentation only)

J. Sauls (retired)

Trane, United States of America

Based on a body of work relating to screw compressor design from the 1990's – early 2000's, this talk will introduce a number of uncertainties that affect compressor design with specific focus on those arising from the manufacturing phase of a compressor's life cycle. I'll share the simple question that was the tipping point for what became a significant change in our screw compressor design process and how this allowed us better engagement with others in our organization - those who provided important design inputs, those designing our products around the compressors, and those who manufactured them.

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