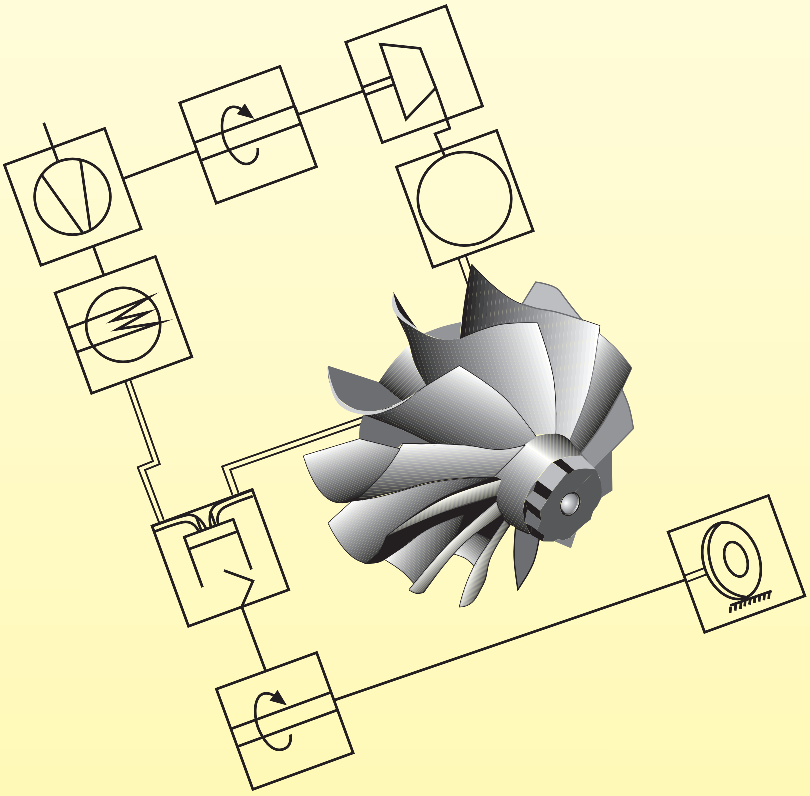
KONFERENZUNTERLAGEN

26. AUFLADETECHNISCHE KONFERENZ

20. / 21. SEPTEMBER 2022 IN DRESDEN



26th SUPERCHARGING CONFERENCE

20th / 21st SEPTEMBER 2022 IN DRESDEN

CONFERENCE DOCUMENTS

26. AUFLADETECHNISCHE KONFERENZ

20. / 21. September 2022 in Dresden

26th SUPERCHARGING CONFERENCE

20th / 21sh September 2022 in Dresden

Tagungsleitung / Conference Chairman

Prof. Dr.-Ing. H. Zellbeck
Technische Universität Dresden

E-Mail: info@aufladetechnische-konferenz.de
Homepage: https://aufladetechnische-konferenz

26. AUFLADETECHNISCHE KONFERENZ
26th SUPERCHARGING CONFERENCE

Conference program **Tuesday, September 20th, 2022**

08:10 a.m.
H. Zellbeck; TU Dresden
Begrüßung / **Salutation**

08:30 a.m.
T. Raikio, T. Raunio; Wärtsilä Finland OY, Vaasa, Finlandia
P. Calcinotto; Wärtsilä Italia S.p.A., Trieste, Italia
Wärtsilä journey for two-stage turbocharging: 4-stroke medium speed diesel engines

09:00 a.m.
F. Fröhlich, A. Flohr, T. Männle, J. Kech; Rolls-Royce Power Systems AG
Future Fuels and Drive Concepts - A Challenge for Turbocharging on the Way to Net Zero

09:30 a.m.
S. Spengler, C. Leitenmeier, H. Benetschik, T. Willeke, L. Aurahs;
MAN Energy Solutions ES
High Cycle Fatigue – Advanced development and design methods for increased robustness

10:00 - 10:30 a.m. – Pause / Break

10:30 a.m.
S. Münch, S. Weihard, L. Aurahs, D. Struckmeier; MAN Energy Solutions ES
Development of a high flow (TCF) and a high pressure (TCP) radial turbocharger series

11:00 a.m.
R. Ryser; Accelleron / Turbo Systems Switzerland Ltd.
Adaptation of turbocharging in interaction with the engine tuning to meet thermodynamic requirements of alternative fuels on large engines
Anpassungen an der Aufladung im Zusammenspiel mit dem Motortuning zur Erfüllung der thermodynamischen Anforderungen alternativer Brennstoffe auf Großmotoren

11:30 a.m.
K. Zhang, R. Dewhirst, S. Hughes; Cummins Turbo Technologies, United Kingdom
Turbine Stage Design Optimisation via Machine Learning Models driven by Engine Cycle Simulation

12:00 a.m.
S. Yadla, J. Keuler, M. Maniar; Garrett Motion Germany GmbH
D. Terber; Garrett Motion Czech Republic s.r.o
P. Davies; Garrett Motion, France
The Role of E-Boosting in future emission legislations

12:30 - 02:00 p.m. – Pause / Break

26. AUFLADETECHNISCHE KONFERENZ
26th SUPERCHARGING CONFERENCE

Conference program **Tuesday, September 20th, 2022**

2:00 p.m.
H. Björnsson, L. Johansson, A. Frosteman, J. Ohlsson;
Powertrain Engineering Sweden AB (AUROBAY), Sweden
Turbo matching for a Gasoline engine with Miller combustion and VTG control

2:30 p.m.
S. Weiske, M. Kosch, B. Dreher; BorgWarner Systems Engineering GmbH
High Efficient Turbochargers for Hybrid dedicated Engines
Turbolader mit höchsten Wirkungsgraden für hybrid-optimierte Verbrennungsmotoren

03:00 p.m.
T. Leonard, M. Model, A. Starke, M. Kiessling;
IHI Charging Systems International GmbH, Germany
T. Asakawa; IHI Corporation, Yokohama, Japan
IHI Variable Geometry System Turbocharger for Gasoline Application – Performance, Durability, Industrialization

03:30 - 04:00 p.m. – Pause / Break

04:00 p.m.
S. Schnorpfeil, C. Glahn, V. Muthusamy; Segula Technologies GmbH
C. Zwyssig, P. Fröhlich; Celeroton AG
Standardized compressors for fuel cell applications
Standardisierte Kompressoren für Brennstoffzellen-Anwendungen

04:30 p.m.
T. Wittmann, S. Lück, C. Bode, J. Friedrichs;
Institut für Flugantriebe und Strömungsmaschinen, TU Braunschweig
Condensation and liquid water in the radial turbine of a fuel cell turbocharger
Kondensation und Flüssigwasser in der Radialturbine eines Brennstoffzellenturboladers

05:00 p.m.
J. Klütsch; Lehrstuhl für Thermodynamik Mobiler Energiewandlungssysteme (TME), RWTH Aachen University
M. Stadermann, D. Lückmann, A. Schloßhauer, M. Walters; FEV Europe GmbH
Fuel Cell Air Compressor Design for Mobile Applications
Auslegung von Kathodenluftverdichtern für mobile Brennstoffzellenanwendungen

05:30 p.m.
K. Prevedel; AVL List GmbH, Austria
Boosting of gasoline engines: review on AVL's presentations for Aufladetechnische Konferenz since 2002 – reflection and preview to the future
Aufladung bei Ottomotoren: Rückblick auf die AVL-Beiträge zur Aufladetechnischen Konferenz seit 2002 – Reflektion und Ausblick in die Zukunft

08:00 – Abendveranstaltung / Evening Event

26. AUFLADETECHNISCHE KONFERENZ
26th SUPERCHARGING CONFERENCE

Conference program **Wednesday, September 21st, 2022**

08:30 a.m.
B. Biedermann, T. Malischewski, S. Löser; MAN Truck & Bus SE
MAN marine dual fuel engine (hydrogen / diesel) for reduced CO_2 emissions
MAN Marine Dual Fuel Motor (Wasserstoff / Diesel) zur CO_2 Reduzierung

09:00 a.m.
E. Schutting; Institut für Thermodynamik und nachhaltige Antriebssysteme,
TU Graz, Austria
Air Management of Heavy-Duty Hydrogen Engines
Aufladung von Heavy-Duty Wasserstoff Motoren

09:30 a.m.
M.-A. Baert, D. V. Santos, B. Seba, U. Weiss;
Liebherr Machines Bulle SA, Switzerland
Hydrogen combustion engine for decarbonisation in Off-Road sector

10:00 - 10:30 a.m. – Pause / Break

10:30 a.m.
P. Grzeschik, P. Biewer, C. Funke, B. Nork; DEUTZ AG
The Air Charging System of The DEUTZ Hydrogen Combustion Engine TCG 7.8 H_2
Das Aufladesystem des DEUTZ Wasserstoff-Verbrennungsmotors TCG 7.8 H_2

11:00 a.m.
S. Weigl, T. Hauck; UTF GmbH
F. Schäfer; SCF-automation GmbH
Conversion and expansion of a hot gas test bench for testing fuel cells and electric turbochargers
Umbau und Erweiterung eines Heißgas-Prüfstandes für Tests von Brennstoffzellen und elektrischen Turboladern

11:30 a.m.
T. Waldron, J. Brin; SuperTurbo Technologies, USA
H. F. Seitz, M. Wieser, W. Hochegger; AVL List GmbH, Austria
Benefits of a SuperTurbo for Hydrogen Internal Combustion Engines

12:00 a.m.
O. Schulz, S. Risse, S. Käseberg, H. Schöder;
Kompressorenbau Bannewitz GmbH
Turbocharging and alternative fuels – challenges and experiences
Abgasturboaufladung und alternative Kraftstoffe – Herausforderungen und Erfahrungen

12:30 - 02:00 p.m. – Pause / Break

Conference program **Wednesday, September 21st, 2022**

02:00 p.m.
T. Hoshi, Y. Fujita, T. Yokoyama; Mitsubishi Heavy Industries, Ltd., Nagasaki, Japan
M. Ebisu; Mitsubishi Heavy Industries Engine and Turbocharger, Ltd., Kanagawa, Japan
C. Meng Soon, T. Feng Xian, K. Jeyoung, S. Rajoo;
UTM LoCARtic, P21 Autolab, Universiti Teknologi Malaysia, Bahru, Malaysia
R. Martinez-Botas; Imperial College London, United Kingdom
Y. Mingyang; Shanghai Jiao Tong University, China
On-engine performance evaluation of non-linear A/R turbine volute for automotive turbocharger

02:30 p.m.
D. Wintergoller, K. Klepatz, H. Rottengruber; Otto-von-Guericke-Universität Magdeburg
A. Lazar; WTZ Roßlau gGmbH
Study of turbocharging concepts for an H_2NG combustion engine
Studie zu Aufladekonzepten für einen H_2NG-Verbrennungsmotor

03:00 p.m.
T. Roß, F. Atzler, R. Werner;
Institut für Automobiltechnik Dresden (IAD), TU Dresden
M. Riha; EVA Fahrzeugtechnik GmbH, München
Downspeeding of a high speed motorcycle engine
Downspeeding eines hochdrehenden Motorradmotors

03:30 p.m.
M. A. Skopil; Antrova AG, Schweiz
Interpretation and discussion of engine measurements with the new pressure wave supercharger (ComprexTM) with an outlook on the highly topical hydrogen application possibilities
Auswertung und Diskussion von Motor-Messungen mit dem neuen Druckwellenlader (ComprexTM) und einem Ausblick auf die hochaktuellen Wasserstoff-Anwendungsmöglichkeiten

04:00 p.m.
H. Zellbeck; TU Dresden
Schlusswort / **Conclusion**

Download Paper and Conference Documents

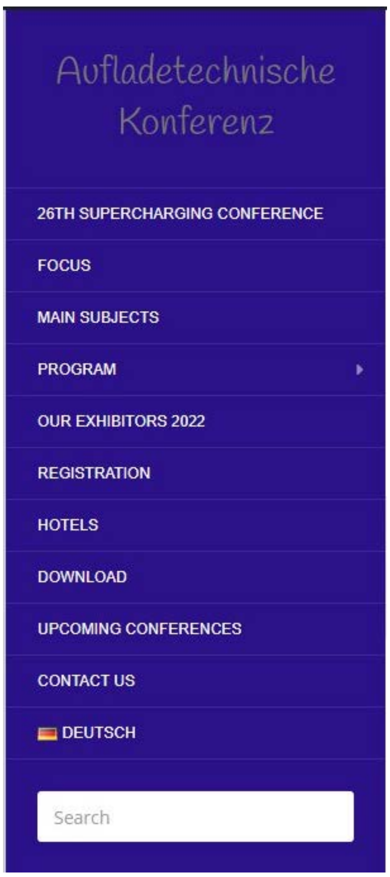
Download Paper und Konferenzunterlagen

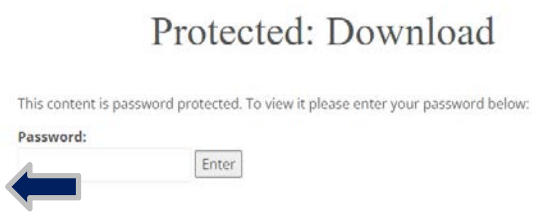
26. AUFLADETECHNISCHE KONFERENZ

26^{th} SUPERCHARGING CONFERENCE

Homepage: https://aufladetechnische-konferenz

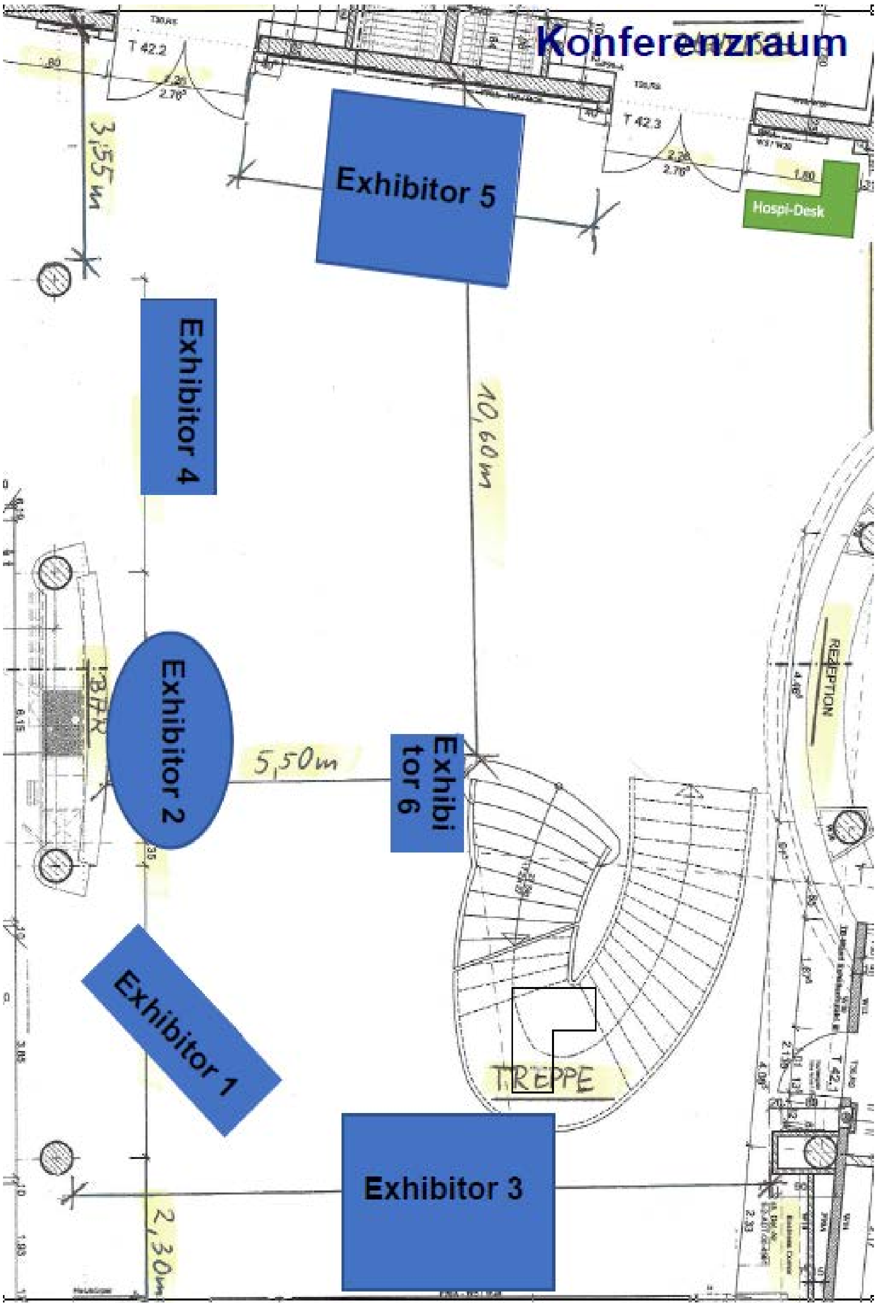
Bitte die separate Information zum *Passwort* beachten!
Please note the separate information about the *password*!





Ausstellerplan / *Plan of Exhibition*

26. Aufladetechnische Konferenz 2022 / 26th Supercharging Conference
20.– 21. September 2022



Eingang / *Entrace*

Aussteller / Exhibitors:	**No.**
ACTech GmbH	1
CRITT M2A	2
Hitchiner	3
Pankl Turbosystems GmbH	6
PBST – A Brand of MAN Energy Solutions	4
Präwest	5

all in - RAPIDEST PROTOTYPING

Willkommen beim Spitzenreiter. Seit 1995 setzen wir die qualitativen und zeitlichen Maßstäbe für schnelle Prototypenproduktion immer wieder neu; mit innovativen, teils selbst entwickelten Verfahren und Technologien, kompletter Inhouse-Abwicklung aller Prozesse und perfekt organisierten Arbeitsabläufen.
Alle für Rapid Prototyping relevanten Verfahren zur Gussteilherstellung und CNC-Bearbeitung bis zum einbaufertigen Teil kann die ACTech intern umsetzen. Das Ergebnis sind hochpräzise, einbaufertig bearbeitete Gussteil-Prototypen in Rekordzeit. Diesen Vorsprung und unsere Zuverlässigkeit schätzen unsere Auftraggeber weltweit, insbesondere aus den Bereichen Automotive, Maschinenbau sowie Luft-und Raumfahrt.
Unser „all in“-Konzept ist die Grundlage dafür, dass wir sämtliche Produktionsprozesse selbst steuern und extrem knapp takten können.
Das macht uns unabhängiger, zuverlässiger und schneller als andere. Gepaart mit unserer Erfahrung aus mehr als 36.000 verschiedenen Prototypen-Projekten ist es letztlich der Grund, warum unsere Kunden immer wieder mit uns „all in“ gehen.

all in - RAPIDEST PROTOTYPING

Welcome to the front-runner. Since 1995, we have been continually setting new standards for rapid prototype production in terms of both quality and speed. Employing innovative methods and technologies partially developed in-house, in conjunction with complete in-house management of processes and perfectly organized workflows.
All casting and CNC machining processes related to rapid prototyping are carried out in-house, right up to the ready-to-install part.
The results are highprecision, finished ready-to-install casting prototypes, produced in record time.
Our customers around the globe, especially in the automotive, engineering and aerospace sectors, place great value on our technological advances and reliability. Our “all in” concept is the basis for our practice of controlling all production processes ourselves and for our ability to realize extremely fast cycle times.
This makes us more independent, more reliable and faster than others.
Ultimately, it is this concept in combination with our experience from more than 36,000 different prototyping projects that convinces our customers to go “all in” with us time and again.

Partner for the energy transition, CRITT M2A is an independent research center set on over 10.000 sqm, considered as a major player in testing and R&D.

For more than 20 years, CRITT M2A has offered its know-how to mobility players through high-tech test means. At the heart of optimizing energy management, the skills of CRITT M2A are organized into 4 major activities:

- **Powertrain Testing**
- **NVH testing**
- **Turbocharger testing**
- **Battery testing**

CRITT M2A has been recognized for its **engine testing** and **vibroacoustic testing** activities and considered by its customers as one of the leading turbocharger testing worldwide. It realizes endurance or development tests on turbines, compressors and associated components thanks to its 5 high standard gas stands.

CRITT M2A has also develop the electrification of the vehicle, engines and turbochargers. Its electrical department can test and characterize the behavior of energy storage systems. Thanks to its large testing capabilities and the highly skilled team, CRITT M2A is a very flexible structure always working with the highest level of confidentiality.

In a rapidly changing sector, the **CRITT M2A** brings its R&D brick to an ever more efficient, economical and ecological car.

Hitchiner counter gravity investment casting technology

Hitchiner is a high volume producer of complete-to-print, complex thin-wall investment castings and fully-finished casting-based subassemblies and components to the Automotive (valve train, transmission, steering, turbocharger turbine wheels …), Aerospace (blades, vanes …), and Defense markets. Hitchiner is a US based company with 3 facilities (Air and Inert Gas melt, Vacuum melt and a facility for Single Crystal and Directional Solidification) and a Research & Development Center, MCT, Inc. in New Hampshire and 2 facilities in Mexico.
Hitchiner investment casting counter gravity technology comes with a high control of metal flow in the mold, together with a unique metallurgical cleanliness. It produces metal components in ferrous alloys, nickel and cobalt base alloys with high geometrical complexity, compactness, combined with superior fatigue properties compared to conventional casting processes, and sometimes forgings.

The evolution of engine design requires components with high stiffness to inertia ratio, fatigue durability, high fuel pressure or temperature resistance with complex geometry allowing compact packaging: Hitchiner can bring solutions to all these demands, in development as well as in high volume production.

Hitchiner Manufacturing Co. Inc. produces castings with its Counter gravity Air melt (CLA) as well as Inert-atmosphere (CLI) patented casting processes, designed for high-volume engine components, such as rocker arms, GDI fuel rails, turbocharger turbine wheels, using all types of steels, as well as refractory alloys like IN713, Mar-M 246, and Nimonic 90.

www.hitchiner.com

Pankl Turbosystems GmbH

Rudolf-Diesel Str. 24
68169 Mannheim | Germany
www.pankl.com

Rodrigo Costa
Director Sales & Business Development
Phone +49 171 2287 022
rodrigo.costa@pankl.com

Die Pankl Turbosystems GmbH (PTSYS) mit Sitz in Mannheim ist eine Tochtergesellschaft der Pankl Racing Systems AG, Österreich. PTSYS ist Anbieter von Hightech-Lösungen für kundenspezifische Anforderungen im Bereich innovativer elektrifizierter und nichtelektrifizierter Turbomaschinen- und Luftmanagementlösungen für Automobil-, Luftfahrt- und Industrieanwendungen. Das Portfolio von PTSYS besteht aus elektrisch unterstützten Turboladern, Hochleistungsturboladern, Turbo-Compound-Systemen, elektrischen Kompressoren und Brennstoffzellen-Luftversorgungssystemen. Die hochmodernen elektrifizierten Lösungen von PTSYS sind mit hocheffizienten Permanentmagnet-Synchronmotoren und integrierter Leistungselektronik ausgestattet.

Pankl Turbosystems GmbH (PTSYS) located in Mannheim, Germany is a subsidiary of Pankl AG, Austria. PTSYS is a high-tech custom solution provider in the field of innovative electrified and non-electrified turbomachinery and air management solutions for automotive, aerospace and industrial applications. PTSYS' portfolio consists of electrically-assisted-turbochargers, high-performance turbochargers, turbo-compound systems, electric compressors and fuel cell air supply systems. PTSYS' leading-edge electrified solutions are fitted with high-efficiency permanent magnet synchronous motors and integral power electronics.

PBST – A Brand of MAN Energy Solutions

The famous brands MAN Turbochargers and PBS Turbo have joined forces to become one strong, new brand: PBST. Headquartered in Augsburg, Germany, PBST designs and produces turbochargers and after treatment solutions for 2-stroke and 4-stroke engines. PBST is your dependable partner for holistic air-management systems. We provide advanced and inspiring air-management systems for applications on water, rails, as well as on the ground.

visit www.pbst.eu

PBST has its roots in Germany and the Czech Republic and has more than 85 years of experience in designing and manufacturing turbochargers and after treatment solutions. We push the limits to create high performance technologies, such as two-stage turbocharging, the EGR blower and SCR reactors for all applications, in order to meet current and future challenges for our customers. Global after-sales services are provided by MAN PrimeServ.

We understand that it's inevitable to think about future challenges for engine manufacturers holistically. While the demand for an emission reduction and consumption is growing, the available space for installations is becoming smaller. For this reason we have integrated exhausts gas after treatment systems and turbochargers in one comprehensive portfolio to be able to provide smart air-management systems for many applications.

Our product range covers holistic air-management systems: a perfect symbiosis of turbochargers and exhaust gas treatments solutions. Due to our history, we know all kind of engines by heart; thus we can optimize our solutions to fit an engine manufacturers individual needs.

Typical applications for our solutions are ship propulsion and auxiliary systems, biogas and diesel power plants, construction machinery and rail traction installations.

Our population of more than 65,000 turbochargers and exhaust gas treatment systems is looked after by our partner MAN PrimeServ that uniquely provides a one stop service world wide, 24 hours a day 365 days a year.

PRÄWEST was founded in 1945 and since then has continued to develop as a dynamic and innovative company. Twenty-four hours a day, 365 days a year, we are meeting the challenges of our customers in our workshop with its ultra-modern machine park. A relationship of mutual trust has grown between ourselves and our customers based on decades of successful cooperation. PRÄWEST is machining complex parts by milling, turning and grinding the following materials: Aluminum, Titanium, Inconel, 17–4 PH and other stainless and heat resistant alloys.
PRÄWEST is investing continuously in new technology in order to support our customer's needs. The simultaneous five-axis-milling of complex parts for all industrial applications is one of the focal points of our production. The PRÄWEST machine park covers more than 130 CNC machines in addition to some 18 robots, 5 EDM machine and 1 SLM machine.

By maintaining our focus on developing and implementing cutting edge manufacturing technology, supporting a highly flexible & skilled workforce and building long term partnerships with a customer base spread among a wide variety of industrial sectors, we aim to manufacture products of the highest quality on time at competitive prices.

www.praewest.com

https://www.linkedin.com/company/pr%C3%A4west-pr%C3%A4zisionswerkst%C3%A4tten-dr.-ing.-heinz-rudolf-jung-gmbh-&-co.-metallverarbeitung/

Gaylord Klammt

Head of Business Area Industry.

26. AUFLADETECHNISCHE KONFERENZ

Kurzfassung

26th SUPERCHARGING CONFERENCE

Abstracts

Wärtsilä journey for two stage turbocharging: 4-stroke medium speed diesel engines

T. Raikio[a,1] **, T. Raunio**[a,2] **and P. Calcinotto** [b,3]

a Wärtsilä Finland OY, Vaasa, FI
Wärtsilä Sustainable Technology Hub, Reininkatu 3, 65170 Vaasa, Finland

b Wärtsilä Italia S.p.A., Trieste, IT
Bagnoli della Rosandra 334, 34018 San Dorligo della Valle, Trieste, Italy

Abstract: Nowadays internal combustion engines are facing demanding requirements: on top of everything the emissions restrictions and the request of reliable efficiency. The increase of air flow density to combustion chamber made by two stage supercharging, is on top among solutions to limit pollutants coming from thermodynamic cycles.
This paper shows some step of the Wärtsilä way to develop a reliable two stage turbocharging system for 4-stroke medium speed diesel engines, for Marine and Energy markets.
Journey starts from early 2000's with first laboratory investigations, till to current serial production and future studies. Wärtsilä two stage engines have remarkable levels of compact and proven design, providing outstanding performance results with high efficiency levels, that at the same time allow compliancy to stricter emission regulations.
As a general overview, good OPEX levels are provided to Customers by efficient maintenance concepts and high safety levels. Some mentions will be provided around design and testing processes, with focus on engineering to fit two stage assembly on engine structure and on product validation. Extensive laboratory experience, together with known market applications, can provide a collection of field experiences about two stage, these results are source to increase knowledge and setting new and higher targets to current products, also in relation with incoming decarbonization process and future fuels.

Key Words: two stage turbocharging, efficiency, emissions, reliability, validation, field experience, decarbonization, engine, turbocharger

---

[1] E-mail: tero.raikio@wartsila.com , URL: www.wartsila.com
[2] E-mail: tomi.raunio@wartsila.com , URL: www.wartsila.com
[3] E-mail: paolo.calcinotto@wartsila.com , URL: www.wartsila.com

Future Fuels and Drive Concepts - A Challenge for Turbocharging on the Way to Net Zero

Dr. Friedrich Fröhlig[a,1], Dr. Andreas Flohr[a,2], Tobias Männle[a,3] and Dr. Johannes Kech[a,4]

a Rolls-Royce Power Systems AG
Maybachplatz 1, 88045 Friedrichshafen, Germany

Abstract: On the way to a CO2 emission-free society, new propulsion concepts and combustion engines for alternative fuels will be required in the off-highway sector, where high-speed, high-performance diesel and gas engines are currently used. This includes the fuel cell, but also engines for the use of hydrogen, methanol or ammonia. In the wide range of applications in the off-highway sector, different application-specific solutions will become established depending on the available installation space and the availability of the respective fuel.
All technologies have one thing in common: they will only be successful if powerful and precisely fitted turbocharging system with maximum efficiency is part of the system solution.
Rolls-Royce Power Systems develops turbochargers for high-speed diesel and gas engines that ensure the required properties such as efficiency, map width and robustness for the respective applications.
In this paper, turbocharging concepts based on turbochargers newly developed by Rolls-Royce Power Systems are discussed as examples for the fuel cell, the methanol and the hydrogen engine. The electrical support, the oil-free bearing and the variability on the air and exhaust side represent an essential part of the solution.

Key Words: Turbocharging concepts; Hydrogen engine; Methanol engine; Fuel cell; Electrical assisted turbocharger; performance map stabilisation

[1] E-mail: Friedrich.Froehlig@ps.rolls-royce.com, URL: https://www.mtu-solutions.com
[2] E-mail: Andreas.Flohr@ps.rolls-royce.com, URL: https://www.mtu-solutions.com
[3] E-mail: Tobias.Maennle@ps.rolls-royce.com, URL: https://www.mtu-solutions.com
[4] E-mail: Johannes.Kech@ps.rolls-royce.com, URL: https://www.mtu-solutions.com

High Cycle Fatigue – Advanced development and design methods for increased robustness

S. Spengler[a,1], C. Leitenmeier[a,2], H. Benetschik[a,3], T. Willeke[a,4] and L. Aurahs[a,5]

a MAN Energy Solutions SE
Stadtbachstr. 1, 86153 Augsburg, Germany

Abstract / Kurzfassung: Modern turbocharging systems significantly contribute to the market success of marine propulsion and stationary engine applications. Therefore turbocharger components must operate safe with high efficiency, high reliability and low operating costs and have to be designed by considering strict product cost requirements. In consequence the rotating components have to operate on their mechanical and aerodynamic limits. Pushing these limits over the last years was mainly caused by the intensive use of advanced numerical methods as well as detailed experimental data analysis. To meet the requirements, engineers of different disciplines assess and optimize the components of turbochargers and its parts within all design stages.
This paper will present newest numerical and experimental methods to assess HCF which are nowadays used by the involved disciplines from the preliminary till the final design phase. The application of these methods and its validation based on component tests will be shown exemplarily for the development process of a new radial turbocharger series for 2-stroke and 4-stroke engines. Since engineers are faced with several multidisciplinary topics also the interrelation between the different disciplines, especially fluid structure interaction (FSI) and its impact on high cycle fatigue (HCF) are in focus of this work. The paper illustrates that a tight collaboration between the design department and the disciplines aerodynamics, thermodynamic performance calculation and structural mechanics is essential for further improvements of the performance defining turbocharger components.
As it will be shown in the first part of the paper, the dimensioning process of the turbo components starts with the design of blades and flow path. The

---

[1] E-mail: sebastian.spengler@man-es.com, URL: www.man-es.com
[2] E-mail: christoph.leitenmeier@man-es.com, URL: www.man-es.com
[3] E-mail: hannes.benetschik@man-es.com, URL: www.man-es.com
[4] E-mail: tobias.willeke@man-es.com, URL: www.man-es.com
[5] E-mail: lutz.aurahs@man-es.com, URL: www.man-es.com

presented HCF simulations, incorporating aerodynamic and structure mechanics to gain insight into damping, excitation and modal behavior, are based on state-of-the-art fully 3D solvers with moving meshes. One important aspect of this paper is the required level of detail of aerodynamic simulation models in order to obtain valid results. It will be shown which kind of effects and features have to be considered to achieve valid load predictions for aerodynamics and mechanic aspects.
Modern turbocharger series cover a wide application range with a bunch of different matching parts in combination with extended compressor and turbine maps. To take care on all of these operating points for HCF evaluations a huge need for HPC resources arises. The final part of the paper will show how the turbocharger series benefits from the massive usage of these resources and improved methods with regard to robust operation to the physical limit.

Moderne Aufladesysteme tragen wesentlich zur erfolgreichen Marktdurchdringung von Motoren in stationären Anlagen oder Schiffsanwendungen bei. Der Turbolader und insbesondere seine rotierenden Komponenten müssen einen ausfallsicheren Betrieb gewährleisten und höchsten Performance-Ansprüchen genügen. Gleichzeitig sind geringe Invest- und Betriebskosten von großer Bedeutung. Um dem gerecht zu werden, müssen die rotierenden Komponenten nahe an den mechanischen und aerodynamischen Grenzen ausgelegt werden. Durch die intensive Nutzung von multidisziplinären numerischen Methoden in Kombination umfangreichen Versuchen können die Grenzen des technologisch Machbaren weiter verschoben werden.
Diese Veröffentlichung gibt einen Einblick in neueste numerische und experimentelle Methoden zur Bewertung von Schaufelschwingungen (high-cycle-fatigue, HCF). Die Anwendung und Verifizierung der Methoden wird am Beispiel der Entwicklung einer neuen radialen Turboladerserie für Zweitakt- und Viertakt-Motoren gezeigt. Der Fokus dieser Arbeit liegt in der Bewertung von HCF an Rotoren mit Hilfe von Fluid-Struktur-Interaktions-(FSI) Verfahren. Einblicke in die Berechnung sowie die Verifizierung der Anregung und aerodynamischen Dämpfung von Systemen mit beschaufelten Statoren werden vermittelt. Die harmonischen Anregungsdruckfelder werden mit nichtlinearen harmonischen Strömungslösern berechnet, wohingegen die Dämpfung CFD Simulationen mit bewegten Netzen erfordert.
Die Turbolader für Großmotoren decken mit Hilfe einer Vielzahl an Matchingteilen einen großen Anwendungsbereich ab. Neben den geometrischen Varianten erzeugt die Auslegung der Betriebslinie im Kennfeld weitere thermodynamische Variationen, welche die Schaufelschwingungen beeinflussen. Beides führt zu einer immensen Zahl an Konfigurationen, die einer HCF Bewertung unterzogen werden müssen, um dem Anspruch nach einem robusten Design gerecht zu werden. Für die Herausforderung, alle benötigten numerischen Ressourcen bereit zu stellen, werden zum Abschluss Lösungsansätze aufgezeigt.

Key Words: HCF; blade vibrations; off design; fatigue; compressor

Development of a high flow (TCF) and a high pressure (TCP) radial turbocharger series

S. Münch[a,1], S. Weihard[a,2], L. Aurahs[a,3], D. Struckmeier[b,4]

a MAN Energy Solutions SE
Stadtbachstr. 1, 86153 Augsburg, Germany
b PBST - a brand of MAN Energy Solutions SE
Stadtbachstr. 1, 86153 Augsburg, Germany

Abstract:
State-of-the-art turbocharging systems are a main contributor to compliance with the emission requirements, compactness and efficiency as well as performance response for four-stroke and two-stroke engines.
MAN ES offers brand new solutions for the future requirements of modern fuels, emission regulations and engine performances, in the low-, medium- and high-speed segments. MAN ES is driving the change towards lower NOx-emissions and higher performance with a new radial turbocharger generation for high-pressure applications as well as for compact high specific flow demands. The whole series supports the engine especially for the requirements of Tier III and similar requirements in the stationary energy generation segment.
This new radial turbocharger generation pushes the limits towards single stage pressure ratios far above 6 and a specific mass flow rate which is best in its class. Therewith a specific cost & NOx-emission reduction of new and existing engine generations is possible. One further cornerstone of the development is the usability of synthetic fuels, which are expected to be the future dominating energy carrier for internal combustion engines in terms of reducing the carbon footprint.

The present paper focusses on necessary tools and methods as well as on special design features of the new radial turbocharger generation to overcome present limits in terms of pressure ratio and specific flow rates. From first concepts, to detailed design, testing and validation, the emphasis lies on the aerodynamic, thermomechanic and structure mechanic design. This

[1] E-mail: stefan.muench@man-es.com, URL: www.man-es.com
[2] E-mail: stefan.weihard@man-es.com, URL: www.man-es.com
[3] E-mail: lutz.aurahs@man-es.com, URL: www.man-es.com
[4] E-mail: daniel.struckmeier@pbst.eu, URL: www.pbst.eu

paper describes the precise forecast of performance features such as efficiency and lifetime, which was the main driver for further pushing the existing numerical tools. Such new methods were encompassed and supported by the whole development process, which is also presented in this paper. The well known requirements of product safety, temperature and material limits had also been accounted for the strategic considerations of the frame size concept of both new turbocharger families which has revealed to be a crucial point in an early project phase.

Key Words: turbocharger, TCP, TCF, high-pressure, hydrogen, ammonia, methanol, Medium-Speed, High-Speed, Low-Speed, single-stage, two-stage

Adaptation of turbocharging in interaction with the engine tuning to meet thermodynamic requirements of alternative fuels on large engines

R. Ryser[a,1]

a Accelleron / Turbo Systems Switzerland Ltd. (formerly ABB Turbocharging)
Bruggerstrasse 71A, CH-5400 Baden, Switzerland

Abstract: In the large engine industry, a transition from fossil towards synthetic and biogenic fuels is imminent. This does not only include adapted production processes of fuels, but also a change of the chemical structure. For stationary applications mainly hydrogen emerges as a substitute fuel, for marine applications rather methanol and ammonia. While properties of methanol are still relatively close to diesel fuels and natural gas, hydrogen and ammonia differ much more from those. Therefore, to ensure a controlled ignition and combustion, fuel specific thermodynamic conditions are required.

Turbocharging plays an important role in this context as it can support the engine operation in the mutual influencing with the choice of the engine tuning parameters on one hand but does also need to be adapted to changing conditions on the exhaust side on the other hand. For dual-fuel engines, where the conditions of two different fuels need to be considered at the same time, the engine concept can be additionally supported by a suitable control of the turbocharging system.

With sensitivity studies the influence on the turbocharging system and hence the relevance of specific engine parameters could be assessed and the turbocharging requirements for future fuels be located according to the current state of knowledge. In this paper results of studies to turbocharging of engines with alternative fuels are presented as well as optimization potential of current products.

Key Words: Large engines; turbocharging; alternative fuels; ammonia; hydrogen

---

[1] E-mail: raphael.ryser@accelleron-industries.com, URL: www.accelleron-industries.com

Turbine Stage Design Optimisation via Machine Learning Models driven by Engine Cycle Simulation

Kai Zhang[a,1] , Robert Dewhirst[a,2], and Stephen Hughes[a,3]

a Cummins Turbo Technologies
St. Andrews Road, Huddersfield, UK, HD1 6RA

Abstract: In tandem with increasingly stringent legislations on greenhouse gas and toxic emissions from internal combustion engines used in commercial on-highway vehicles, matching and designing turbocharger turbine to maximise engine performance across multiple operating conditions from various regulatory and application duty cycles have become a challenging task, especially with adoptions of other engine technologies in combustion, valvetrains, air handling, aftertreatment, etc., as well as the deployment of complicated engine control strategies. In addition, maximizing and utilising energy that is available in pulsating exhaust flow for twin entry turbine and its unique fluid dynamics behaviours under unequal admission conditions add another layer of complexity for turbine stage design.
A novel methodology is proposed in this paper that links twin entry turbine wheel and housing design, geometry modelling, fluid dynamics analysis, performance map generation under various admission conditions, and engine cycle simulation in an automated process. Machine learning algorithms are applied to create an 'electronic shelf' of plausible turbine designs in advance, so that best turbine can be 'picked up' by engine simulation program with significantly reduced lead time. Finally, the use of numerical optimiser exploring a large design space allows duty cycle engine fuel consumption to be minimized while monitoring engine and turbocharger mechanical, thermal, and manufacturing limitations, so that turbine stage design can be performed in simulation-based product development (SBPD) process.
Key Words / Schlagworte: Key Word 1; machine Learning 2; engine cycle simulation 3; twin entry turbine 4; exhaust pulsation 5; optimisation

---

[1] E-mail: kai.zhang@cummins.com
[2] E-mail: robert.dewhirst@cummins.com
[3] E-mail: stephen.huges@cummins.com

The Role of E-Boosting in future Emission Legislations

S.Yadla[(a)], D.Terber[(b)], J.Keuler[(a)], M.Maniar[(a)], P.Davies[(c)]

a Garrett Motion Germany GmbH
Max-Eyth-Strasse 35, 71088 – Holzgerlingen, Germany
b Garrett Motion Czech Republic s.r.o
V parku 2326/18, 148 00 - Prague, Czech Republic
c Garrett Motion
2 rue de l'Avenir, Zone Innova 3000, Thaon-les-Vosges, France, 88600

Abstract: Future legislation will focus on real time control of harmful species both at cold start and throughout extended ranges of temperatures, pressures and other operating conditions. While legislation generally prescribes tailpipe emissions, an OEM and its partners have choices to make in how to divide the task between the engine raw emission and the efficiency & reliance placed upon the Exhaust Aftertreatment System (EATS). Furthermore, it's necessary to develop engines and EATS concurrently to innovate robust systems that cover all operating modes, make efficient use of precious materials and are cost effective.

One promising solution is the use of Secondary Air Injection (SAI) for "cold start". The technology has been implemented in series production for some time now in markets like the USA, for SULEV standards. As regulations tighten in Europe, it's use is once again being considered for EU7. The components however will need considerable adaption or upgrade if they are to be successfully applied to meet RDE and its extended boundary conditions. Hybrid powertrains are now the norm, opening the way to advanced EATS layouts which could include electrically heated catalysts and ammonia slip catalysts. This paper addresses these requirements and showcases how electric boosting products (E-Compressors & E-Turbos) can both help to reduce raw emission and minimize the size of future EATS by assisting them to reach the operating window of peak efficiency more quickly.

Key Words: Emission Regulation; EU7; RDE; Secondary Air Injection; SAI; E-Compressor; E-Turbo

Turbo matching for a Gasoline engine with Miller combustion and VTG control

H. Björnsson [a,1] L. Johansson [a,2] A. Frosteman [a,3] J. Ohlsson [a,4]

a Powertrain Engineering Sweden AB, UNI3 Pumpgatan 1, 417 55 Gothenburg, Sweden.

Abstract: Aurobay have added a 145kW (LP version) Miller engine to the Aurobay VEA gasoline engine line-up. This new engine shares base technology with the VEP MP engine but uses the Miller cycle and a VTG Turbo in addition to reduce fuel consumption.

The Miller concept that was developed for the VEP LP engine includes increased compression ratio, a short intake valve opening duration, new intake ports as well as new piston design and a new VTG turbo. The Miller concept, together with the integrated exhaust manifold, enables operation in the complete operating range of the engine without the need for fuel enrichment. The VTG turbo, together with an improved intake camshaft phaser provides the torque increase to the same rate as the VEP MP non-Miller engine. Meanwhile, the Miller cycle contributes to significant fuel efficiency improvements in the complete engine map compared to the non-miller derivatives.

Since the fundamental strategy of the Miller cycle leads to a reduction in volumetric efficiency, one of the most critical design aspects is to perfectly match the turbo charger to the combustion

In addition, this Miller engine proves that there’s a high potential to reduce fuel consumption as well for high specific performance engine as the next step in ICE development.

Key Words: VTG; Miller; Fuel consumption;

High efficient turbochargers for dedicated hybrid engines / Turbolader mit höchsten Wirkungsgraden für hybrid-optimierte Verbrennungsmotoren

S. Weiske [a,1], M. Kosch [a,2], B. Dreher [a,3]

a BorgWarner Systems Engineering GmbH
Marnheimer Strasse 85-87, 67292 Kirchheimbolanden

Abstract:

In addition to turbochargers with variable turbine geometry (VTG), increasingly used in hybrid optimized Miller engines, refined fixed geometry turbochargers are being in discussion for dedicated hybrid optimized ICE. With the Fixed Vane Turbine (FVT), BorgWarner has developed a new, highly efficient supercharging technology with an overall maximum efficiency of more than 60% for this kind of applications.
The following article discusses the potential for adapting the boosting system for dedicated hybrid engines and their application in potential future drivetrain scenarios.

Key Words: Turbocharging; Hybrid; Variable Turbine Geometry; Vaned Diffuser; Dedicated Hybrid Engines

[1] E-mail: sweiske@borgwarner.com, URL: www.borgwarner.com
[2] E-mail: mkosch@borgwarner.com, URL: www.borgwarner.com
[3] E-mail: bdreher@borgwarner.com, URL: www.borgwarner.com

IHI Variable Geometry System Turbocharger for Gasoline Application – Performance, Durability, Industrialization

T. Leonard[a,1], M. Model[a], A. Starke[a], M. Kiessling[b], T. Asakawa[c]

a IHI Charging Systems International GmbH, Germany
Haberstrasse 24, 69126 Heidelberg, Germany

b IHI Charging Systems International GmbH, Germany
Wolff-Knippenberg-Straße 2, 99334 Amt Wachsenburg OT Ichtershausen

c IHI Corporation, Yokohama, Japan
1, Shin-Nakahara-cho, Isogo-ku, 235-8501 Yokohama, Japan

Abstract: Many modern gasoline engines (GE) employ variable geometry system (VGS) turbochargers to enable the use of the Miller cycle. The target of stochiometric combustion also leads to higher exhaust gas temperatures. Therefore, there is a need for VGS turbochargers for GE applications that can withstand exhaust gas temperatures in excess of 1000°C.

This article details the development process of the IHI VGS turbocharger for GE applications with high exhaust gas temperatures. Building on a competitive aerodynamic layout, and incorporating experience from Diesel engine (DE) VGS and high temperature GE waste-gate applications, a systematic study was completed to select suitable materials based on oxidation, sliding wear and impact wear tests. Pre-oxidation was investigated as a method to improve these behaviours while avoiding the use of costly nickel-based alloys. FEA simulations were used to refine the mechanical design of the VGS before validation of the hardware by endurance testing on both hot gas and engine test benches.

The industrialisation of the VGS assembly was also significantly improved, with full automation achieved to reduce cycle times and operator count. 100% traceability and functional measurements, together with the principles of Poka-Yoke, ensure stable, high levels of quality and a reduction in assembly failure rates.

Key Words: IHI; Miller Cycle; Turbocharging; Variable Geometry System; Variable Turbine Geometry

[1] E-mail: t.leonard@ihi-csi.de, URL: www.ihi-csi.de

Standardized compressors for fuel cell applications

S. Schnorpfeil [a,1], C. Glahn[a,2], V. Muthusamy[a,3] and C. Zwyssig [b,4], P. Fröhlich[b,5]

a Segula Technologies GmbH
Rugbyring 12, 65428 Rüsselsheim am Main, Germany

b Celeroton AG
Industriestrasse 22, 8604 Volketswil, Switzerland

Abstract: Fuel cells for mobile application such as passenger cars, commercial vehicles (forklifts, delivery vans, trucks, buses) and train applications require an air supply with a compressor. Focusing on reducing system costs a standardization of components in the compressor is necessary. This study targets to solve this challenge by a smart combination of compressor system building blocks for different specifications including mainly electric motor, converter, air bearings and compressor wheel. This allows the development of compressor systems with lower cost and lower validation effort than fully application specific compressor systems and higher efficiency than existing, but non-optimal compressor systems. The research results from this project shall allow the fuel cell research and development community to improve efficiency and lower cost, and therewith strengthen the fuel cell technology and market acceptance.

Kurzfassung:
Brennstoffzellen für mobile Anwendungen wie PKWs, kommerzielle Fahrzeuge (Gabelstapler, Auslieferfahrzeuge, LKWs, Busse) und Züge benötigen eine Luftversorgung mit einem Kompressor. Insbesondere unter dem Fokus auf der Reduzierung der Systemkosten ist eine Standardisierung der Kompressor Komponenten erforderlich. In diesem Paper wird die Umsetzung der Standardisierung durch smarte Kombinationen von Kompressor-System-Bausteinen beschrieben. Dies umfasst vor allem die Komponenten Elektro-Motor, Konverter sowie Luftlagerung und Verdichterrad. Damit lassen sich

---

[1] E-mail: stephanjohannes.schnorpfeil@segulagrp.de, URL: www.segulatechnologies.com
[2] E-mail: claus.glahn@segulagrp.de, URL: www.segulatechnologies.com
[3] E-mail: vimal.muthusamy@segulagrp.de URL: www.segulatechnologies.com
[4] E-mail: christof.zwyssig@celeroton.com, URL: www.celeroton.com
[5] E-mail: patrik.froehlich@celeroton.com, URL: www.celeroton.com

Kompressor-Systeme mit geringeren Kosten und niedrigerem Validationsaufwand als anwendungsspezifische Kompressor-Systeme entwickeln. Die Auswirkungen z.B. auf den Verdichterwirkungsgrad werden diskutiert.

Key Words / Schlagworte: Fuel Cell; Electrical compressor; Fuel Cell Compressor; Standardization; System costs

Condensation and liquid water in the radial turbine of a fuel cell turbocharger

T. Wittmann[a,1], S. Lück[a,2], C. Bode[a,3] and J. Friedrichs[a,4]

a Institute of Jet Propulsion and Turbomachinery,
Technische Universität Braunschweig
Hermann-Blenk-Straße 37, 38108 Braunschweig, Germany

Abstract: The air management system of a proton exchange membrane fuel cell (PEMFC) is responsible for supplying the fuel cell stack with ambient air at appropriate conditions. The compressor of the air management system can be partially driven by the expansion of the fuel cell exhaust air in a turbine. The fuel cell exhaust air is partially or completely saturated with water vapour. The expansion in the turbine causes supersaturation of the flow. This leads to the nucleation of droplets and their subsequent growth by condensation. This study gives an overview of the different effects of condensation and liquid water on the turbine of a PEMFC turbocharger. Condensation causes phase transition losses and the release of latent heat. The latter also leads to thermal throttling of the turbine. In addition, condensation can cause a circumferentially asymmetrical turbine outflow. Liquid water in the turbine can be responsible for droplet erosion, corrosion and water-induced damage. The basis for this work are numerical simulations of earlier studies, which focused on individual aspects of the above-mentioned effects.

Key Words: radial turbine; turbocharger; fuel cell; condensation; water droplet erosion

---

[1] E-mail: t.wittmann@ifas.tu-braunschweig.de
[2] E-mail: s.lueck@ifas.tu-braunschweig.de
[3] E-mail: chr.bode@ifas.tu-braunschweig.de
[4] E-mail: j.friedrichs@ifas.tu-braunschweig.de
[a] URL: www.tu-braunschweig.de/ifas

Fuel Cell Air Compressor Design for Mobile Applications

J. Klütsch[a,1], M. Stadermann[b,2], D. Lückmann[b,3], A. Schloßhauer[b,4] and M. Walters[b,5]

a Chair of Thermodynamics of Mobile Energy Conversion Systems TME
RWTH Aachen University
Forckenbeckstraße 4
52074 Aachen, Germany

b FEV Europe GmbH
Neuenhofstraße 181
52078 Aachen, Germany

Abstract:

Centrifugal compressors are used to supercharge the cathode air path of fuel cell powertrains to increase efficiency and power density.

However, the turbomachine designer faces challenging application-specific boundary conditions (i. e. speed-limit of the electric compressor drive and oil-free air bearing system). Maximum overall efficiency can only be achieved if the air compressor is properly matched to the fuel cell system. Nevertheless, "off-the-shelf" compressors must oftentimes be used as an application-specific design is not economically feasible.

The following article presents a simulation-based design approach for fuel cell air compressors. Design specifications are derived from 1D fuel cell system simulations. Compressor preliminary design is accomplished with 0D / 1D aerodynamic performance models, 3D CFD is used for stage geometry optimization. All design steps are integrated into a seamless software toolchain to accelerate the development process and reduce costs.

Key Words:

PEM Fuel Cell; 1D System Simulation; Centrifugal Compressor Design; 1D Meanline Performance Model; Computational Fluid Dynamics

---

[1] E-mail: kluetsch@tme.rwth-aachen.de URL: www.tme.rwth-aachen.de
[2] E-mail: stadermann@fev.com URL: www.fev.com
[3] E-mail: lueckmann@fev.com URL: www.fev.com
[4] E-mail: schlosshauer@fev.com URL: www.fev.com
[5] E-mail: walters_m@fev.com URL: www.fev.com

Boosting of gasoline engines: review on AVL's presentations for Aufladetechnische Konferenz since 2002 – reflection and preview to the future

K. Prevedel[a,1]

a AVL List GmbH
Hans List Platz 1, 8020 Graz, Austria

Abstract:

With introduction of direct injection boosting has become an enabler for a wide implementation of gasoline engines to the market as an alternative to the increasingly powerful diesel engines of that time. Measures like scavenging gas exchange, scroll separation, specific wheel aerodynamics for high flow and low rotating inertia, variable turbine geometry, ability for elevated exhaust gas temperature, 2 stage boosting and finally, electrification, have been introduced and tuned over the time in order of maximum tradeoff benefits for performance in steady-state, dynamic operation, specific fuel consumption and thermomechanical integrity.
Subsequent implementation of Miller Cycle combustion systems had led to specific adaptations and tuning of turbochargers for the achievement of continuously improving engine results. Considering the engine as an integral part of a hybridized / electrified powertrain and using tailored boosting systems engine BSFC maps with increasingly wide areas of brake thermal efficiency >40% and peak values of >45% will become achieved. Again, requirements for TC efficiency and rotating inertia will find specific tradeoffs for such applications. In future perspective the use of gaseous fuels like H2 would again call for specific matching and tuning of turbochargers.
Be invited to stroll through AVL's past of boosting gasoline engines and let's have an outlook to what may come in future.

[1] E-mail: kurt.prevedel@avl.com

MAN marine dual fuel engine (hydrogen / diesel) for reduced CO_2 emissions

B. Biedermann[a,1], T. Malischewski[a,2] and S. Löser[a,3]

a MAN Truck & Bus SE
Vogelweiherstraße 33, 90441 Nürnberg, Germany

Abstract: Operational safety of diesel engines as well as the high energy content of bunkered fuels are well known and appreciated features of today's marine propulsion systems.
To realise substantial CO_2 reductions also in the marine sector new technologies are needed. They are difficult to introduce in this conservative setting. With as little modifications as possible, the hydrogen dual fuel capability was integrated together with CMB.TECH into a conventional single stage turbo charged diesel engine. The operational safety remains unchanged, whereas the CO_2 emissions are clearly reduced.
To avoid spontaneous ignition of hydrogen due to high temperatures of the combustion chamber, the gas amount must be limited at high engine loads. Thermodynamic calculations show optimisation potentials to increase the hydrogen share. With the chosen combination of a reduced effective compression ratio and two stage turbo charging, first promising test results have been gained.

Key Words / Schlagworte: Hydrogen; dual fuel; two stage turbo charging; CO_2 reduction; marine

---

[1] E-mail: Benjamin.Biedermann@man.eu, URL: www.man-engines.com
[2] E-mail: Thomas.Malischewski@man.eu, URL: www.mantruckandbus.com
[3] E-mail: Stefan.Loeser@man.eu, URL: www.man-engines.com

Air Management of Heavy-Duty Hydrogen Engines

E. Schutting[a,1]

a Institute of Thermodynamics and Sustainable Propulsion Systems, Graz University of Technology
Inffeldgasse 19, 8041 Graz, Austria

Abstract: Hydrogen engines with supercharging and lean combustion are a highly suitable solution for sustainable mobility, specifically for high-duty applications. The properties of hydrogen as a fuel, and the characteristics of hydrogen combustion have an impact to the turbocharging system that needs to be considered.
The most important things to regard are the strong tendency of hydrogen towards combustion anomalies, and the specific dependency of the NO_x-formation on the air fuel ratio. Furthermore, the very low density of hydrogen needs to be taken into account.
All challenges are even aggravated during transient operation, where turbocharger lag becomes critical.

Key Words: Hydrogen; turbocharging; transient; combustion anomalies; NO_x

---

[1] E-mail: schutting@ivt.tugraz.at, URL: www.itna.tugraz.at

Hydrogen combustion engine – A suitable concept for Decarbonisation in Offroad sector

Michaël-Alexandre Baert, Daniel Vidinha Santos, Dr. Bouzid Seba, Ulrich Weiss,
Liebherr Machines Bulle SA, CH-1630 Bulle, Switzerland

Abstract

The global target of Greenhouse gases (GHG) reduction for 2050 is one of the focus on selection and definition of the future power train in several business sectors. The EU has agreed on new regulations to limit the CO2 emissions of new heavy-duty vehicles by 15% from 2025 and by 30% (or higher) from 2030 considering 2020 as reference. The off-road sector expects similar emission reduction targets.

Hydrogen, as a combustion fuel, represents an alternative and efficient solution for decarbonisation of future powertrains in the Off-road sector. The combustion of hydrogen is possible thanks to new system configurations. Injection technology, air path configuration and ignition technology are among the most notable system characteristics.

This new solution shall be convenient to operate in harsh environments and offer a lower product cost compared to other zero emission technologies. Furthermore, the new engine architecture shall ensure easier engine integration, higher power density, better system efficiency and higher lifetime.
The dual fuel (DF) and direct injection (DI) technologies stand among the possible solutions to a relevant hydrogen powertrain. Their distinctive configurations regarding the above-mentioned system characteristics enables the assessment of each characteristic and that of their combination. The air path plays an important role in engine performance, dynamic behavior and emission compliance. Two-stage charging system and single stage with EGR are two possible air path configurations capable to ensure ultra-lean combustion. The later aims are to lower NOx emissions and increase power density.

The technology is robust and ensures a quick time to market thanks to unchanged vehicle interfaces. Besides the advantages of this hydrogen technology, there are some challenges that this technology has to face. The main challenge is to reach an acceptable hydrogen storage volume able to guarantee the typical working time of an off-road machine.

Key words

ICE : Internal combustion engine
DI : Direct injection
PFI : Port fuel injection
DF : Dual fuel
ZE : Zero-emission
ZEP : Zero-emission powertrain
EGR : Exhaust gas recirculation

The Air Charging System of the DEUTZ Hydrogen Combustion Engine TCG 7.8 H2

P. Grzeschik [a,1], **P. Biewer** [a,2] , **C. Funke** [a,3], **B. Nork** [a,4]

a DEUTZ AG
Ottostr. 1, 51149 Köln, Germany

Abstract: Minimizing of greenhouse gases is the decisive challenge for the development of future sustainable powertrains. While battery electric vehicles seem to be the answer for passenger car applications, the question for the future propulsion of high energy demand, on-/off-highway and non-road applications is not yet clearly answered. DEUTZ AG is taking this challenge by developing highly efficient Diesel engines as well as electrified drive systems and hydrogen combustion engines.
This paper covers the special tasks and solutions for turbocharged hydrogen engines, particularly the new TCG 7.8 H2. As a basis, the motivation and boundary conditions for development of hydrogen engines are presented. Available charging concepts are discussed against the special demands of hydrogen combustion systems. Theoretical considerations as well as preliminary calculations lead to the selection of a single-stage VTG turbocharger. This concept is validated by detailed simulation of steady-state operation as well as transient behaviour as well as results obtained on a real-world demonstrator engine.

Key Words: Sustainable Powertrains, Hydrogen Combustion Engine, VTG Turbocharger

---

[1] E-mail: paul.grzeschik@deutz.com
[2] E-mail: philipp.biewer@deutz.com
[3] E-mail: carsten.funke@deutz.com
[4] E-mail: benedikt.nork@deutz.com

Umbau und Erweiterung eines Heißgas-Prüfstandes für Tests von Brennstoffzellen und elektrischen Turboladern

Conversion and expansion of a hot gas test bench for testing fuel cells and electric turbochargers

S. Weigl[a,1], T. Hauck[a,2] und F. Schäfer[b,3]

a UTF GmbH
Erzstraße 15, 09618 Brand-Erbisdorf, Deutschland

b SCF-automation GmbH
Emmy-Noether-Ring 18, 85716 Unterschleißheim, Deutschland

Kurzfassung: Ein Heißgasprüfstand zum Test von Abgasturboladern kann für vielfältige Anwendungen erweitert und umgerüstet werden.
Der Vortrag befasst sich mit der Möglichkeit der Umrüstung des Heißgas-Erzeugers auf Wasserstoffbetrieb. Somit können Kohlenstoff-Emissionen im Prüfbetrieb reduziert werden.

Alternativ kann der Heißprüfstand mit überschaubarem Aufwand als Brennstoff-Zellen-Prüfstand umgebaut werden. Damit lassen sich dann Brennstoffzellen, BSZ-Befeuchter-Module und elektrische Turbolader getestet werden

Abstract: A hot gas test stand for testing exhaust gas turbochargers can be expanded and converted for a wide range of applications.
The lecture deals with the possibility of converting the hot gas generator to hydrogen operation. This means that carbon emissions can be reduced during testing.

Alternatively, the hot test bench can be converted into a fuel cell test bench with reasonable effort. This can then be used to test fuel cells, FC humidifier modules and electric turbochargers.

Schlagworte: Abgasturbolader; Prüfstand; E-Turbolader; Brennstoffzelle; Wasserstoff
Key Words: turbocharger; Test bench; e-turbocharger; fuel cell; hydrogen

---

[1] E-mail: sebastian.weigl@utf-bed.de
[2] E-mail: thomas.hauck@utf-bed.de
[3] E-mail: frank.schaefer@scf-automation.de

Benefits of a SuperTurbo for Hydrogen Internal Combustion Engines

T. Waldron[a,1], J. Brin[a,2], H. Seitz[b,1], W. Hochegger[b,2]

a SuperTurbo Technologies
3755 Precision Dr. Ste 170, Loveland CO 80538, USA

b AVL List GmbH
Hans-List-Platz 1, 8020 Graz, Austria

Abstract: Restrictive future CO_2 emission regulations are incentivizing evaluation of carbon-free fuels. This is particularly true in the difficult to electrify heavy commercial vehicle segment. The reemergence of hydrogen internal combustion (H_2 ICE) for large displacement engines can both expedite hydrogen adoption and reduce total cost of ownership. This paper will cover how the application of a SuperTurbo can address challenges unique to H_2 ICE. The research being presented is joint simulation conducted by AVL List GmbH and SuperTurbo Technologies on a 13L H_2 ICE. The first H_2 ICE challenge that will be addressed is the requirement for the engine to maintain a lean-burn combustion strategy. The high Lambda requirement can create challenges for turbochargers when available turbine power is insufficient for the desired compressor power. The on-demand air functionality of the SuperTurbo negates this problem and can be used to optimize air-fuel ratio in steady-state and transient cycles. The simulation will show low NO_x formation through combustion optimization and time to torque transients equivalent to diesel. The second H_2 ICE challenge that will be addressed is how to maintain highest BMEP and BTE for hydrogen internal combustion engines The ability of SuperTurbo exhaust energy recovery through turbo-compounding, in combination with combustion optimization, will demonstrate an ability to improve H_2 ICE BMEP/BTE/BSFC.

Key Words / Schlagworte: SuperTurbo; H_2 ICE; Lean; Turbo Compound; Supercharging, Hydrogen; NOx, WHTC

---

[1] E-mail: twaldron@superturbo.net, URL: www.superturbo.net
[2] E-mail: jbrown@superturbo.net, URL: www.superturbo.net
[3] E-mail: hans-felix.seitz@avl.com, URL: www.avl.com
[4] E-mail: wilfried.hochegger@avl.com, URL: www.avl.com

Turbocharging and alternative fuels – challenges and experiences

O. Schulz[a,1] , Dr. S. Risse[a,2] , S. Käseberg[a,3] and H. Schröder[a,4]

a Kompressorenbau Bannewitz GmbH
Windbergstrasse 45, 01728 Bannewitz, Deutschland

Abstract:

The reduction of fossil fuels for combustion engines also calls for new concepts in the large engine sector. An economic and efficient switch to complete electrification of marine applications can only be expected in a limited power range in the near future. For greater power requirements and ranges, however, alternative fuels are becoming increasingly important.
Alternative fuels pose new challenges for the development of combustion engines, including health protection and safety requirements. The differences of the alternative fuels with regard to chemical and physical properties as well as to the fuels used so far require the (further) development of internal combustion including the adaptation of the engine components. Especially the application in hydrogen operation will hardly reach the known high demands on power density and efficiency in the operation of conventional fuels without a targeted new development of the turbochargers. This means, however, that the turbocharged combustion engine can and will remain an integral part of the process chains in both stationary and mobile applications in the large engine sector. Many years of experience with process and special gases show the clear potential here, also in terms of maintenance and wear.

Key Words: Turbocharging; alternative fuels; hydrogen; methan; methanol; ammonia

---

[1] E-mail: oliver.schulz@kbb-turbo.com, URL: www.kbb-turbo.com
[2] E-mail: silvio.risse@kbb-turbo.com, URL: www.kbb-turbo.com
[3] E-mail: steffen.kaeseberg@kbb-turbo.com, URL: www.kbb-turbo.com
[4] E-mail: heiko.schroeder@kbb-turbo.com, URL: www.kbb-turbo.com

On-engine performance evaluation of non-linear A/R turbine volute for automotive turbocharger

T. Hoshi [a,1], Y. Fujita [a], T. Yokoyama [a], M. Ebisu [b,2], C. Meng Soon [c], T. Feng Xian [c], K. Jeyoung [c], S. Rajoo [c,3] , R. Martinez-Botas [d,4] , Y. Mingyang [e,5]

a Mitsubishi Heavy Industries,Ltd., 717-1, Fukahori-machi, 5-chome, Nagasaki, 851-0392, Japan
b Mitsubishi Heavy Industries Engine and Turbocharger, Ltd., Sagamihara District 3000, Tana, Chuo-ku, Sagamihara, Kanagawa, 252-5293, Japan
c UTM LoCARtic, P21 Autolab, Universiti Teknologi Malaysia, 81310 Johor Bahru, Malaysia
d Imperial College London, Faculty of Engineering, Level 2, Faculty Building, Exhibition Road, London, SW7 2AZ, United Kingdom
e Shanghai Jiao Tong University, 800 Dong Chuan Rd. Shanghai 200240, PR. China

Abstract: As a countermeasure for global warming, CO_2 emission regulation has become stricter. In July 2021, European Commission proposes for strengthening post-2020 CO2 standards. The proposal raises the ambition of the 2030 target to -55% for new passenger cars relative to a 2021 baseline [1]. As a result, improving vehicle fuel economy has become one of the challenges to automotive manufacturer. Turbocharger attracts many research attentions as it is an essential component for engine downsizing, which is the key technology that allows engine to reduce emission without reducing power.

In general, the turbocharger operates under engine exhaust pulsating condition, therefore it is important that non-steady-state performance must be improved. Thus, a lot of studies have been done in order to improve the turbocharger performance. Previously, the author has presented that the effect of pulsation are essentially the result of changes in absolute flow angle at the exit of the turbine volute, and has proposed a design concept to suppress such loss [2].

---

[1] E-mail: toru.hoshi.tc@mhi.com, URL: http://www.mhi.com/jp
[2] E-mail: motoki.ebisu.et@mhi.com, URL: http://www.mhiet.co.jp
[3] E-mail: srithar@utm.my, URL: https://www.utm.my/locartic/
[4] E-mail: r.botas@imperial.ac.uk, URL: https://www.imperial.ac.uk/
[5] E-mail: myy15@sjtu.edu.cn, URL: http://en.sjtu.edu.cn/

In this research, a 1.6 litre gasoline engine performance is assessed with a non-linear A/R scroll volute, which was designed in order to improve turbo-charger's performance under exhaust pulsation. The engine performance with a conventional linear A/R volute is also assessed and compared on an equivalent basis. The result shows that non-linear A/R volute allows more advance injection timing, compared to when linear volute is used. The reason for this is because non-linear A/R volute has reduced turbine inlet pressure, making it more difficult for knocking to occur. Fuel consumption in the WLTC drive cycle were also evaluated for both the volutes, and the results show that fuel consumption improves by 1.7% with the non-linear A/R, which proves the effectiveness of the non-linear A/R volute concept.

Key words: twin scroll turbocharger; turbine housing A/R; WLTC drive cycle; fuel consumption; gasoline engine

Study on supercharging concepts for a H_2NG combustion engine

D. Wintergoller [a,1], K. Klepatz [a,2], Prof. R. Rottengruber [a,3], A. Lazar [b,4]

a Otto-von-Guericke-University Magdeburg,
Chair of Energy Conversion Systems for Mobile Applications
Universitätsplatz 2, 39106 Magdeburg, Deutschland

b WTZ Roßlau gGmbH,
Mühlenreihe 2a, 06862 Dessau-Roßlau, Deutschland

Abstract: To ensure compliance with emission targets, alternative fuels are playing an increasingly important role in reducing exhaust emissions. A modern internal combustion engine that can run on both hydrogen (H_2) and methane (CH_4) in mixed operation is one way of reducing emissions quickly, cost-effectively and sustainably. Hydrogen as a carbon-free fuel can be a viable alternative to conventional fuels. Due to the still insufficient production, distribution and refueling of hydrogen, a transitional solution is to be realized by admixing methane (natural gas or biogas). However, converting conventional engines to operate on hydrogen-methane mixtures requires some adjustments. Due to the specification of low NO_x raw emissions, the hydrogen combustion engine must be operated as lean as possible ($\lambda > 2$). However, the combination of a targeted lean operation with the fast combustion speed of hydrogen also results in a low exhaust gas enthalpy in addition to the effect of high engine efficiency. This has a particularly negative impact on the response of the exhaust gas turbocharger at low engine speeds and high loads, the LET (low-end torque) range. At higher engine speeds, on the other hand, the exhaust gas enthalpy increases significantly in hydrogen engines due to the higher mass flow rate. Accordingly, the turbocharger must be adapted for operation with methane, hydrogen and any mixtures of the two fuels at both low and high speeds. For this occasion, a concept study of turbochargers is carried out using a one-dimensional simulation model. The basis of the model is a direct-injection internal combus-

[1] E-mail: dmitrij.wintergoller@ovgu.de, URL: www.ema.ovgu.de
[2] E-mail: kevin.klepatz@ovgu.de, URL: www.ema.ovgu.de
[3] E-mail: hermann.rottengruber@ovgu.de, URL: www.ema.ovgu.de
[4] E-mail: lazar@wtz.de, URL: www.wtz.de

tion engine of a commercial vehicle converted from diesel to hydrogen operation. The impact of different turbocharger concepts on engine performance is investigated. Fundamental considerations are being worked out for the development of an exhaust gas turbocharger that is optimized for engine operation with methane, hydrogen and any mixtures.

Key Words: hydrogen engine; natural gas; H_2NG; supercharging; alternative fuels

Downspeeding of a high speed motorcycle engine

T. Roß [a,1], F. Atzler [a,2], M. Riha [b,3], R. Werner [a,4]

a Technische Universität Dresden, Chair of Internal Combustion Engines and Drive Train Systems, George-Bähr-Str. 1b, 01069 Dresden, Germany
b EVA Fahrzeugtechnik GmbH, Heidemannstraße 41a, 80939 München, Germany

Abstract:

The development of powertrains with combustion engines for road vehicles is essentially driven by the legal requirements on emission, the general demand for low fuel consumption, with the simultaneous provision of appealing driving dynamics. Supercharging of the combustion engine in this respect is one of the key technologies and is up to today the most effective and efficient method to increase power density and engine efficiency. Contrary to passenger car powertrains, supercharging could not be established up to now for motorcycles. Since the potential advantages in the engine processes can nevertheless be expected, this fact is not to be attributed to supercharging itself, but more to the emphasis on characteristics like spontaneous engine response or attractive (brand specific) engine acoustics.

In this contribution the potential of supercharging will be demonstrated on a large volume 2 cylinder motorcycle engine. Contrary to the general trend towards turbocharging a scroll-type supercharger was used. The low inertia of this device allows for the on-demand switching on and enables a quick pressure build up for a downspeeding concept without traction interruption. Both are the basis for a high engine efficiency as well as low pollutant emissions.

Key Words: downspeeding, supercharging, response, scroll-type supercharger, efficiency, pollutant emission, noise emission, motorcycle

---

[1] E-mail: tilo.ross@tu-dresden.de, URL: www.tu-dresden.de
[2] E-mail: frank.atzler@tu-dresden.de, URL: www.tu-dresden.de
[3] E-mail: maximilian.riha@evafahrzeugtechnik.de, URL: www.evafahrzeugtechnik.de
[4] E-mail: ronny.werner@tu-dresden.de, URL: www.tu-dresden.de

Interpretation and discussion of engine measurements with the new pressure wave supercharger (Comprex^{TM}) with an outlook on the highly topical hydrogen application possibilities

Dr. sc. techn. ETH Mario A. Skopil[a,1]

a Antrova AG
Adress (Hofwisenstasse 13, 8260 Stein am Rhein, Schweiz)

Abstract:

The **Comprex^{TM}** pressure wave supercharger (PWS) from **Antrova AG**, equipped with newly developed features, was already presented in 2019 at the Aufladetechnische Konferenz (ATK) Dresden. The design innovations were explained at that time and are described in [15].
The current publication is now about proving that the new Comprex^{TM} has all the advantages mentioned in 2019 not only theoretically, but also in practice.
On the basis of measurements at the Swiss Federal Institute for Materials Testing (Empa) on a gas engine (CNG or Biogas) from 2021, interesting results can now be presented and discussed.
On the one hand, this is thermodynamically interesting to explain observed phenomena of the pressure wave supercharger, but also the significance of these results for highly topical problems such as the charging of hydrogen combustion engines is quite explosive.
The advantageous properties of the Comprex^{TM} with regard to boost pressure build-up, response, exhaust gas temperatures or oil feed into the charge air are quantified and discussed in detail in this publication.

Key Words: Pressure Wave Supercharger 1; Emissions 2; Efficiency 3; Combustion Engine 4; Comprex^{TM} 5

[1] E-mail: mail@antrova.com, URL: www.antrova.com

List of Participants

Name	Firma	Stadt
Al-Hasan, Nisar	BMTS Technology GmbH & Co. KG	Stuttgart
Anton, Nicholas	Scania CV AB	Södertälje
Archer, Jamie	Cummins Turbo Technologies	Huddersfield
Atzler, Frank	Technische Universität Dresden	Dresden
Aurahs, Lutz	PBST – a Brand of MAN Energy Solutions	Augsburg
Benczur, David	Sonceboz Automotive SA	Sonceboz
Biewer, Philipp	DEUTZ AG	Köln
Bitzer, Ingo	MAT German Holdings GmbH	Neunkirchen
Björnsson, Håkan	Aurobay/ Powertrain Engineering Sweden AB	Gothenburg
Boucand, Vincent	Liebherr Machines Bulle SA	Bulle
Cafarelli, David	Turbo Systems Switzerland Ltd	Baden
Davies, Peter	Garrett Motion France SAS	Thaon Les Vosges
Dietrich, Ingo	BorgWarner Systems Engineering GmbH	Kirchheimbolanden
Douglas, Keith	Bowman eTurbo Systems	Southampton
Dowman-Tucker, Paul	Bowman eTurbo Systems	Southampton
Dreher, Bernhard	BorgWarner Systems Engineering GmbH	Kirchheimbolanden
Flohr, Andreas	Rolls-Royce Power Systems AG	Friedrichshafen
Gödeke, Holger	G+L innotec GmbH	Laupheim
Grzeschik, Paul	DEUTZ AG	Köln
Guilain, Stéphane	Renault Group	Lardy
Günter, Peter	Liebherr Machines Bulle SA	Bulle
Halilovic, Edis	FAKT GmbH	Heimertingen
Hammer, Michael	DELUPA Turbotechnik GmbH	Stockstadt am Rhein
Hatabu, Atsuhiro	Mazda Motor Corporation	Hiroshima
Hauck, Thomas	UFT GmbH	Brand-Erbisdorf
Herbst, Mark	SuperTurbo Technologies, Inc.	Loveland, Colorado
Hoffer, Pierre-Alain	FERRARI S.P.A.	Maranello
Hoshi, Toru	Mitsubishi Heavy Industries	Nagasaki
Jaeger, Laurentius	Garrett Motion	Brno
Jäger, Tobias	SCHENCK RoTec GmbH	Darmstadt
Jarschel, Vincent	Technische Universität Braunschweig	Braunschweig
Jaspart, Ludovic	HITCHINER Manufacturing	Buc
Jedro, Jan	Audi AG	Ingolstadt
Johansson, Lena	Aurobay/ Powertrain Engineering Sweden AB	Gothenburg
Jorzick, Jörg	Oerlikon Balzers Coating Germany GmbH	Bingen
Kadioglu, Mustafa Ümit	Deutsche Luft- und Raumfahrt	Stuttgart
Kech, Johannes	Rolls-Royce Power Systems	Friedrichshafen

List of Participants

Klammt, Gaylord	PRÄWEST PRÄZISIONSWERKSTÄTTEN	Bremen
Klütsch, Johannes	RWTH Aachen University	Aachen
Kniestedt, Lukas	WTZ Roßlau gGmbH	Dessau-Roßlau
Koerner, Stefan	Turbo Energy Germany GmbH	Mannheim
Kopp, Adrien	Pankl Turbosystems GmbH	Mannheim
Kratz, Franziska	INNIO Jenbacher GmbH & Co OG	Jenbach
Krawczyk, Lukasz	BorgWarner Poland Sp.z.o.o.	Rzeszów
Krueger, Markus	Caterpillar Motoren GmbH & Co. KG	Kiel
Kumar, Samir	Fiat Powertrain Industrial S.P.A	Torino
Lagasse, Philippe	CRITT M2A	Bruay-la-buissière
Langecker, Florian	AUDI AG	Ingolstadt
Larsson, Per-Inge	Scania CV AB	Södertälje
Lauckner, Jan	Volkswagen AG	Wolfsburg
Legler, Rainer	ACTech GmbH	Freiberg
Len, Krzysztof	BorgWarner Poland Sp.z.o.o.	Rzeszów
Leonard, Thomas	IHI Charging Systems International GmbH	Heidelberg
Lien, Chun-Kuang	TOYOTA GAZOO Racing Europe GmbH	Köln
Lim, Swee Luan	Cummins Turbo Technologies	Huddersfield
Lindemann, Guillaume	Turbo Systems Switzerland Ltd	Baden
Löser, Stefan	MAN Truck & Bus SE	Nürnberg
Männle, Tobias	Rolls-Royce Power Systems	Friedrichshafen
Manta, Eugenio	Punch Torino S.P.A.	Torino
Martinetz, Christoph	Ruhr-Universität Bochum	Bochum
Müller, Christoph	Dr.Ing.h.c.F. Porsche AG	Weissach
Münch, Stefan	PBST – a Brand of MAN Energy Solutions	Augsburg
Nakamura, Yohei	Mitsubishi Heavy Industries Engine & Turbocharger	Nagasaki
Nibler, Simon	BMTS Technology GmbH & Co. KG	Stuttgart
Petit, Michel	Hitchiner Manufacturing	Milford, NH
Prevedel, Kurt	AVL LIST GmbH	Graz
Rabbolini, Silvio	FERRARI S.P.A.	Maranello
Raunio, Tomi	Wärtsilä Finland Oy	Vaasa
Reith, Christian	PBST – a Brand of MAN Energy Solutions	Augsburg
Rexhäuser, Frank	Fahrzeugsystemdaten GmbH	Dresden
Ritter, Thomas-Michel	Technische Universität Dresden	Dresden
Roß, Tilo	TU Dresden – Institut für Automobiltechnik Dresden	Dresden
Rothenberger, Peter	Dr.Ing.h.c.F. Porsche AG	Stuttgart
Ruhnow, Rene	Continental Aerospace Technologies GmbH	St. Egidien
Ryser, Raphael	Accelleron	Baden
Sandor, Ivo	BMTS Technology GmbH & Co. KG	Stuttgart

Schmid, Lothar	Schmidt Automotive GmbH	Westhausen
Schmidt, Heiko	Schaeffler Technologies AG & Co. KG	Herzogenaurach
Schmidt, Oliver	Turbo Energy Germany GmbH	Mannheim
Schmitt, Frank	BorgWarner Systems Engineering GmbH	Kirchheimbolanden
Schnorpfeil, Stephan	SEGULA Technologies GmbH	Rüsselsheim a. Main
Schulz, Oliver	Kompressorenbau Bannewitz GmbH	Bannewitz
Schulze, Daniel	BMTS Technology GmbH & Co. KG	Stuttgart
Schutting, Eberhard	TU Graz, ITnA	Graz
Sitter, Mirko	Mitsubishi Turbocharger and Engine Europe B.V.	Almere
Skopil, Mario	Antrova AG	Stein am Rhein
Spengler, Sebastian	PBST – a Brand of MAN Energy Solutions	Augsburg
Staats, Arne	Volkswagen AG	Wolfsburg
Stadermann, Max	FEV Europe GmbH	Aachen
Tasche, Alexander	Schaeffler Technologies AG & Co. KG	Herzogenaurach
Teichelt, Sönke	ebm-papst Mulfingen GmbH & Co. KG	Mulfingen
Tomita, Sho	TOYOTA GAZOO Racing Europe GmbH	Köln
Tsukamoto, Kohei	Mitsubishi Heavy Industries Engine & Turbocharger	Sagamihara
Tuvesson, Stefan	Aurobay/ Powertrain Engineering Sweden AB	Gothenburg
Twickler, Jan	Volkswagen AG	Wolfsburg
Vachon, Nicolas	CRITT M2A	Bruay-la-buissière
Vancoillie, Jeroen	DAF Trucks NV	Eindhoven
Velde, Oliver	CFturbo GmbH	Dresden
Verdoorn, Werner	Porsche AG	Weissach
Voigt, Patrick	Hanseatische Waren Handelsgesellschaft mbH & Co. KG	Bremen
Wagenplast, Michael	Mercedes Benz AG	Stuttgart
Wahlers, Reiner	PRÄWEST PRÄZISIONSWERKSTÄTTEN	Bremen
Waldron, Thomas	SuperTurbo Technologies, Inc.	Loveland, Colorado
Weidl, Rebecca	INNIO Jenbacher GmbH & Co OG	Jenbach
Weigl, Sebastian	UFT GmbH	Brand-Erbisdorf
Weisbrod, Tobias	MAN Energy Solutions SE	Augsburg
Weise, Andreas	ACTech GmbH	Freiberg
Weiske, Sascha	BorgWarner Systems Engineering GmbH	Kirchheimbolanden
Werner, Ronny	Technische Universität Dresden	Dresden
Winkle, Florian	AUDI AG	Ingolstadt
Wintergoller, Dmitrij	Otto-von-Guericke-Universität Magdeburg	Magdeburg
Wittmann, Tim	TU Braunschweig, IFAS	Braunschweig
Yadla, Surya Kiran	Garrett Motion Germany GmbH	Holzgerlingen
Zellbeck, Hans	Technische Universität Dresden	Dresden
Zellbeck, Claudia	Tagungsassistenz Aufladetechnische Konferenz	Dresden

Zerbst, Ulrich	Volkswagen AG	Wolfsburg
Zhang, Kai	Cummins Turbo Technologies	Huddersfield
Ziegler, Roland	Schmidt Automotive GmbH	Westhausen
Zimmer, Brain	Hitchiner Manufacturing	Milford, NH

Bitte vormerken:

27. AUFLADETECHNISCHE
KONFERENZ 2023
IN DRESDEN

28. – 29. September 2023

https://aufladetechnische-konferenz.de/zukuenftige-termine-2/

Save the Date

27th SUPERCHARGING
CONFERENCE 2023
IN DRESDEN

28th – 29th September 2023

https://aufladetechnische-konferenz.de/en/upcoming-conferences/

www.aufladetechnische-konferenz.de