

Project **ROTREX**TM

Development of the Rotrex Supercharger
to compression of water vapor.



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Project Rotrex

- **About Rotrex**
- **OEM**
- **Extreme applications to make the S/C durable and robust**
- **Description of the technology**
- **Why heat pumps**
- **Compression heat pumps**
- **Differences in compression of air and water vapor**
- **Challenges in design changes.**
- **Conclusions**



About *ROTREX*

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- *ROTREX* dates back to the early 1970's when Anders P. Kolstrup - today Technical Director - being a passionate race driver, was continuously looking for improvements in engine development and performance.
- In 1996 the first patent was issued for a planetary traction drive.
- Develops, produces and markets superchargers for a wide range of industries based on patented traction technology for OEM, OES, and aftermarket companies worldwide.



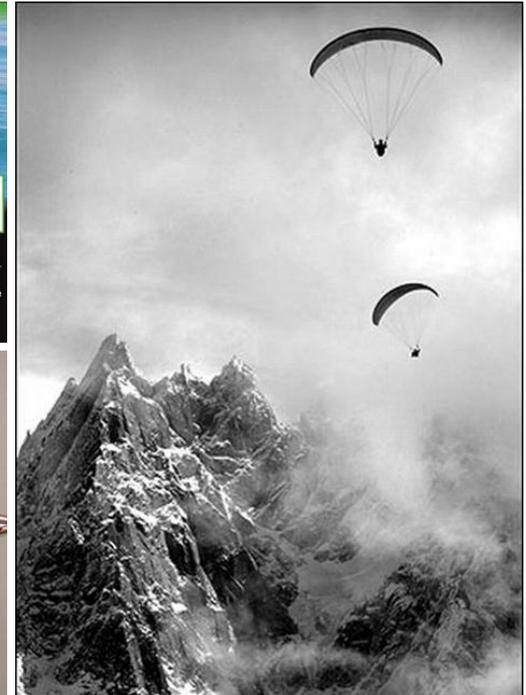
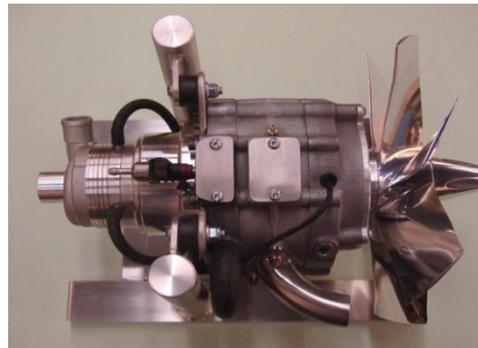
OEM

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- *ROTREX* superchargers are designed to reflect the 10 year lifetime requirement of an automotive component.
- Has passed both hot and cold OEM durability tests.
- A standard range of superchargers is available to match a broad range of applications.
- The *ROTREX* supercharger can be easily customized for client applications optimizing integration, performance and cost.
- The *ROTREX* technology is ideal for the rapidly growing boosting market for downsized gasoline engines and fuel cells.

Extreme applikations

- Successful collaboration with Kawasaki France
- **World champions 2009**
- **EU champions 2009**
- Collaboration w Honda USA
- **20 land speed records**
- Koenigsegg Supercar
- **Fastest car in the world**
- Discovery Channel
- **Flew over the summit of Mt. Everest**
- **European champion in drifting**



Efficient and durable in tough conditions

Fuel cell applications: *Proven, innovative design*

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- Ballard Power Systems, Inc. (CA/US)
- Proton Motor (Germany)
- Projects targeting large scale production

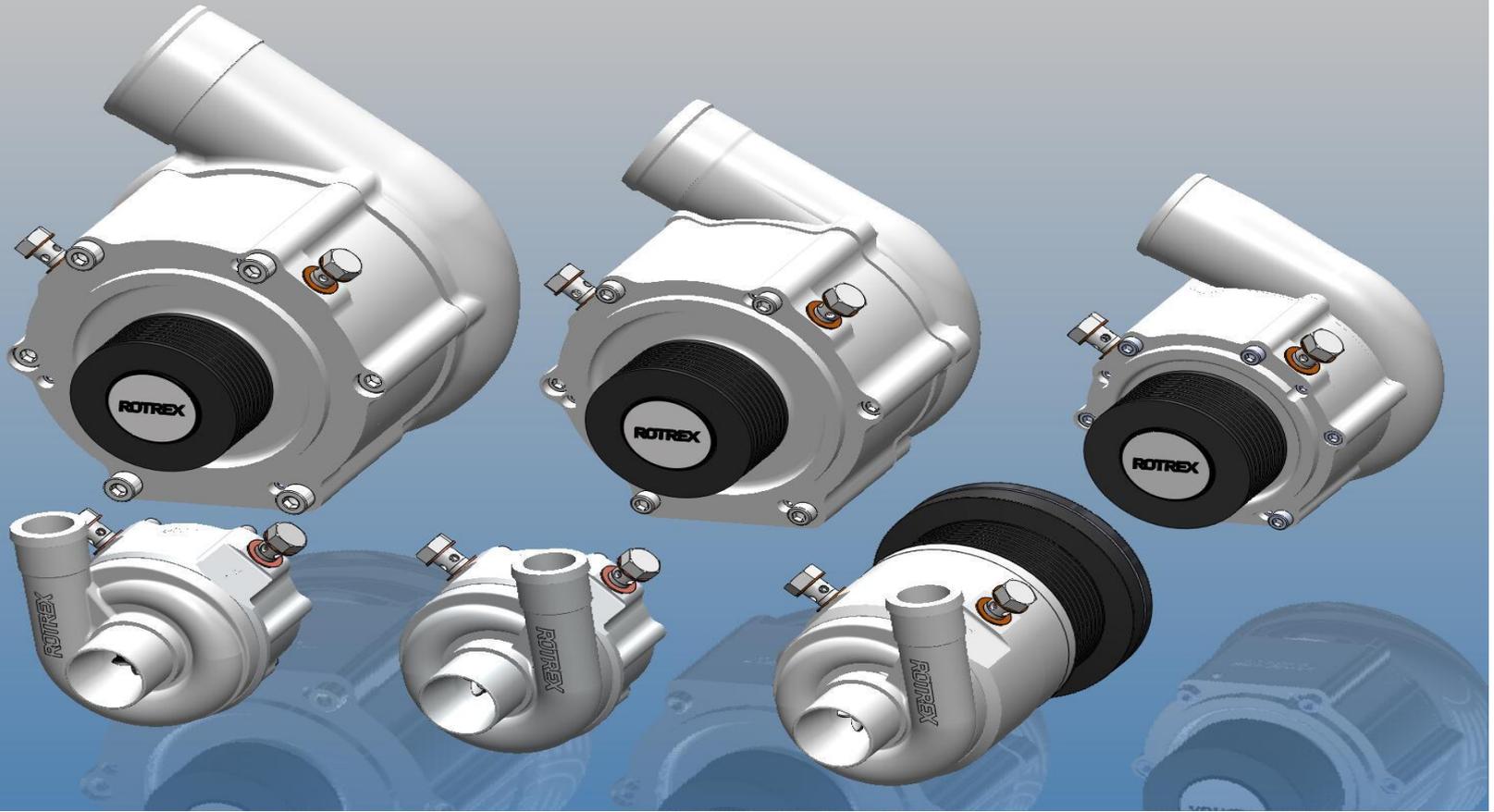
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Technology matured to OEM level

ROTREX technology

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Design overview

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Exploded view of a standard *ROTREX* unit



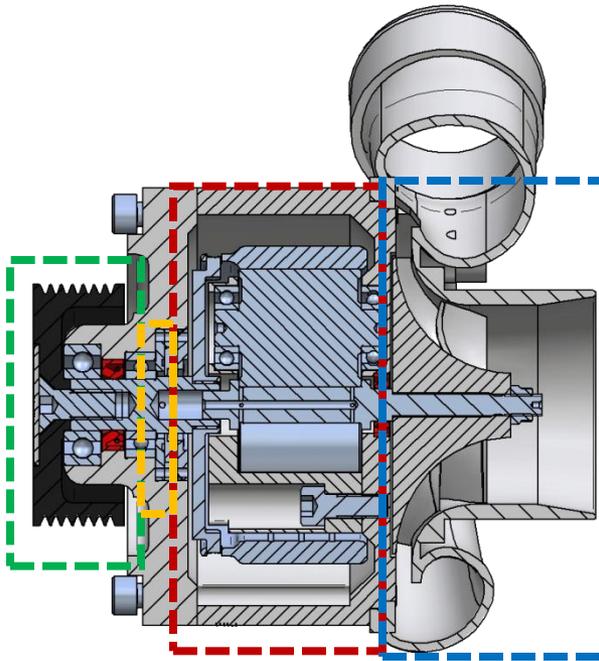


Design overview

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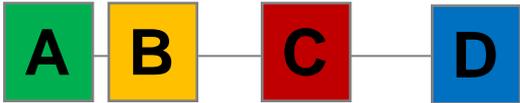
Benefits:

- High speed – production units released for speeds up to 201.500 rpm
- Compact and lightweight
 - ✓ power transmission density of 20 kW/Kg
- Good NVH properties
 - ✓ no pulses, traction drive
- High efficiency, even at high pressure ratios



Sections:

- A - Input Drive:**
 - Belt or shaft
 - Simple integration
- B - Oil Pump:**
 - Self-contained oil-system
- C - Traction Drive:**
 - Low noise
 - Speed up to 293.000 rpm
- D - Turbo Compressor:**
 - Adiabatic efficiency up to 82%





Why Heat Pump

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- Current use of fossil fuels contributes to the amount of CO₂ in the atmosphere and hence according to most scientists the global warming, it makes a lot of sense to reuse as much of the waste heat as possible and thereby reduce the amount of fossil fuels. Heat pumps are very effective devices to do this.
- The problem today is not lack of energy (sun energy from 1% of the Sahara desert can supply all needed energy on earth) but lack of useful energy. The modern community needs to change the waste heat energy into useful heat, electricity and mechanical energy.
- Until fuel cells, cold fusion and other future sources is commercial available, heat pumps seems to be a very useful and obvious choice.



Compression Heat Pump

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- One of the key components in this solution, if a compression heat pump is used, is the compressor itself.
- Therefor the compressor needs to be very efficient. The most efficient type of pump is a centrifugal one. To have an efficient centrifugal pump the speed of the compressor wheel needs to be high. Spinning the compressor wheel called the impeller at high speed is a challenge to a traditional gearbox because the lubricating oil is slung away from the contact surfaces, and the durability is not sufficient for continuous use.
- The Danish invented compressor Rotrex can do very high speed, the smallest version C8 can reliably do 300k, and the largest C38 will run reliable for more than 10k h when pumping air.
- All the various units from C8 over C15 and C30 to C38 has been fully developed and commercialized, and now in use in a lot of cars as OE equipment.



Compressing water vapor instead of air

- *ROTREX* superchargers are designed to reflect the 10 year lifetime requirement of an automotive component, and has passed both cold and hot OEM durability tests.
- Compressing Water vapor needs higher speed since the density is lower
- Impeller and scroll design and materials has to be adapted to the new media and the higher temperatures, up to 200 deg. C.
- The seal between the hot water vapor and the gearbox oil needs to be redesigned, because no water is allowed in the gear.
- The higher speed needs better balancing of the impeller.



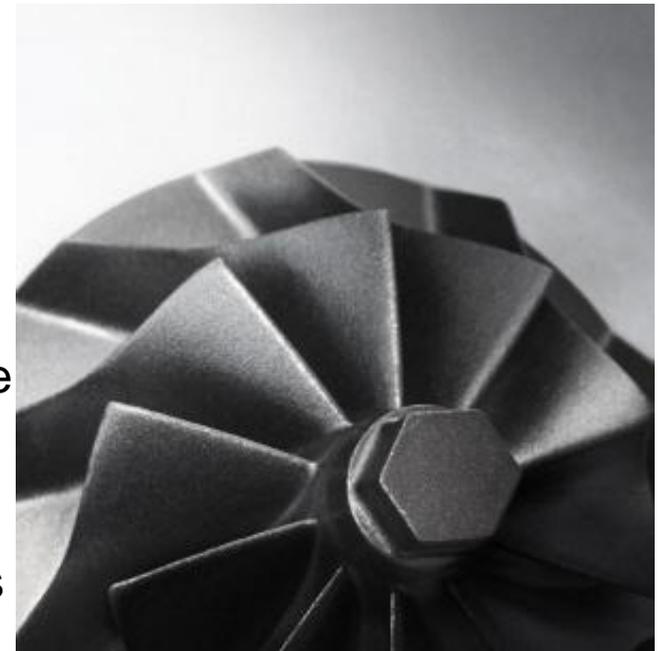
Design suggestions

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Revised design needs to deal with:

Sealing, heat transfer properties, impeller and scroll design, erosion and korrosion.

- Titanium impeller: fully machined or 3D inj. Molded
- New laser fusion process, like 3D printing.
- Materials with high wear resistance
- Alternative material or inserts in Compressor house
- Face type balanced seal
- Redesigned oil pump for optimal vacuum in gear
- Direct drive from new type of high speed el. motors
- Verify mechanical efficiency on new Rotrex testrig.





Conclusion

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Necessity is the mother of invention

At Rotrex difficult situations inspire to ingenious solutions

Together with the project group we are not only confident on a solution, but also a solution that within the frame of the Rotrex supercharger, will secure a highefficient, cost effective and reliable solution.

With the silent and compact design, we hope to be an essential part of the future HEAT PUMPS.



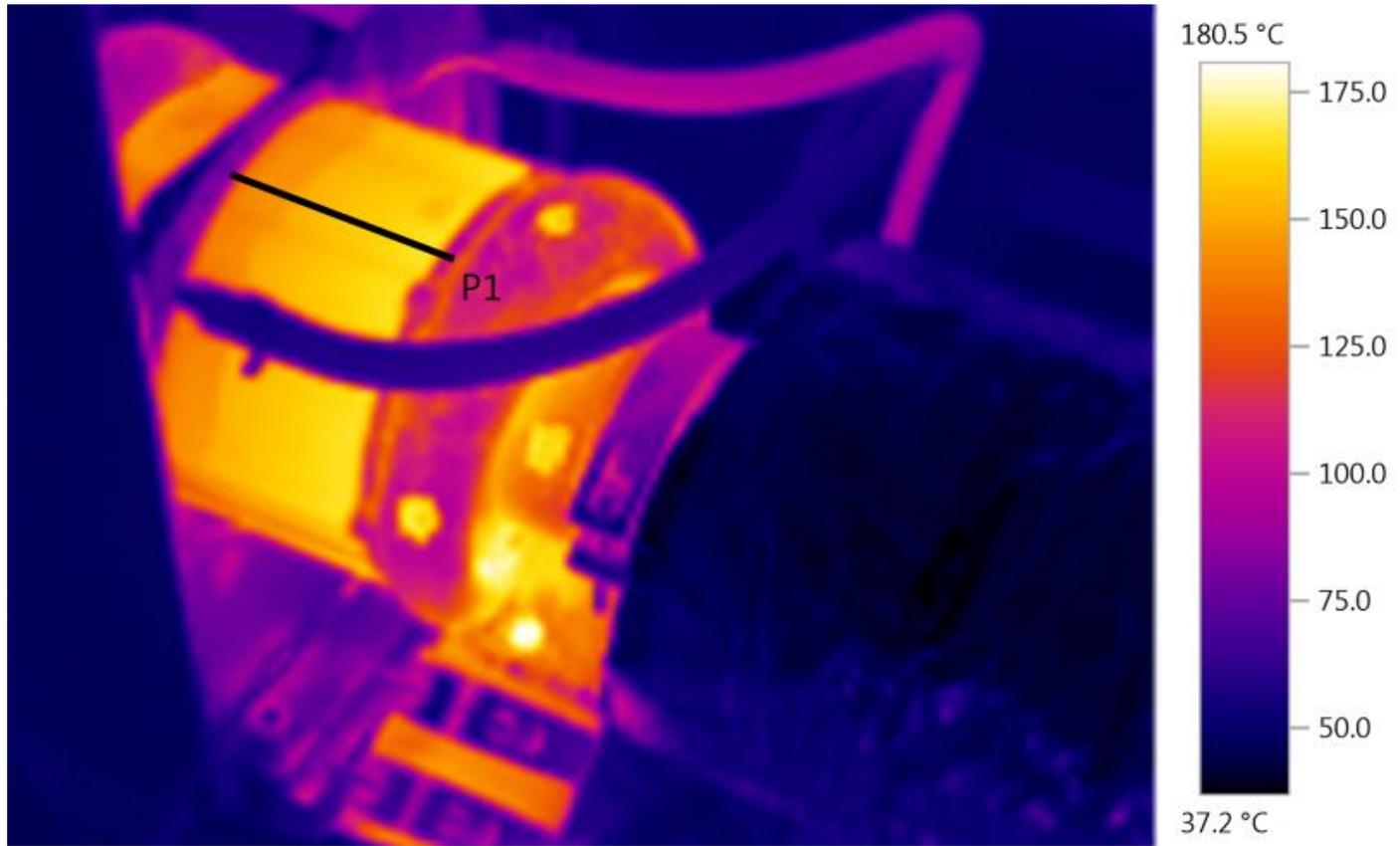
Weel & Sandvig





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Thank you for your attention!

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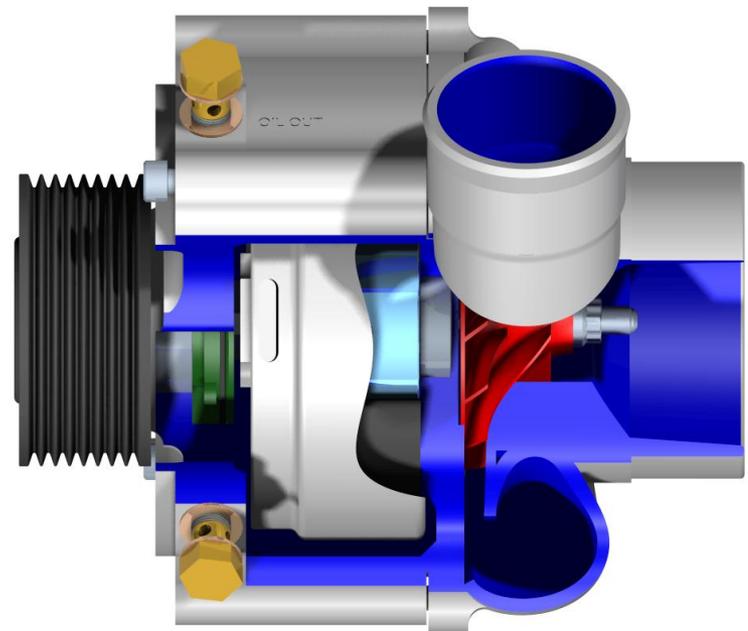
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We welcome questions!