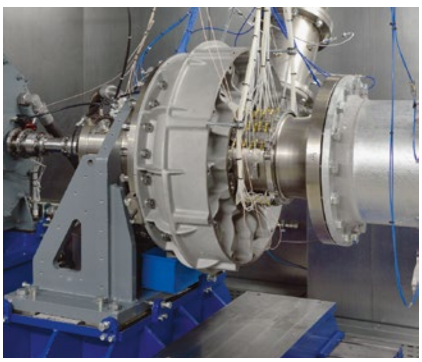
Continuously Optimising the Design of Centrifugal Compressors

Centrifugal compressors are suitable for a wide variety of applications. Their best-known area of implementation is turbochargers, which are an indispensable component of internal combustion engines, like turbodiesel in passenger cars or ships, due to their efficiency enhancing effects. In order to optimally design them, experimental pilot examinations on a test stand are essential. Experts from the scientific community and turbomachinery industry now jointly developed and built a brand new high performance test stand at the RWTH Aachen University. The project was co-financed by Deutsche Forschungsgemeinschaft (German Research Foundation – DFG) and FVV. The facility was specified in such a way to allow for the entire spectrum of industrial applications to be covered and also for it to be flexible and expandable. Other important aspects of the test stand concept were robust safety and noise protection technology as well as modern (pressure and temperature) measurement and plant control. With a drive power of 2 MW and its outstanding technical features, the new FVV test stand is one of the most powerful centrifugal compressor research facilities in Europe. It makes possible pressure ratios – ratios from end to suction pressure – of 6 to 7 as well as the examination of transonic compressor stages. The focus of future research work lies in optimising transonic radial compressor stages with respect to noise reduction and greater efficiency as well as improving numerical calculation methods. Currently, the SRV-4 and NUMECA-C impellers are being tested for performance and acoustic measurements. The optimised properties of both impeller wheels had been shown to date by numerical simulations only. An experimental validation is therefore absolutely necessary in order to be able to verify the performance increase and noise reduction actually in the test. This is just one of many examples how important this new testing tool is for the manufacturers, suppliers and service providers of the turbomachinery industry for optimally designing innovative centrifugal compressors.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The new FVV test stand is one of the most powerful centrifugal compressor research facilities in Europe

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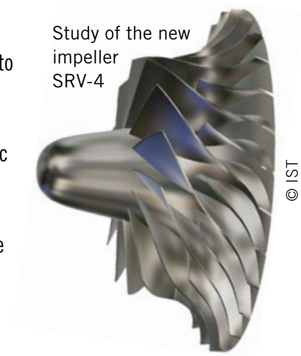
Study of the new impeller SRV-4

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Improved Engine Control Software for Highly Supercharged Engines

In a BMWi / AiF-funded FVV research project, an engine control software developed in previous FVV projects was extended for the operation of multistage spark-ignition engine turbocharging systems. In order to determine the amount of air that remains inside the cylinder during scavenging, a method was developed which evaluates the linear relation between charging efficiency and the indicated mean effective pressure of the high pressure slope in the case of homogeneous combustion processes. This method only refers to the measurement technique usually applied during the application phase. To adapt the set path for boosted operation two different variants (linear/nonlinear) of model predictive controllers were developed exemplarily for a two-stage turbocharged gasoline engine and validated in a vehicle. The linear model predictive controller is characterised by low calibration efforts of about 1 h but nevertheless provides very good results over a wide operating range as well as under dynamic conditions, with two linear models providing a multistage set point calculation. The non-linear variant shows high potential due to the possibility of taking into account limitations of the system, but requires a considerable effort in the development of the model and the implementation on the hardware. To ensure a safe operation of turbocharged SI engines, functions for detecting and prohibiting knock and pre-ignition events were developed, too. The calibration effort is thereby reduced to two hours due to the direct evaluation of the cylinder pressure signal. The design of a low-pressure exhaust gas recirculation system and the functions developed for the control and regulation of the individual components create the basis for an expansion of the model predictive controller for a simultaneous control of the charge pressure and the exhaust gas recirculation rate.

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FVV – RESEARCH ASSOCIATION FOR COMBUSTION ENGINES E.V.

The FVV was founded in 1956 and has developed into a worldwide and unique network for engine and turbine research. It promotes pre-competitive joint research projects for this industry, bringing together industry experts and scientists to ensure continuous improvements in the efficiency and emissions of engines and turbines – to the benefit of our economy, our environment and our society as a whole. Furthermore, it provides support for junior researchers. Its members are small, medium-sized and large companies in the industry: automotive companies, engine and turbine manufacturers and their suppliers.

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