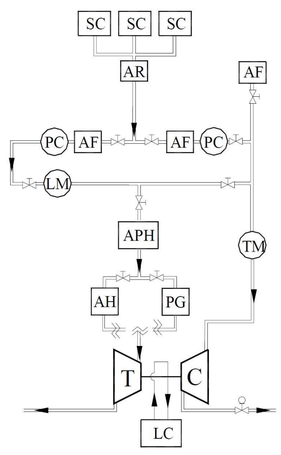
Joint FINAL EVENT

Experimental definition of performance maps for advanced automotive boosting systems

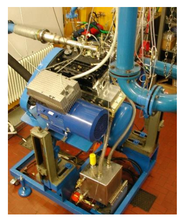
Skills of the Internal Combustion Engines Group (ICEG) of the University of Genoa

- Accurate definition of compressor and turbine maps (no automatic mapping)
- Cold and hot (up to 1000 K) gas tests
- Efficiency maps correction for heat transfer phenomena
- Extended TC maps (for implementation in GT Power environment)
- Subassembly characterization (TC + engine I/E circuit)
- Unsteady flow effect on turbine and compressor performance
- Effect of waste-gate or VGT position
- Single and two-entry turbines characterization
- Interpolation techniques for GT Power implementation
- Evaluation of mechanical losses in TC bearings
- Compressor surge limit definition
- Study on electrically assisted turbocharger

Test facility

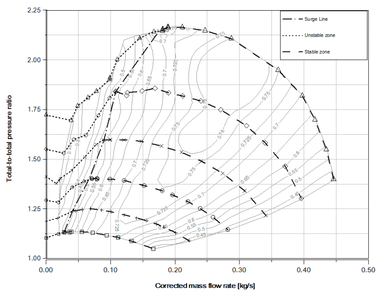


AF	Air Filter	LM	Laminar Flow Meter
AH	Air Heater	PC	Pressure Control
AR	Air Reservoir	PG	Pulse Generator
APH	Air Pre-Heater	SC	Screw Compressor
C	Compressor	T	Turbine
LC	Lubricating Circuit	TM	Thermal Mass Flow Meter

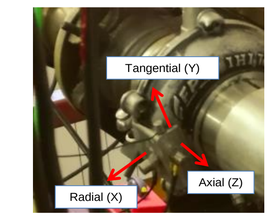


- "Cold" (about 400 K) and "hot" (max 1000 K) air tests on I/E components and subassemblies
- Maximum available air flow rate 0.65 kg/s at 8 bar
- Particularly suitable to test automotive turbochargers: two independent feeding lines available for the TC turbine and compressor
- Electrical air heating modular system (max power 320 kW)
- Turbine and compressor performance investigated under unsteady flow through two different pulse generator systems:
  - Rotating valves
  - Cylinder head

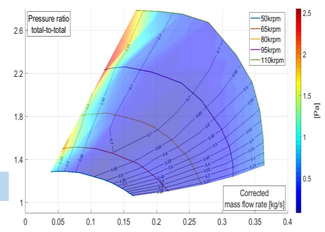
Surge line detection



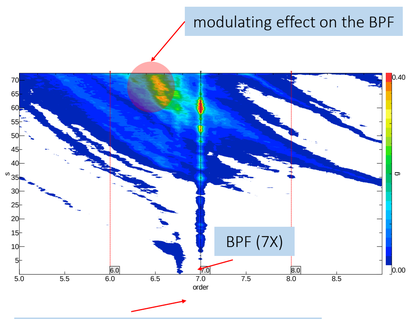
Out-of-standard investigations (compressor unstable zone investigations, influence of intake geometry configuration, specific boundary conditions, etc.)



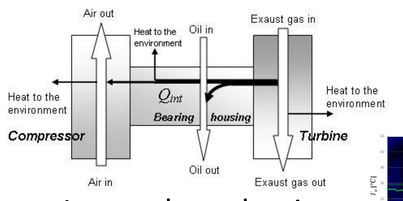
Detail of the three accelerometers on the compressor housing



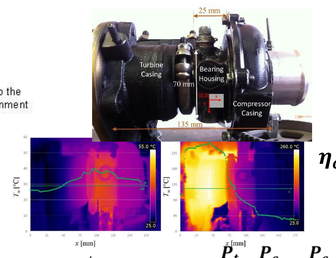
Colourmap of RMS value in the whole sub-synchronous frequency range for the for the acoustic pressure at the inlet section.



Heat transfer effect on experimental compressor maps



Internal conductive heat transfer



$$P_c = M_c \cdot c_{pc} \cdot (T_{T2} - T_{T1})$$ — Affected by heat transfer

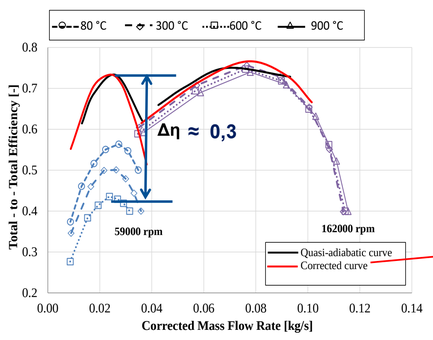
P_c usually overestimated

$$\eta_{cTT} = \frac{P_{cis}}{P_c} = \frac{M_c \cdot c_{pc} \cdot (T_{T2is} - T_{T1})}{M_c \cdot c_{pc} \cdot (T_{T2} - T_{T1})}$$

η_c usually underestimated

$$\eta'_t = \eta_{tTS} \cdot \eta_m = \frac{P_t}{P_{tis}} \cdot \frac{P_c}{P_t} = \frac{P_c}{P_{tis}} = \frac{M_c \cdot c_{pc} \cdot (T_{T2} - T_{T1})}{M_t \cdot c_{pt} \cdot T_{T3} \left[1 - \left(\frac{p_{S4}}{p_{T3}}\right)^{\frac{k-1}{k}}\right]}$$

η'_t usually overestimated



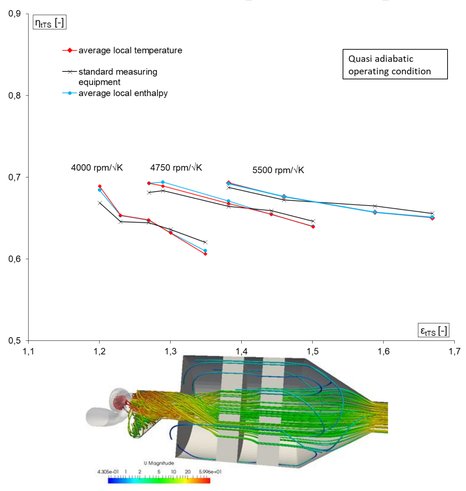
Heat transfer effects

- Influence of turbine inlet and lubricating oil temperatures

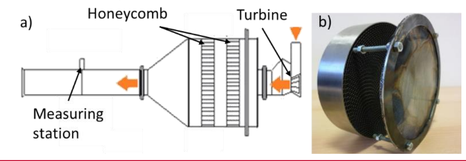
- Heat transfer correction model developed by the University of Genoa [2]
- Good agreement between quasi-adiabatic curves and those corrected by the correction model

Direct measurement of turbine efficiency

$$\eta_{tTS} = \frac{T_{T3} - T_{T4}}{T_{T3} - T_{S4is}} = \frac{T_{T3} - T_{T4}}{T_{T3}\left[1 - \left(\frac{p_{S4}}{p_{T3}}\right)^{\frac{k-1}{k}}\right]}$$ — difficulty in the evaluation of the outlet temperature

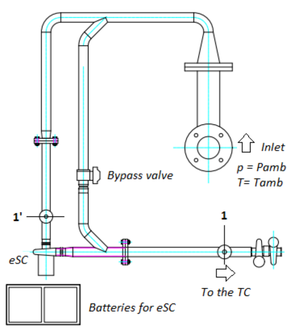


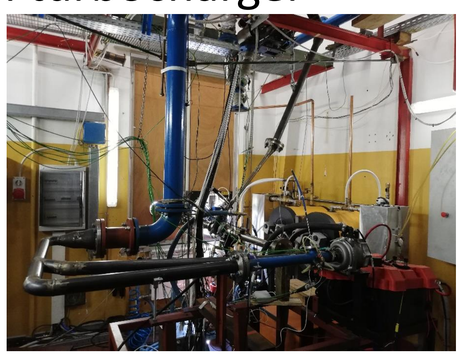
- Identification of a flow conditioning device for direct measurement of turbine efficiency using a three hole probe for local measurements (University of Genoa) [3]
- CFD simulations (OpenFOAM ® code) performed to estimate the impact of heat transfer and flow distribution on isentropic efficiency (Politecnico di Milano).



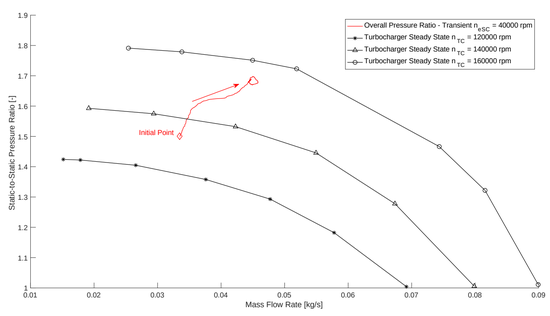
Electrically assisted turbocharger transient response

Layout of the e-booster coupled to the main turbocharger



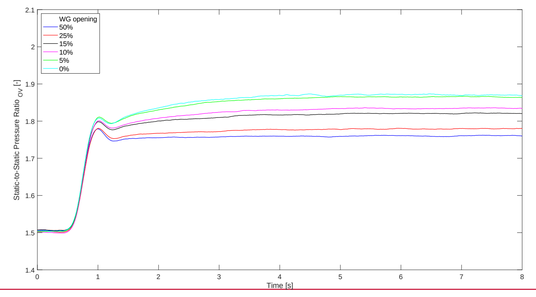


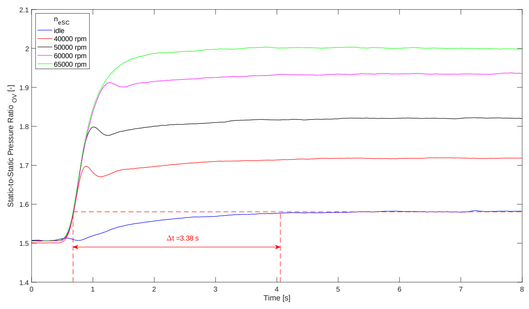
Upstream configuration



Transient operation starting point
12 bar BMEP x 1750 rpm

Thanks to the presence of the eSc, it is possible to change the waste-gate valve position reducing the back-pressure, i.e. the engine fuel consumption





In the presence of the eSc, the outlet pressure level is achieved with different trend in less time reducing the turbo-lag

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