Detailed modeling of single & double turbines

Johan Fjällman

johanf@mech.kth.se

KTH CCGEx

Abstract

As the emission legislation is getting tougher and tougher for car manufacturers in Europe and in other parts of the world the need for newer and more efficient engines has risen. One way of dealing with the emission problem is downsizing the engine; a smaller engine has less geometrical losses i.e. frictional losses. One effective way of downsizing an engine is to give it a turbocharger. A turbocharger increases the engine efficiency and power output without increasing the fuel consumption or emissions as much.

Background

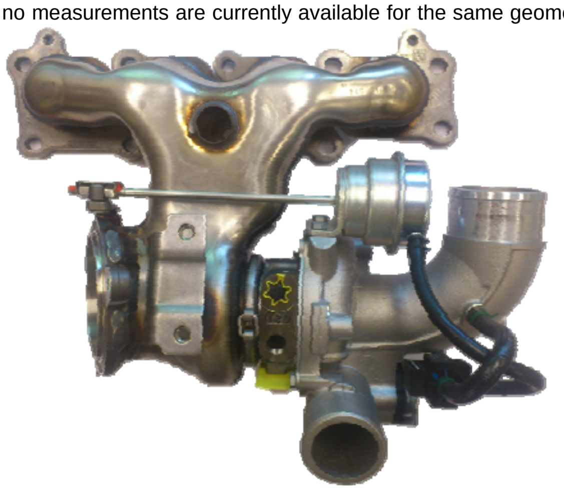
Turbo-charging (TC) is essential for enabling down-sizing and for enabling emission reduction while maintaining or enhancing combustion efficiency. The energy in the hot exhaust gases can be utilized in order to compress the air that is provided to the cylinders and thereby the utilization of the combustion chamber volume is enhanced. For faster response and for better operation over a wider range of engine load one has proposed using 2 staged TC (for example in tandem). This project shall explore some issues that can be related to such systems.

When doing calculations on turbochargers in the industry today one is often restricted to 1D simulation tools in which the turbochargers are implemented as maps. These maps are commonly from the manufacturer and measured at constant massflow and low temperatures. This is very far from the environment the turbochargers are in, where the flow is highly pulsatile and the temperatures are much higher. Part of this project is aimed at looking at the differences between steady flow and pulsating flow and how much the turbine performance is changed by this.

Method

For this project Unsteady RANS and Large Eddy Simulations are being performed on a single stage turbine. Both steady and pulsating flow is being simulated and different inflow conditions are being applied.

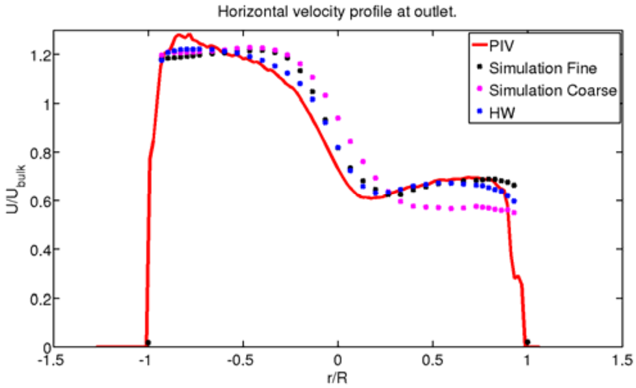
For the steady cases experiments have been performed at the Saab Gas-stand in Trollhättan where a wide range of flow conditions were measured extensively, both in hot and cold conditions. For pulsating flow no measurements are currently available for the same geometry.



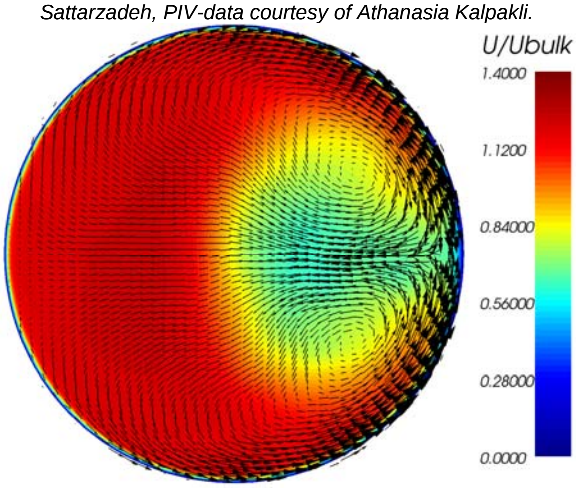
To validate the simulation software an easier case has been setup where flow in a bended pipe is being studied. Within the center measurements of the same case has been performed so the data available for validation is good and easily accessible.

Results

For the bended pipe flow simulations comparisons have been made between LES and experiments (PIV and HWA).



When comparing the simulations (2 grids shown) with both PIV and HWA good agreement is seen. HWA-data courtesy of Sohrab Sattarzadeh, PIV-data courtesy of Athanasia Kalpakli.



Mean velocity divided by bulk velocity at the outlet after the pipe bend. Both dean vortices can be seen and scalar levels are quantitatively similar to those of the PIV.

Conclusions

For the bended pipe good agreement between measurements and simulations can be shown for the outlet velocity profile.

For the bended pipe simulations the software is predicting the flow accurately compared to experiments.