REYNOLDS AVERAGED NAVIER-STOKES SOLVER BASED ON A NON-LINEAR k-ε MODEL

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Turbulence is a common and important phenomenon in fluid dynamics and its applications, so that its study is an interdisciplinary activity: in a wide range of technologies and natural conditions, turbulence is the most common state of fluid flow. Virtually all flows of practical engineering interest are turbulent: external flows e.g. the wakes of vehicles such as rockets, airplanes, ships or automobiles are turbulent, as well as internal flows e.g. flow through pipes, internal combustion engines, pumps, compressors, turbines, industrial burners. Turbulence dominates in geophysical phenomena, such as river currents, oceanic flows, the momentum transfer between winds and ocean currents, the planetary boundary layer and the motion of clouds.

As turbulence strongly influences the performance of any single component of a plant involving a fluid motion, it is important to have numerical tools to predict turbulent flows or to estimate the most important overall characters of the flow or quantities: wall drag, forces on any profiles, efficiency of fluid-wall heat transfer into heat exchangers, mixing processes in chemical reactors and industrial combustion applications. Navier Stokes equations describe the behavior of any flows, turbulent ones included but, due to the fact that their direct numerical solution or large eddy simulations are not yet available for complex flows of engineering interest, an usual approach is the solution of the Reynolds averaged Navier Stokes equations, based on some turbulence model.

One of the most widely and successfully used model is the k-ε model, implemented in commercial codes. From its original version (Launder and Spalding , 1972), many variants have been proposed, each of them more or less optimized for the widest possible range of flows. Among them, the non-linear variants are interesting with respect to the fact they can give better predictions for separated or secondary flows, typically present in external flows, where other models are preferably used.

A cubic k-ε model, proposed by Merci&Dick (e.g.: Flow, Turbulence and Combustion, Vol.66, No.2, 133-157, 2001) was implemented in the Reynolds averged Navier Stokes solver CAMUS, a code developed and validated by Nicholas Waterson at VKI within his Ph.D. thesis. The new model has also been tested with two simple but fundamental test cases: the channel flow and the backward facing step.

The results obtained with CAMUS were compared with those ones coming from a linear k-ε model (already present in CAMUS) to point out differences and with the results of Merci&Dick to check the correctness of the present implementation. Examples are shown below.

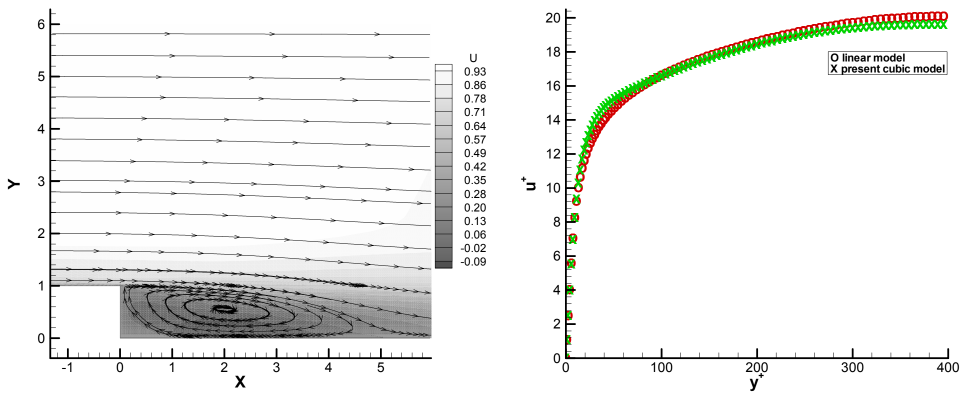

Figure 1: Left :backward facing step, streamlines and velocity field; right: channel flow velocity profile, comparison between linear and present cubic model.