Report on the meeting of SIG10 on Transition Modelling
At TU Czestochowa, 28 September 2005

1. Objective of the meeting

The objective was to revitalise the special interest group on Transition Modelling after a period of relative inactivity. The low activity level during the past 4 years was caused by the EC-research project UTAT, in which some of the SIG-members participated. The regular meetings of the UTAT-project, every six months, prevented supplementary meeting activity of the SIG. At the meeting, organization of the SIG was discussed, activities of the members were summarized and preliminary plans for funding of research activities were made.

2. Coordination of the SIG

Based on discussions at the meeting and on e-mail contacts after the meeting, it is agreed that, starting from October 2005, the co-ordination team will be composed by:
Erik Dick, Ghent University, chairman and co-ordinator for RANS-URANS models;
Franco Magagnato, Karlsruhe University, deputy-chairman for DNS-LES simulations;
Witold Elsner, Technical University Czestochowa, deputy-chairman I for experiments;
Apostolos Goulas, Aristoteles University Thessaloniki, deputy-chairman II for experiments;
Ferruccio Pittaluga, Genua University, deputy-chairman for database;
Mark Savill, Cranfield University, deputy-chairman for best practice guidelines.

3. Presentations on activities

3.1. Andrzej Boguslawski, Director Institute of Thermal Machinery, TU Czestochowa.

Andrzej gave an overview of the general activities of the institute.

3.2. Wolfgang Rodi, Karlsruhe University: DNS of transitional flow over turbine blades.

Wolfgang presented DNS-simulations performed by Jan Wissink and himself on a flat plate with a separation bubble and periodic perturbation of the incoming flow velocity. K-H instability is forced in the free shear layer by the periodic inflow. Further simulations have turbulence superimposed at the inflow, either uniformly distributed or concentrated in wakes. With turbulence uniformly added, disintegration of the shear layer is faster and turbulence structures are finer. Streaky structures are generated under wakes. Simulations were shown for the T106A test case with Re~50k on inflow conditions. There is periodically separating flow on the suction side. On the pressure side, there are vortical structures that enhance heat transfer. Further, simulations were shown for a MTU-blade with Re~70k on inflow conditions. Without wakes, the boundary layers remain laminar. Wake impact causes bypass transition, but only on the suction side. At the end of the suction side, transition is not yet fully completed. The wakes increase the heat transfer, but in the boundary-layer regions remaining laminar, not as much as in the experiment.

3.3 Franco Magagnato, Karlsruhe University: Nonreflecting BC for the prediction of transition on turbine blades with LES.

Franco presented simulations of flow through the VKI turbine cascade, under steady inflow, as measured by Genoa University, with Re~590k and ~1.6M on exit conditions. Reflections at boundaries are avoided with a buffer layer technique. On the suction side, K-H instability is created in the zone of incipient separation with dominant frequency equal to the frequency of the wake shedding.

3.4 Pavel Jonas, Czech Academy of Sciences: Conditional analysis of wall friction in a transitional boundary layer.

Pavel presented experimental results for bypass transition on flat plates with conditional sampling of the shear stress. The influence of the length scale of the incoming turbulence is analyzed. The onset of transition shifts forward and the transition length shortens for large scales of the incoming turbulence. The earlier transition and the shortening of the transition zone demonstrate that larger turbulence structures have a bigger impact on the transition mechanism.

3.5 Witold Elsner, TU Czestochowa: Experimental analysis of wake induced transition on turbine blades.

Witold presented experimental results from Robert Zarzycki and himself on the influence of background turbulence intensity and wake size for wake-induced bypass transition on the N3-60 turbine blade. Larger background turbulence leads to earlier bypass transition, but also modifies the wake structure. The wake for higher free-stream turbulence dissipates and spreads faster. This results in a wider wake, which means a wider area of interaction. The increase of the diameter of the disturbing elements provokes both shift of the transition point upstream and broadening of the wake induced area. It was shown that the wake parameters, especially the turbulence in the wake and wake width have a big influence on the position and the extend of the induced transition.

3.6 Ferruccio Pittaluga, Genoa University: The transition database of Genoa University.

Ferruccio presented the current status of the database of the SIG, as it has remained since the end of the Transpreturb project in mid 2001. The database is presenting, in organised form, the outcome of the experimental activities performed by members of SIG10 as well as by participants to Transpreturb network. The database is freely on-line accessible on a dedicated server at the University of Genoa at URL: http://transition.dimset.unige.it

3.7 Florian Menter, Ansys Germany: Industrial transition model formulation in CFX.

Florian presented the transition model developed at Ansys. The model uses a dynamic equation for intermittency. The production term and the destruction term in the k-equation of the SST-model are multiplied with functions of the intermittency factor. The start of transition is determined by an algebraic criterion generating a value of Re-theta. A particular feature of the method is that Re-theta is not calculated from integrals through the boundary layer, since this would involve local information. The Re-theta value is obtained by a transport equation.

3.8 Wladek Piotrowski, TU Czestochowa: Application of intermittency based methods for modeling transitional boundary layers.

Wladek presented simulation results from himself and Witold Elsner on wake-induced transition for a number of cases with the N3-60 cascade. The prescribed unsteady intermittency method from Cambridge University and the dynamic intermittency method from Ghent University are studied. Both lead to good results for the studied test cases. These have all transition of bypass type.

3.9 Zygmunt Wiercinski, Polish Academy of Sciences: Experimental transition investigation of an induced boundary layer of a heated and a cold flat plate.

Zygmunt presented results of transition on a heated and a cold flat plate. Measurements were done of the Reynolds analogy coefficient of the momentum and heat transport for different flow conditions: natural transition Tu=0.08%, grid generated turbulence Tu = 1.5 % and flows with wakes generated by a single cylinder and a squirrel cage. For the unsteady flow with wakes from the squirrel cage, the Reynolds analogy coefficient is 10 % greater than for the other flows. That means that the velocity gradient across the boundary layer is about 10 % greater than the gradient of the thermal boundary layer. The reason for such a behavior is probably the greater time constant of the heat transport than the momentum transport.

3.10 Jaromir Prihoda, Czech Academy of Sciences: Recent activities on modelling of bypass transition at the Institute of Thermomechanics.

Jaromir presented the current status of the modelling approach at the Czech Academy of Sciences. The bypass transition model is based on an algebraic relation for the intermittency factor with empirical criteria for the onset and the length of the transition region. The effect of free stream turbulence, pressure gradient and wall roughness is considered. The model is implemented into in-house numerical codes for compressible flows in blade cascades. The codes are based on the modified algebraic turbulence model and/or on the SST model. The applications are up to now limited to structured grids due to the use of the momentum Reynolds number as criterion. Good results were obtained for transonic flow through a turbine blade cascade.

3.11 Erik Dick, Ghent University: Modelling of wake-induced transition with dynamic intermittency equations.

Erik presented the model developed by Koen Lodefier and himself. The model uses the SST-model as turbulence model and two dynamic equations for description of intermittency: one for the intermittency caused by impact of free-stream turbulence at the edge of the boundary layer and one for the intermittency generated inside the boundary layer by the transition process. Empirical criteria are used to determine start of transition and growth rate of transition. Three types of transition are modeled: bypass transition in attached state, small scale free shear layer transition due to free-stream turbulence and large scale free shear layer instability due to cinematic wake impact. For a number of test cases, with varying Reynolds number and background turbulence level, reasonable results are obtained. The RANS-methodology, however, has inevitable shortcomings for large scale free shear layer instability, since the breakdown of the roll-up vortices cannot be captured.

4. Future funding of research activities

In the near future, the SIG10 will use the funds available in the COST-action on LES for meeting activities related to the SIG. At the meeting, the same plan was formulated for the possible funds in the Network of Excellence proposal. Shortly after the meeting, it became known that this proposal was rejected. The SIG will try to find further funds to cover costs related to its activities.

Erik Dick, 15 November 2005