ON SOME FEATURES OF WALL FRICTION DURING BY-PASS TRANSITION

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The results acquired during investigation of transitional intermittency in zero pressure gradient boundary layers developing on plate covered with sand paper are presented in this contribution. Analysed wall friction records were obtained from hot wire measurements. The start of the analysis with histograms of these records is meaningful because they clearly physically depict behaviour of the wall friction with progress of transition. Histograms N_L (non-turbulent state) and N_T (turbulent state) derived from measurements in the rough wall boundary layer under free stream turbulence [Iu=0.03; Le = 33.4 mm] are shown in Figure 1 as an example.

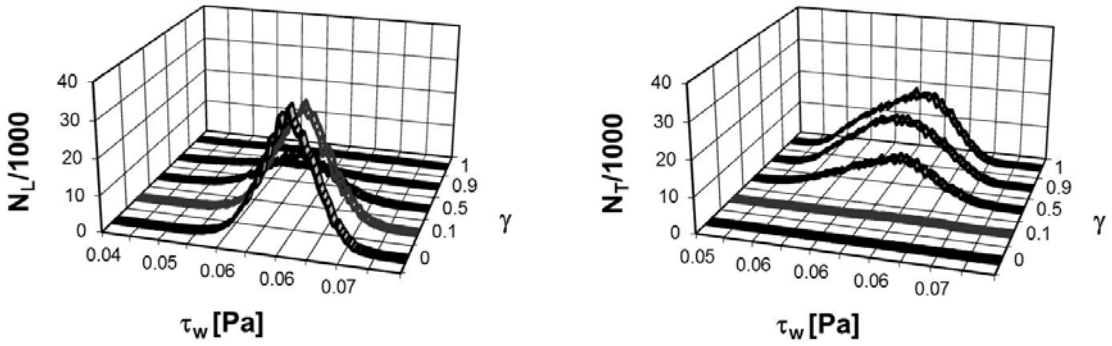

Figure 1. Example of the wall friction histograms

The mean durations of the wall friction stay in non-turbulent condition $(\Delta t)_L$ (white symbols) and turbulent condition $(\Delta t)_T$ (smaller black symbols) are plotted for rough wall boundary layers in Figure 2.

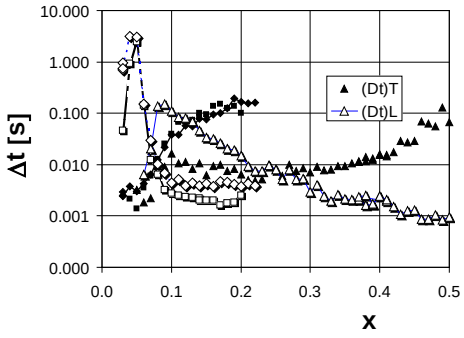

Figure 2.Mean time of the laminar- turbulent events duration; rough wall layers.

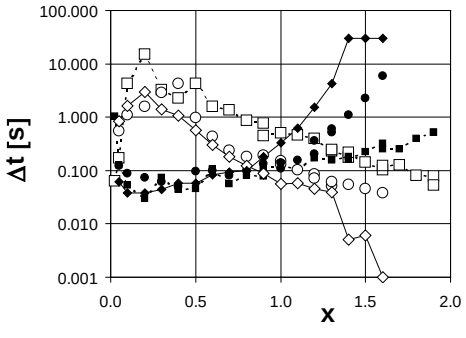

Figure 3.Mean time of the laminar- turbulent events duration; smooth wall layers.

It is evident that periods $(\Delta t)_L$ are of orders longer then the turbulent periods $(\Delta t)_T$ at the start of transition x_s and vice versa at the end of transition. Similar courses can be found

in smooth wall boundary layers but at that time the events durations are roughly of order longer as is evident from the comparison of the Figure 2 with Figure 3 (see e.g. [1, 2]).

The distributions of the conditional mean wall friction in boundary layers on the rough plate under free stream turbulence are shown in Figure 4. The non-turbulent/laminar means $(\tau_w)_L$ follow the Blasius distribution (full line) up to the location where the intermittency factor γ becomes positive. Afterwards the values $(\tau_w)_L$ start to grow. The increase continues little beyond the end of transition region $\gamma = 1$ and then possibly the decrease follows. Behaviour of the wall friction $(\tau_w)_T$ during turbulent events is similar to the above discussed with only small differences.

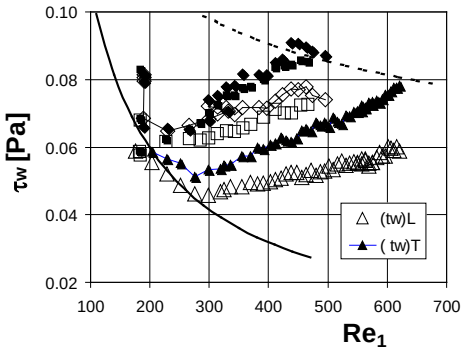

Figure 4. Conditional wall friction in rough wall layers.

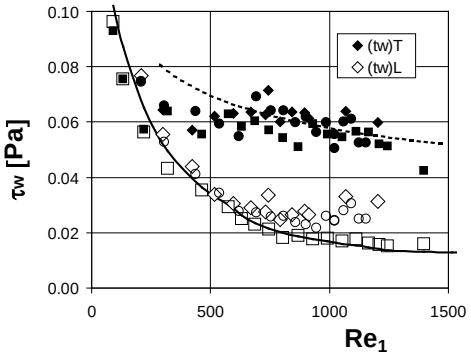

Figure 5. Conditional wall friction in smooth walllayers

The distributions determined in rough wall layers are similar to the relevant ones in smooth wall layers in the earlier departures of turbulent means $(\tau_w)_T$ then the departures of laminar means $(\tau_w)_L$ from the Blasius distribution and that the turbulent means $(\tau_w)_T$ are joining the Ludwieg and Tillmann curve (dashed line) at last. However the courses of $(\tau_w)_T$ between „departure" and „joining" are different. The conditional means of turbulent events remain about on constant level in smooth wall boundary layer transition region.

Acknowledgements

This work has been supported by the Czech Science Foundation, the projects GA101/08/1112 and GAP101/12/1271 and with the institutional support, projects AV0Z20760514.

References

[1] Jonas P., Mazur O. and Uruba V., 2004, "Some results of the conditional analysis of the skin friction in transitional boundary layers", *Proc. Advances in Turbulence X*, CIMNE, Barcelona, Spain, pp. 811.

[2] Jonas P., Mazur O. and Uruba V., 2006, "Experimental study of the wall-friction development during boundary layer by-pass transition", *Proc. Colloquium Fluid Dynamics 2006*, IT AS CR, Praha, pp. 67-70.