Skin Friction Estimation in Adverse Pressure Gradient Boundary Layers Using Corrected Clauser-Chart Method

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Abstract: Estimation of the wall skin friction in a turbulent boundary layer (TBL) is always challenging due to the large gradient of mean velocity in the near-wall region and requires precise measurements of mean velocity in viscous sublayer. This problem becomes even more serious for a flow with a strong positive pressure gradient where the low velocity closes the wall occurs. Hence, choosing an appropriate measuring technique for the wall skin friction measurement is an important issue. Most commonly used for this purpose is hot-wire technique, where determination of mean velocity gradient is strongly dependent on resolution and quality of measurements very close to the wall. Therefore, Clauser's indirect method, which do not require precise measurements in viscous sublayer as it is based on logarithmic overlapping layer universality assumption, became quite popular. The paper discusses modification of this method and its application for a very demanding case, where a low shear stress is present and where their estimation may be associated with a large measuring errors. The new approach, which is based on physical concept found in the wall-bounded flows, shows that the skin friction can be directly estimated based on the location of intersection point between the inner-scaled streamwise velocity profile and the log-law line which location covers with the point of the local maximum of the turbulence intensity in the outer region of the turbulent boundary layer. The results showed that the proposed method allows for estimation of the skin friction velocity with uncertainty lower than 2% for the Clauser-Rota pressure parameter β up to the value typical for near separation.

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