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MODELING OF REYNOLDS-STRESS AUGMENTATION IN SHEAR LAYERS WITH STRONGLY CURVED VELOCITY PROFILES

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Improvements of a modern differential Reynolds-stress turbulence model (RSM) are presented. At the Institute of Fluid Mechanics of TU Braunschweig, the JHh model by Jakirlić and Hanjalić [1] was implemented into the flow solver DLR-TAU [2] and further refined [3, 4].

It was noted that the current version of the Reynolds-stress model (JHh-v2) tends to underestimate the growth of Reynolds stresses in free shear layers which contain an inflection point. As a remedy, an additional sink term was implemented into the length-scale equation with the intention of locally reducing dissipation and hence supporting the development of turbulence. After implementation, the RSM is re-calibrated and named as JHh-v3. The sink formulation was derived from the Scale Adaptive Simulation (SAS) concept [5], which employs an additional source term within the length-scale equation to sensitize turbulence models for resolving instabilities. While the SAS concept intends to resolve a wide part of the turbulent spectrum in unsteady flow regions, our goal is to consider a higher spectrum of instabilities within the turbulence model. Therefore the SAS source term is used as a sink term in the length-scale equation of the Reynolds-stress model:

$$\frac{D\varepsilon^h_{(JHh-v3)}}{Dt} = \frac{D\varepsilon^h_{(JHh-v2)}}{Dt} - P_{SAS} \,. \tag{1}$$

Clear improvements can be seen when simulating the flow over a backward facing step, where the length of the separation is sensitive to the turbulence which develops in the shear layer downstream of the step. Figure 1 shows the skin-friction coefficient along the wall, comparing the different model versions to experimental data as well as to the SST model.

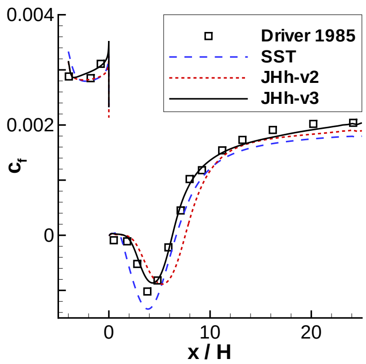

Figure 1: Skin-friction coefficient of flow over Backward Facing Step

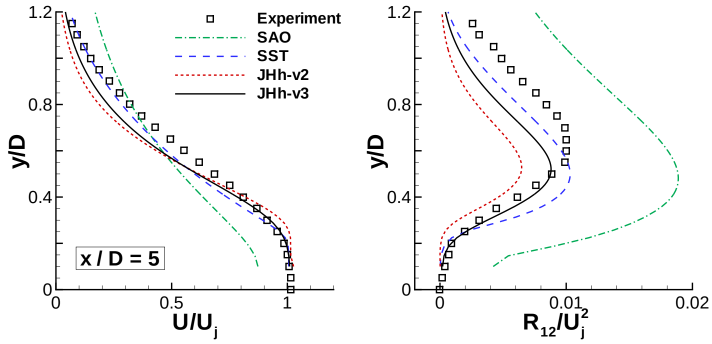

Figure 2: Profiles of velocity (left) and turbulent shear stress (right) in round-jet flow, Ma = 0.75, $x/D = 5$

A second test case of the new model version is the round-jet flow, where the prediction of turbulence in the shear layer has a strong influence on the jet-core length as well as on the spreading rate. In Fig. 2, improved turbulent shear stress of the JHh-v3 model can be seen in comparison to the JHh-v2 model.

Further improvements can be found in the test case of an axisymmetric transonic bump.

Additionally it was assured that the good results of the JHh-v2 model when simulating airfoil flows [4] can be preserved.

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