The global drag of heterogeneously rough surfaces

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The drag of rough surfaces is classically quantified in terms of an equivalent sand grain roughness. However, it is unclear whether this quantity can be meaningfully applied for rough surfaces with a large degree of heterogeneity. In the present work we consider strips of sandpaper that are aligned in the mean flow direction. This considered surface roughness is thus invariant in streamwise direction and is periodic in spanwise direction.

In order to determine the global drag behavior of sandpaper strips we carry out an extensive experimental campaign with sandpaper strips of different width. In all cases 50% of the total surface is covered by sandaper. The pressure drop in a channel flow facility is employed to determine the relation between the global skin friction coefficient C_f and the bulk Reynolds number Re_b for fully developed turbulent channel flows in the range $4.5 \times 10^3 < Re_b < 8.5 \times 10^4$.

Fig. 1 shows the obtained results for four different roughness strips in comparison to smooth wall and homogeneously rough wall data. Roughness strips of width δ and 2δ are considered where 2δ corresponds to the channel height. For each case the roughness strips are once glued on top of the smooth surface and once submerged in a groove such that the roughness mean height is at the same level as the smooth surface part. It can be seen that these four curves do not co-incide and that neither one of them reaches fully rough state, i.e. a state in which C_f is independent of Re_b which is required for the evaluation of an equivalent sand grain roughness. The conference contribution will discuss the impact of the rough channel height definition on the data evaluation and options of predicting the rough strip behavior based on the well-known homogeneously rough drag curve.

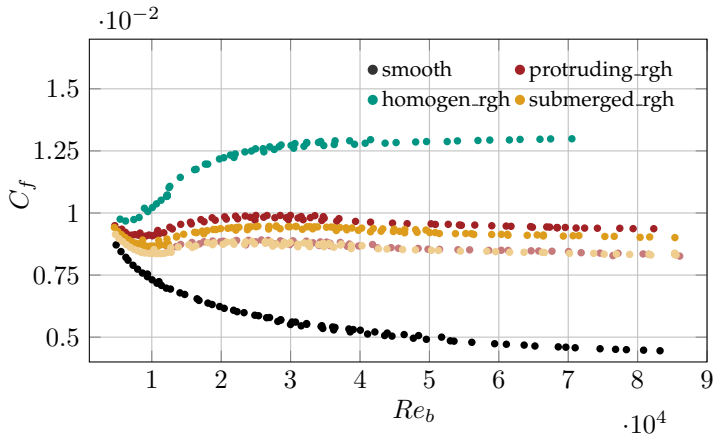

Figure 1: Skin-friction coefficient C_f as a function of Re_b. Dark color: $w \approx \delta$, light color: $w \approx 2\delta$

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