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The friction coefficient of heterogeneous rough surfaces

Carola Schmidt[1,*], Davide Gatti[1], Simon Dalpke[1], Jonathan Neuhauser[1] and Bettina Frohnapfel[1]

[1] Institute of Fluid Mechanics (ISTM)
Karlsruhe Institute of Technology (KIT), 76131 Karlsruhe, Germany
[*] carola.schmidt@kit.edu

ABSTRACT

Many technical surfaces exposed to flow are heterogeneously rough. The global friction coefficient for such surfaces is of interest, but its prediction remains challenging (Chung et al., 2021). Existing suggestions for prediction tools are based on (power mean) averaging of smooth and rough values (Hutchins et al. (2023), Neuhauser et al. (2022)), but reference data is needed for validation.

To widen the data base, an extensive experimental campaign is carried out investigating spanwise heterogeneous surfaces of alternating smooth and rough strips. The portion of the surface covered with P60 sandpaper is kept constant ($50\,\%$) for all configurations, whilst the strip width s is varied in relation to the half channel height δ. The pressure drop in a channel flow facility is employed to obtain the global friction coefficient of the surfaces over a bulk Reynolds number range of $4.5 \times 10^3 < Re_b < 8.5 \times 10^4$.

The results are shown in Fig. 1, together with those of a surface fully covered with sandpaper (hom rgh) and those of a smooth surface as well as the prediction by Neuhauser et al. (2022). It can be seen that all drag curves show a similar behaviour at high Re_b (width of $s = 1\delta$ yielding the largest drag coefficient) which significantly exceeds the predicted global drag. At lower Re_b the drag behaviour distinctly differs from the one observed at higher Re_b, indicating that different flow phenomena might govern the global drag.

To shed more light on the different mechanisms, the conference contribution will feature results from hot wire anemometry experiments and DNS on selected cases.

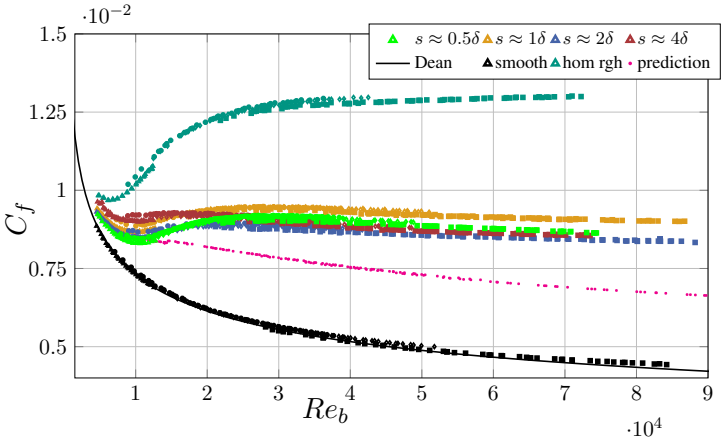

Figure 1: Global C_f-values of spanwise heterogeneous surfaces as function of Re_b.

References

Chung, Hutchins, Schultz and Flack. Predicting the drag of rough surfaces. *Annual Review of Fluid Mechanics*, 53:439-471, 1 2021

Hutchins, Ganapathisubramani, Schultz and Pullin. Defining an equivalent homogeneous roughness length for turbulent boundary layers developing over patchy or heterogeneous surfaces. *Oc. Eng.*, 271:113454, 2023.

Neuhauser, Schäfer, Gatti and Frohnapfel. Simulation of turbulent flow over roughness strips. *JFM*, 945:A14, 2022.