UNSTEADY PHENOMENA IN SEPARATED AND REATTACHING FLOWS: FROM STATISTICAL CHARACTERISTICS TO INSTANTANEOUS SPACE-TIME FIELDS

P.S. ZANKO[1,c], A. POLLARD[2], N.I. MIHEEV[1]

[1]Research Centre for Power Engineering Problems, Russian Academy of Sciences, Kazan, 420111, Russia
[2]Department of Mechanical and Material Engineering, Queen's University, Kingston, ON, K7L3N6, Canada

[c]Corresponding author: Tel.: +7(843)2364803; Fax: +7(843)2739231; Email: zanko_philipp@mail.ru

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ABSTRACT: Existence of the quasi-periodic pulsation of the instantaneous reattachment point in various separated flows is a well-known experimental fact. Understanding of the phenomenon is essential, for instance, for developing of separation control methods. An important tool for statistical description of unsteady phenomena is the technique of conditional sampling and averaging. The criterion of early/late reattachment is often used for the skin friction in the reattachment region of a separated flow (for example, [1]). The criterion fixes the statistical correlation between the instantaneous reattachment position and other overall characteristics of the separated region, but the physical meaning of the late reattachment is still unclear. Using results from DNS and LES of the separated and reattaching flat-plate boundary layer under an adverse pressure gradient [2] the unsteady phenomena are visualized and analyzed (x=0 is the location where $Re^*=\delta_0^* U_0/\nu=550$; δ_0^* – local displacement thickness, U_0 – free stream velocity, ν - kinematic viscosity). The late reattachment criterion is described in terms of instantaneous space-time flow images (fig.1). Some recommendations for local (e.g., hot-wire) measurements of the instantaneous reattachment point pulsation are proposed.

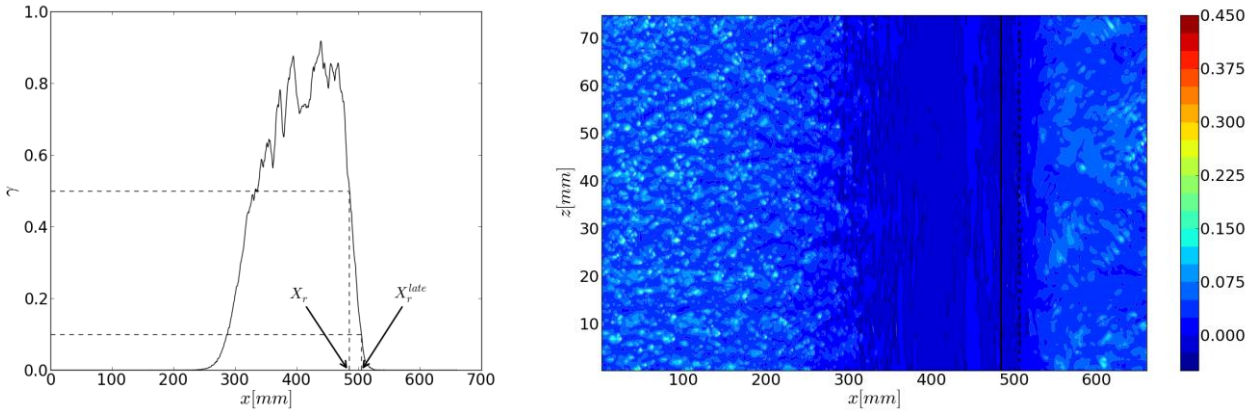

Fig. 1. Probability of reverse flow γ (left; X_r – mean reattachment line, X_r^{late} corresponds to late reattachment criterion), and instantaneous skin friction field corresponding to late reattachment criterion (right; solid black line – mean reattachment line, dashed black line corresponds to late reattachment criterion)

References

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