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Short Paper

Surface Flow Visualization around Competitive Swimmers by Tufts Method

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1. Introduction

What is presented in this Note is part of a partnership convention with the French swimming federation, which was defined in the case of the preparation for the Beijing Olympic Games. The originality of this approach came from the realistic nature of the experiments which took place in the swimming pools of the National Institute for Sports and Physical Education (INSEP) which is the French national team training centre in Paris. Two complementary analyses were conducted, namely energy expenditure measurements of athletes by infrared thermography (Zaïdi et al., 2007) and a specific hydrodynamic analysis. The aim of the hydrodynamic part of the swimming protocol, which is the core of the present short paper, was to analyse the hydrodynamic mechanisms inherent to high level swimming in underwater swimming situations in order to optimize specific positions which could offer less resistance. In order to identify wake separation areas, the surface dynamic fields have been visualized around French team swimmers (females and males) equipped with integral swimsuits. The use of classical techniques of flow visualization with the coupling of laser lighting and tracers which could pollute the basin is prohibited in swimming pools (Fujisawa et al., 2007; Yang and Lee, 2006). Therefore, the choice has been related to a method by non-intrusive fluorescent tufts located on the swimsuit.

2. Experimental Method

The tufts method was used for the first time in swimming by Tagori (1984 and 1985) to visualize the flow around the trunk and various members of swimmer bodies, then by Hay and Thayer (1989) followed by Toussaint et al. (2002) with the aim of studying the structure of the flow around the hand and the forearm. The present experimental protocol used to visualize the flow around swimmers was similar to that already used by the latter authors, except that in the context of our study tufts were fixed directly to the swimsuit instead of being glued directly to the skin. To obtain the most accurate information, the tufts were placed in a very fine regular mesh drawn on the suit as shown in Fig. 1. The tufts were about 0.08 m long and chosen to respond promptly to changes in the direction of the flow with a specific gravity equal to that of the water ensuring neutral buoyancy. The motions were recorded with a Canon EOS 300D-type camera operating at 25 Hz.

Fig. 1. Mesh used on the competitive swimsuit.

3. Results and Discussions

Figure 2 presents the surface flow around a female high level swimmer during underwater swimming corresponding to the starting phase (after the start-dive) or following a turn. The tufts clearly indicate the preferred directions of the flow around the body. In theory, the more the body is streamline shaped, the more the tufts are parallel together in the main flow direction, leading to an enhancement of the profile drag. In practise, because the body has a complex geometry, it is shown that the surface flow trajectories circumvent the curved areas of the swimmer. We also observed from flow visualization an upward orientation of the tufts in a few areas of the swimmer's body which indicates the existence of large scale separation phenomena. These areas were seen at the back and downstream the buttocks for female subjects and for males as well.

Therefore, one of the objectives was to optimize arms, head and hands positions to minimize the size of the observed separated areas. Indeed, underwater swimmers have to adopt a streamlined shape, as flat as possible, to prevent the boundary layer from separating. Improper position of the swimmer may cause an increase in the size of separation areas inducing an increase of energy losses due to the recirculation of the fluid. Consequently this leads to an increase of the drag characterized by a degradation of performance. Experiments in-situ have indicated that the tufts method is an efficient tool to investigate the way the performance of high level swimmers can be enhanced.

(a) lateral view

(b) ventral view

Fig. 2. Flow around a female swimmer in underwater phase of start.

References

Fujisawa, N. et al., Journal of Visualization, 10-2 (2007), 163-170.
Hay, J. G., Thayer, A. M., Journal of Biomechanics, 22 (1989), 11-17.
Tagori, T., Album of flow visualization, 1 (1984), 28-29.
Tagori, T., Album of flow visualization, 2 (1985), 36-39.
Toussaint, H. M. et al., Medicine and Science in Sports and Exercise, 34 (2002), 314-319.
Yang, C. J. and Lee, Y. H., Journal of Visualization, 9-1 (2006), 13-22.
Zaïdi, H. et al., Acta of Bioengineering and Biomechanics, 9 (2007), 47-51.