界面活性剤による抵抗低減水路流の空間的構造に 及ぼすレイノルズ数の影響

Reynolds number effect on spatial structure of drag-reducing channel flow
by surfactant additives

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The structure of turbulence in a drag-reducing surfactant solution channel flow has been studied with a particle image velocimetry. Fig. 1a shows the experimental setup. The present experiments are carried out in a closed-circuit water channel. The channel is made of transparent acrylic resin and has length of 10 m, height (H) of 0.04 m and width of 0.5 m. The PIV measurement position is located at 7 m (175H) downstream of

Fig. 1a Optical configurations for PIV measurements,
(a) in the x - y plane; (b) in the x - z plane.

channel entrance. A 25 ppm aqueous solution (at 30°C) of a cationic surfactant, cetyltrimethylammonium chloride (CTAC) with chemical formula of $C_{16}H_{33}N(CH_3)_3Cl$, is used as the drag-reducing working fluid. The sodium salicylate (NaSal) is added to the solution with the same weight concentration as that of CTAC for providing counterions. Local tap water is used as the solvent. Measurements were performed for water and surfactant solution flow at three regions with different drag-reducing features: regions 2, 3 and 4 with respect to the Reynolds number

as indicated in Fig. 2a, in the x - y and x - z planes for each run. The experimental conditions are shown in Table 1.

Fig. 2a Frictional factor and drag-reduction versus
Reynolds number (25 ppm CTAC, at 30°C)

Table 1 Flow parameters

Cases		Re	U_0 (m/s)	u_r (m/s)	DR (%)	location of x - z plane (y^+)
Water	W1	5444	0.110	0.00715	-	8.9
	W2	15950	0.321	0.0183	-	22.7
	W3	20102	0.405	0.0224	-	27.8
	W4	24878	0.501	0.0270	-	33.5
	W5	36256	0.731	0.0376	-	46.6
CTAC	C1	6509	0.131	0.00581	49	7.2
	C2	14322	0.289	0.0105	60	13.0
	C3	18175	0.366	0.0153	43	19.0
	C4	25776	0.519	0.0264	12	32.7
	C5	33171	0.668	0.0353	0	43.7

It has been observed that the drag-reducing flows at regions 2 and 3 showed different characteristics, even though the DR levels were similar. The intensity of the wall-normal velocity fluctuations was decreased at both regions, but that of the streamwise velocity fluctuations, normalized with bulk velocity, was decreased at region 2 whereas increased at region 3 near the wall. The Reynolds shear stress was depressed more greatly at region 2. At region 4, the surfactant solution flow did not display characteristic features as in a Newtonian fluid flow.