EFFECT OF POLYACRYLAMIDE ADDITIVE ON THE REDUCTION OF HYDRAULIC LOSSES IN WATER STREAMS WITH SUSPENDED SOLID PARTICLES

I. L. Povkh and A. B. Stupin

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Results are shown of an experimental study concerning the reduction of hydraulic losses in streams with suspended solid particles.

Experimental studies made by various authors have shown that the addition of small quantities of soluble polymers appreciably reduces the hydraulic drag (a survey of some of these studies is given in [1]). It appears that the hydraulic drag decreases at low concentrations of polymer material. This phenomenon, therefore, is of considerable scientific interest. A reduction of hydraulic drag is, of course, interesting also from the technical standpoint, especially in hydraulic transport.

The purpose of this study was to analyze the effect of polyacrylamide additive on the reduction of hydraulic drag in streams with suspended solid particles.

The tests were performed with nonhydrolyzed 8% polyacrylamide as the macromolecular additive. Aqueous solutions of this polymer in various concentrations were prepared by means of a mechanical mixer. Quartz sand, ash, clay, brown coal, and hard coal served as the solid phase. The tests were performed in smooth-walled glass tubes of various diameters. The effective (technical) reduction of hydraulic drag was calculated from test data according to the formula:

$$\frac{\Delta\lambda}{\lambda}=\frac{\lambda_1-\lambda_2}{\lambda_1}\ 100\%.$$

The reduction of hydraulic drag as a function of polyacrylamide concentration is shown in Fig. 1 for various concentrations of the solid component. The tests were performed in a tube with a 7 mm diameter and at a Reynolds number Re = 12,300. The solid phase was quartz sand with particles 0-1.2 mm in size. The concentration of polyacrylamide C_p was varied from 0 to 10^{-3} g/cm^3, the concentration of sand C_s was varied from 0 to 37.5%.

The diagram indicates that, when an aqueous solution of polyacrylamide in small concentrations flows without a solid component ($C_s = 0$), the reduction of hydraulic drag increases to a maximum $\Delta\lambda/\lambda = 58\%$ at some optimum concentration ($C_p = 2.4\cdot10^{-4}$ g/cm^3). As more polyacrylamide is added, the reduction of hydraulic drag becomes less again.

The addition of a solid component (sand) to an aqueous solution of polyacrylamide suppresses the reduction of hydraulic drag over the entire range of polyacrylamide concentrations. Moreover, the maximum reduction of hydraulic drag (within the test range of solid particles concentration) occurs at the same polyacrylamide concentration ($C_p = 2.4\cdot10^{-4}$ g/cm^3). As more sand is added, the hydraulic drag is reduced less. It will be noted that the reduction of hydraulic drag as a function of polyacrylamide concentration (for the entire range of solid particles concentration) follows qualitatively the same trend as in an aqueous solution of polyacrylamide without sand ($C_s = 0$).

The test data obtained with ash as the solid component have been evaluated on a GRES and are shown in Fig. 2. The size of ash particles, density 1.3 g/cm^3, was varied from 0 to 2.5 mm. It is evident here

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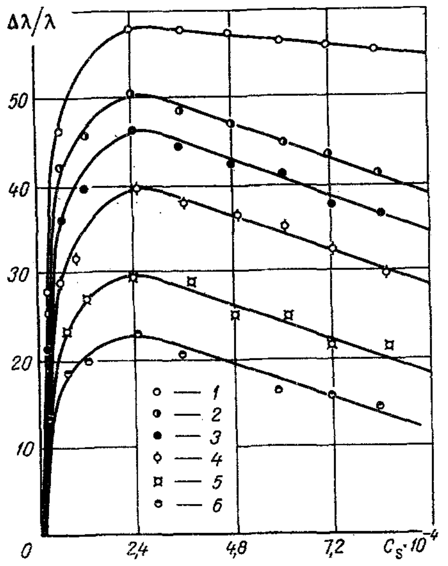

Fig. 1

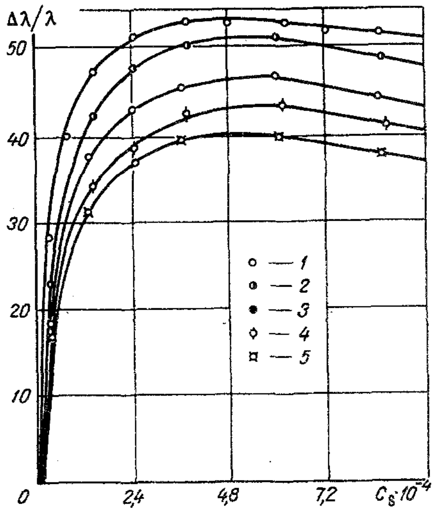

Fig. 2

Fig. 1. Reduction of hydraulic drag as a function of the polyacrylamide concentration, at various concentrations of quartz sand: 1) C_s (wt.) = 0; 2) 7.5%; 3) 15%; 4) 22.5%; 5) 30%; 6) 37.5%.

Fig. 2. Reduction of hydraulic drag as a function of the polyacrylamide concentration, at various concentrations of ash: 1) C_s (wt.) = 0; 2) 7.5%; 3) 15%; 4) 22.5%; 5) 30%.

that, as polyacrylamide is added, the reduction of hydraulic drag increases to a maximum at $C_p = 5 \cdot 10^{-4}$ g/cm^3 (for the entire range of solid particles concentration). Moreover, the maximum reduction of hydraulic drag is greater here than at corresponding concentrations of sand. This has to do with the different densities of ash and sand, as a result of which less energy is wasted on suspending ash particles in a turbulent stream.

No reduction of hydraulic drag was observed in the tests performed with brown and hard coal. This is, apparently, because polyacrylamide molecules coagulate with coal particles and the damping effect on hydraulic drag is lost. Negative results were also obtained in the tests with brown clay. As polyacrylamide is added to the aqueous suspension of clay, floccular structures are formed which precipitate from the solution.

On the basis of these tests with coal and clay, of course, no conclusion can yet be drawn as to the impossibility of reducing the hydraulic drag in suspensions of these materials. One may expect some other polymer additive to eventually reduce the hydraulic drag in this case.

Thus, our experimental study has shown that the addition of polyacrylamide to a turbulent stream with solid particles (sand, ash) does reduce the hydraulic losses. It is to be hoped that the use of macromolecular additives will greatly improve the efficiency of hydrotransporting loose material.

NOTATION

λ_1 is the friction coefficient in a water stream with a certain concentration of solid particles;
λ_2 is the friction coefficient with polyacrylamide added to the water stream with the same concentration of solid particles;
Re is the Reynolds number;
d is the tube diameter;
C_p is the concentration of polyacrylamide;
C_s is the concentration of solid particles.

LITERATURE CITED

1. G. I. Barenblatt, V. A. Gorodtsov, and V. N. Kalashnikov, in: Heat and Mass Transfer [in Russian], Izd. Tekhnika i Nauka, Minsk, Vol. 3 (1968).