ZESZYTY NAUKOWE POLITECHNIKI ŚLĄSKIEJ 1979

Seria: ENERGETYKA z. 71 Nr kol. 599

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RHEOLOGY INVESTIGATIONS OF FUEL MIXTURE OF GAS PRODUCER TAR WITH HUMID COAL DUST

Summary. By means of measurements it was shown, that the investigated mixture (suspension) of the gas producer tar (79%), coal dust (14,7%) and water (6,3%) behaves like a pseudoplastic liquid. The influence of temperature on the dynamic coefficient of mixture viscosity was determined (Fig. 6).

The importance of various waste heavy (non-volatile) liquid hydrocarbon fuels, residual pulverized coal of high humidity, muds, etc., increases very much in present fuel situation. Utilization of these substances as fuels for combustion in various industrial arrangements is very desirable because of possible extension of the fuel resources. When utilizing these resources there arises the essential problem depending on the way of economical transportation of considered fuels to the combustion arrangements. Very often the waste fuel liquid and combustible dust are at disposal simultaneously and in this case the good transportation way depends on application of the pipeline for solid-liquid mixture flow. Considering such a flow problem and also considering the process of correct atomization in combustion chambers, one needs to know the rheology properties of given solid-liquid mixture. These properties were investigated already many years ago [1], but recently the interest in combustible solid-liquid mixtures is arousing again.

The present paper presents the investigations of the solid-liquid mixture viscosity in particular case when the liquid is a tar condensed from a producer gas and the solid substance is a dust seperated in dedusting process of this gas. In the dedusting arrangements the dust is moistened. In considered case one obtains for combustion process the mixture whose composition is determined by gram fractions as follow: tar 79%, dust 14,7% and water 6,3%. The gas producer is fed with a long flame coal. The chemical composition given by gram fractions of the tar and dust as well as the calorific value of these substances are presented in Table 1. The result of sieve analysis of dried dust is presented in Figure 1, denoting by z the gram fraction of particles of diameter s within the given diameter range. The density ρ of tar and mixture versus the temperature T presents Figure 2.

Table 1

Chemical composition of tar and dust

Medium	C	H	O	N	S	Ash	Calorific value MJ/kg
Tar	84,22	7,24	6,27	1,49	0,45	0,33	34,3
Dust	74,44	5,16	5,09	1,26	3,45	10,60	27,7

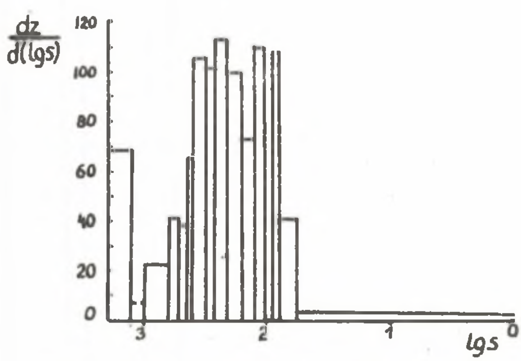

Fig. 1. The granulation of dust

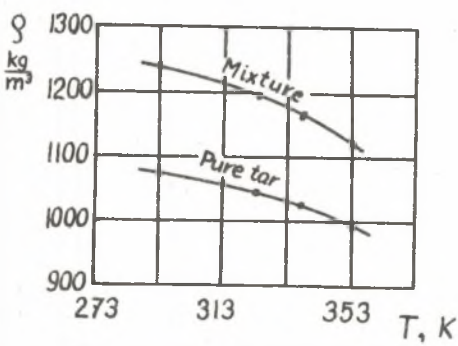

Fig. 2. The density of mixture and pure tar

The investigations were carried out by means of a standard type of viscosimeter Rheotest 2 [2]. The liquid being investigated fulfils the space between two concentric cylinders. The outer cylinder is motionless and the inner one rotates with a properly controlled speed and there is possible to adjust the determined constant velocity gradient $\frac{\partial w}{\partial y}$ in a laminar layer of investigated liquid. If the shear stress τ is at the same time measured, the value of dynamic coefficient η of viscosity can be calculated from the well known equation

$$\tau = \eta \frac{\partial w}{\partial y} \qquad (1)$$

The function

$$\tau = \tau \left(\frac{\partial w}{\partial y}\right) \qquad (2)$$

determined by the measurement data can be of various character (Fig. 3) and be showing, which kind of liquid is that being investigated [3]. The slope of the curves in Figures 3 determines the value of η.

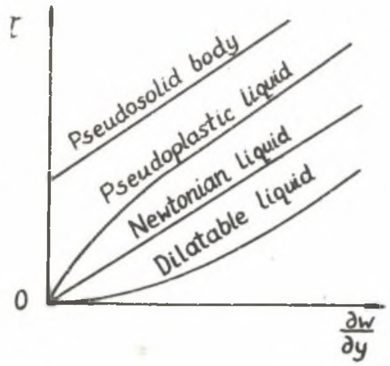

Fig. 3. The flow curves of non-newtonian fluids in comparison with flow curves of newtonian fluid

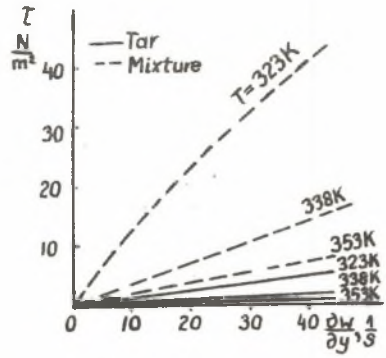

Fig. 4. The effect of velocity gradient (shear rate) on shear stress

For three different values of temperature the relation (2) for tested mixture is presented in Figure 4, which for comparison shows also the proper data for pure tar. The data in Figure 4 does not show diatinctly the character of the curve corresponding to mixture. In such a case one examines the values of k and n appearing in the relation

$$\tau = k\left(\frac{\partial w}{\partial y}\right)^n \qquad (3)$$

which after taking logarythms assumes the form

$$\ln\tau = \ln k + n\ln\frac{\partial w}{\partial y} \qquad (4)$$

Figure 5 presents the measurement data which substituted by properly averaged straight lines are the diagrams of function (4). Hence result the values of k and n (Table 2), which give evidence that the tar is a newtonian liquid (n = 1), and the mixture of tar and dust is a pseudoplastic liquid ($n < 1$).

Table 2

Values of k and n for tar and mixture

Medium	Factor	Temperature K		
		323	338	353
Mixture	k	1,32	0,51	0,301
	n	0,95	0,92	0,87
Tar	k	0,127	0,0424	0,0187
	n	1	1	1

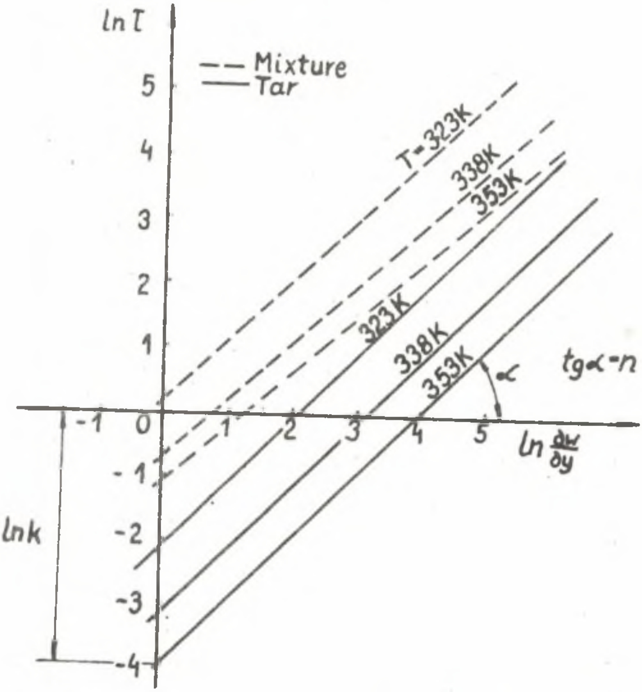

Fig. 5. The determination of values of k and n from the diagram

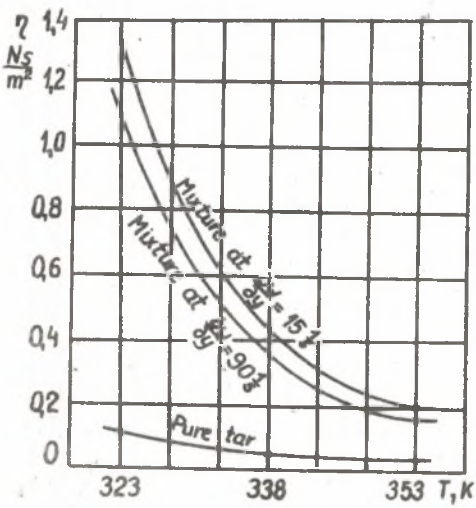

Fig. 6. The effect of temperature on dynamic coefficient of viscosity

As a function of temperature, Figure 6 presents the dynamic coefficient of mixture viscosity at two different values of velocity gradient and for comparison presents also the same coefficient of pure tar.

The velocity gradient value 90 1/s corresponds by its order to the values which one meets when considering the problems of mixing, atomizing etc. The value of 15 1/s corresponds to a liquid in a rather slow motion e.g. at transportation by pipeline.

One can conclude, that the introduction of dust into a tar makes a considerable increase in a viscosity of created mixture. The higher mixture temperature, the smaller influence of temperature increase on the decreasing of mixture viscosity.

For practical purposes there arises the need of continuation of investigation in order to determine the quantitative influence of the dust fraction and grain size distribution in mixture on the rheology mixture properties. Also appears the need of theoretical explanation of some experimental relations for an entire understanding of the problems.

The authors kindly thank to Dr L. Michalik for making available the apparatus and for the valuable advices.

LITERATURE

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BADANIA REOLOGICZNE PALIWOWEJ MIESZANINY SMOŁY CZADNICOWEJ Z WILGOTNYM PYŁEM WĘGLOWYM

S t r e s z c z e n i e

Za pomocą pomiarów wykazano, że badana mieszanina smoły (79%), pyłu (14,7%) i wody (6,3%) zachowuje się jak ciecz pseudoplastyczna oraz określono wpływ temperatury na wartość dynamicznego współczynnika lepkości tej mieszaniny (rys. 6).

РЕОЛОГИЧЕСКИЕ ИССЛЕДОВАНИЯ ТОПЛИВНОЙ СМЕСИ ГАЗОГЕНЕРАТОРНОЙ СМОЛЫ С ВЛАЖНОЙ УГОЛЬНОЙ ПЫЛЬЮ

Р е з ю м е

На основании измерений доказано, что смесь смолы (79%), угольной пыли (14,7%) и воды (6,3%) ведёт себя как псевдопластичное жидкое тело, а также определено влияние температуры на величину динамического коэффициента вязкости этой смеси.