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METHOD AND INDIRECT MEASUREMENT DEVICE OF DYNAMIC VISCOSITY OF NON-NEWTON, REOPEXICS LIQUIDS AND GRANULAR SUSPENSIONS

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ABSTRACT
This paper has presented a method and indirect measurement device of dynamic viscosity of non-Newton or reopexics liquids and granular suspensions as additives oils, etc. This methods had at base of Cuette's relation from circular flow of liquids and is used a rotative disk within a cylinder fixed of dynamic strain gage captor. The method is supposed determination of Cuette's moment for etalon liquid with known dynamic viscosity and moment dynamic viscosity for measured. For determination of proportionality coefficient of measured moments equal with dynamic viscosity ratio is easy determined of dynamic viscosity of non-Newton measured liquid.
Keywords: additives, granular suspensions, reopexics liquids.

1. INTRODUCTION
In flow are usually met the cases in which has used tribology systems, additive liquid lubrications with solid lubrications of E.P. with natural antifriction proprieties [4-6]. The solid additives have got in oils, under micro-powders form, formed Newton's granular suspensions with unlimited flow laws of Bingham type [6,11]. In specialty papers [11] have mentioned only the flow law of these suspensions, without determination of reo-slope curves of dynamic viscosity and tangential friction stresses.
For determination of some Newton liquids parameters, such as friction coefficients and dynamic viscosity it's well known the Cuette's viscosimeter [11]. With this installation is measure the friction movement necessary revolution of external concentric cylinder around solid fixed nucleus, within cylinder is getting the test liquid. The disadvantage of method consists in bearish and complex rotative cylinder construction, which assuring a quality assembly of mechanic-electric captors resistive type [1].
This paper has presented a simple and efficient method of viscosity-η determination of granular suspensions and reopexics liquids viscosity with rotated disc, known from hydrodynamic [11] and a captor of friction movement taken over at specific parameters of drilling process [1].

2. METHOD OF ROTATED DISC. THEORETICAL FUNDAMENTALS
The proposal method for determination of flow character of additive oils E.P. and of reopexics liquids has based on withstand of bodies advance from hydrodynamic [11], which are used the friction of rotated disc in a liquid, presented in Fig.1.
The rotated disc with diameter-d is revolution with angular speed-ω in a liquid, formed a layer of them particles adheres at free surface of disc.
The friction forces-F_r, which appearance on both disc surfaces due to a moment-M that is withstand the moving [11]:

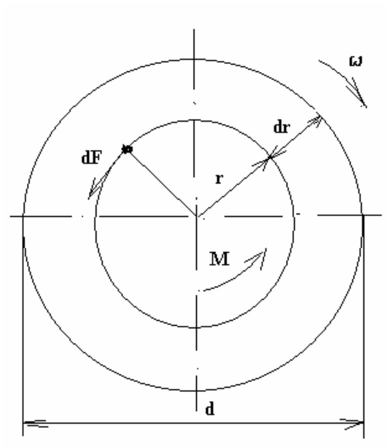

Figure 1. Friction of rotated disc.

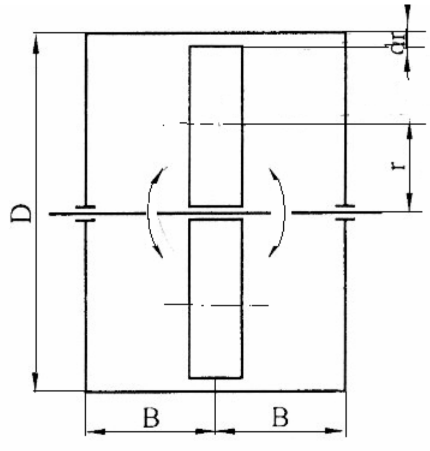

Figure 2. Revolution disc in frame.

$$M = 2\int_0^{2\pi}\int_0^{r} r dF = 2\int_0^{2\pi}\int_0^{d/2} r C_F \frac{\rho w \omega^2}{2} dA = \int_0^{\pi/2} r C_F \cdot \rho w \omega^2 r^2 2\pi r dr = \frac{4\pi C_F}{5}\left(\frac{\rho\omega^2}{2}\right)\left(\frac{d}{2}\right)^5 = C_M \frac{\rho\omega^2}{2}\left(\frac{d}{2}\right)^5 \quad (1)$$

Where: ρ-is liquid density, C_F-friction coefficient, C_M-moment coefficient in function of Reynolds number-R_C.

$$R_C = \frac{\omega d^2}{2\nu} \quad (2)$$

Where: ν-is cinematic viscosity of fluid (ν=η/ρ). For granular suspensions (additive oils with solid lubrications as MoS_2, PTFE, colloidal graphite) and reopexics liquids (gyps paste), dynamic viscosity-η it's doesn't known, which it's looking for. The problem has done by similitude, considering the revolution disc inside of closed cylindrical frame, in which is getting the test liquid. This revolution disc inside of frame, the medium being oil additive of E.P. or gyps paste (sprocket) has presented in Fig.2. About the disc is acting a friction moment:

$$M_F = f(R, \omega, \rho, \eta) \quad (3)$$

The disc engaged in moving adherent oil layer, which transmitting the moving by viscosity forces to other layers. In conjecture of drawing moving, the speed has a linear variation from the value of u = ωr on disc to 0 on frame. The tangential unitary stress at radius-r is getting by Newton Law:

$$\tau(r) = \eta\frac{u}{B} = \eta\frac{\omega r}{B} \quad (4)$$

The primitive force corresponding of primitive area-dA = 2πrdr, is for these two active faces:

$$dF = 2\tau(r) 2\pi r dr = 4\pi\eta\frac{\omega}{B} r^2 dr \quad (5)$$

The primitive moment corresponding forces-dF from both faces of disc is:

$$dM = r dF = 4\pi\eta\frac{\omega}{B} r^2 dr \quad (6)$$

By integration has obtained the moment-M_F:

$$M_F = 4\pi\eta \frac{\omega}{B}\int_0^{D/2} r^3 dr = \frac{\pi\eta\omega R_c^4}{16B} \tag{7}$$

The relation (7) includes Reynolds number and angular speed-ω:

$$\omega = \frac{\pi n}{30} \tag{8}$$

For the values n, R_c and B knowing is measured total moment, determined the dynamic viscosity-η from relation:

$$\eta = \frac{16 M_F B}{\pi\omega R_c^4} \tag{9}$$

By knowing the value of η its can be determined the tangential friction stress at granular suspensions after Bingham Law:

$$k(\tau - \tau_c) = \eta \frac{\omega R_c}{B} \tag{10}$$

, and for reopexics liquids after a law deduction from Bingham Law by form:

$$k(\tau + \tau_c) = \eta \frac{\omega R_c}{B} \tag{11}$$

, where: k-is fluidity factor, τ_c-tangential flow stress of solid particles from granular suspensions and reopexics liquids.

3. METHOD OF DYNAMIC VISCOSITY MEASUREMNT BY ROTATED DISC

The propose method for dynamic viscosity measurement has based on determination of friction moment at revolution disc located within of closed cylinder by strain gage dynamometer captor fixed on a main plate of drilling machine (Fig.3).

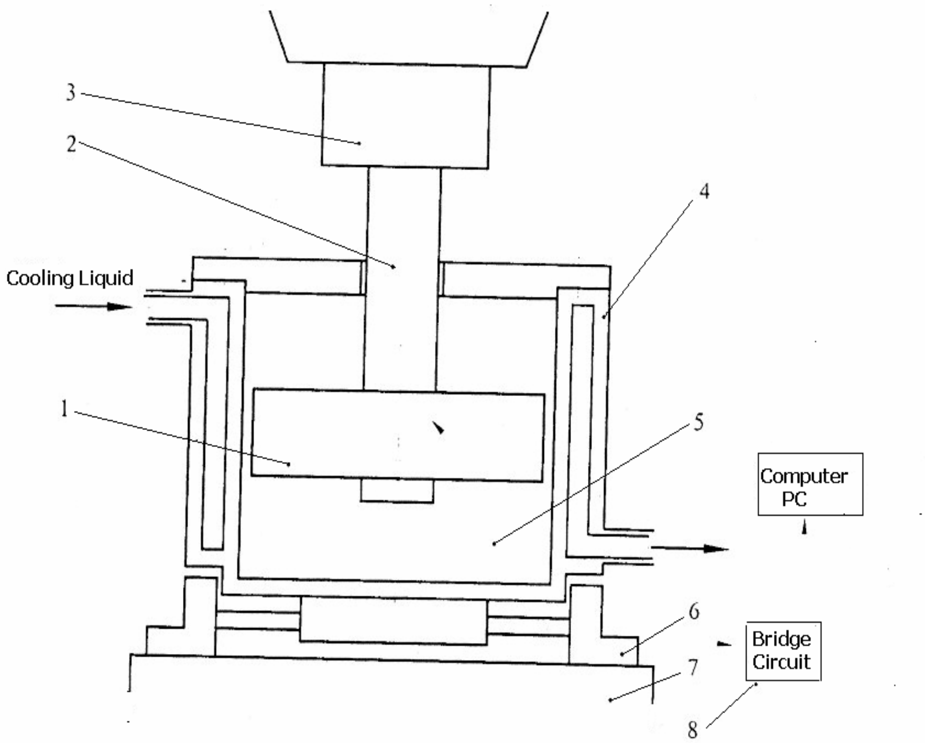

Figure 3. Measurement of dynamic viscosity $\eta = f(M_F)$.

Where: 1-is rotated disc, 2-fixed tap, 3-spindle sleeve, 4-cylinder, 5-test liquid, 6-strain gage dynamometric captor, 7-main plate, 8-bridge circuit.
The rotated disc-1 is fixed on tap-2 with Morse con in a main spindle of drilling machine. The granular suspension is getting in cylindrical recipient-4 with double walls cooling with water. The friction moment-M_F has determined from condition:

$$M_F c_f = M_t \tag{12}$$

, where: M_t is torsion moment get by circuit bridge of dynamometric captor-6, and c_f-correction coefficient, function of quality surfaces of rotated disc and inner surface of cylinder.
For measurement of dynamic viscosity of a granular suspension or a reopexics liquid, has determined in first phase for an etalon liquid with dynamic viscosity knowing-η_e, the friction moment-M_{fe} used at calibration of bridge circuit. The dynamic viscosity-η of test liquid has determined after the relation:

$$\eta = \eta_e \frac{M_F}{M_{fe}} \tag{13}$$

The research mode has presumed using and an electronic assembly for recorded in real time of test liquids temperature and for spindle speeds of rotated disc, connected at PC. The test data processing has done with MATLAB Program. The method is now in experimental phase, following with research for determination of dynamic viscosity for motor oils and additive transmissions with solid lubrications under micro-powder of MoS_2, PTFE and graphite.

4. CONCUSIONS

The method of dynamic viscosity measurement at flowing of granular suspensions and reopexics liquids has presented in this paper with rotated disc and dynamometer captor is simple and easy to realize has the some advantages as:

- allowing the measurements in real working conditions of flow process;
- assured high precision of measurement by electronic gage;
- allowing the measurement of phenomena fast;
- has a practical using.

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