IOP Conference Series: Earth and Environmental Science

Study on the determination of the parameters of the electric purifier

To cite this article: A S Berdyshev *et al* 2021 *IOP Conf. Ser.: Earth Environ. Sci.* **939** 012023

Study on the determination of the parameters of the electric purifier

A S Berdyshev[1*], Z Z Djumabayeva[1], A A Abdullaev[1], and A Mussabekov[2]

[1]Department of Electrotechnologies and Operation of Electrical Equipment, Tashkent Institute of Irrigation and Agricultural Mechanization Engineers, 100000 Tashkent, Uzbekistan
[2]Faculty of Natural Sciences, NJSC South Kazakhstan state pedagogical university, 160012 Shymkent, Kazakhstan

Email: berdyshev66@mail.bk

Abstract. The article is devoted to the determination of the parameters on which the filter performance depends on the hydrodynamic, electromagnetic and geometrical parameters of the fluid and pollution. These include fluid viscosity and flow rate, magnetizing force, particle size of contamination, gap height, and the distance between the turns.

1. Introduction

When designing the electromagnetic part of the filter [1], it is important to determine the optimal values of the magnetizing force, at which high speed can be obtained with minimal energy loss. It should be noted that the heating of the winding in this case has positive phenomenon. As the temperature increase, the viscosity of the liquid decreases, which leads to the decrease in the Stokes drag force that slows down the cleaning process [2]. The efficiency of the filter depends on the hydrodynamic, electromagnetic, and geometric parameters of the liquid and the contaminants [3-9], like the viscosity of the liquid and its flow rate, the magnetizing force, the particle size of the contamination, the gap height, and the distance between the coils.

2. Methods and Results

If the particle is in the close vicinity of the wall, where the tension increases by 103 times, not only the transverse component of the ponderomotive force increases sharply, but also the longitudinal one. Therefore, due to a significant increase in this force, the particle begins to move faster, which is confirmed by the calculated dependence shown in Figure 1.

The analysis of the calculated graph showed that the coil-to-coil distance of 1 mm with the accepted parameters, the particle inside the purifier passes in 0.0026 s. Therefore, there cannot be the switching speed limitation of the cleaner windings in electrical circuits, since the main parameter in the calculations will be the flow rate of the liquid.

Figure 2 shows the time variation of the longitudinal component of the ponderomotive force. As expected, it first increases as the particle approaches the side wall, reaches its maximum on the surface, and then begins to decrease.

This happens because with a constant transverse coordinate ρ, the longitudinal coordinate z continues to increase, which leads to a decrease in the longitudinal component of the ponderomotive force.

The longitudinal component of the ponderomotive force is inversely proportional to z and $(R^2 - \rho^2)^2$. Theoretically, we determined that at the beginning of the cleaning process, the coordinate ρ first increases as it approaches the side wall, and then, when the particle is attracted to it, remains unchanged. The longitudinal coordinate z continues to increase all the time. First, before the particle reaches the side wall, the longitudinal component of the ponderomotive force is influenced by an increase in ρ, and this force increases. The further cleaning process takes place at a constant coordinate ρ and increasing z. Therefore, there is the decrease in the value of the ponderomotive force. This can be seen in Figure 3.

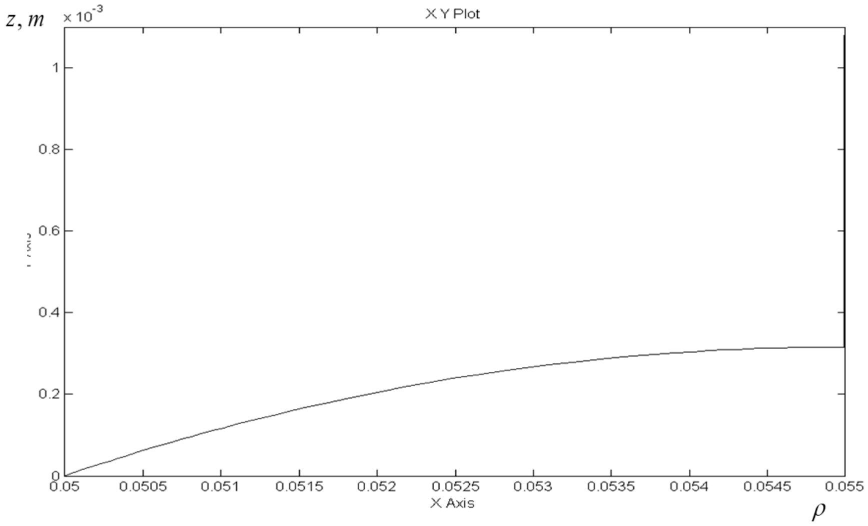

Figure 1. Dependence of the change in the longitudinal z coordinate of a particle on the transverse component ρ

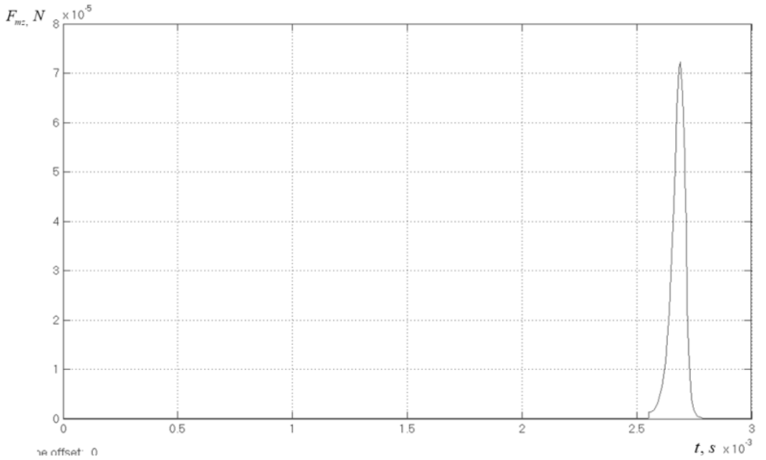

Figure 2. Time dependence of the longitudinal component of the ponderomotive force

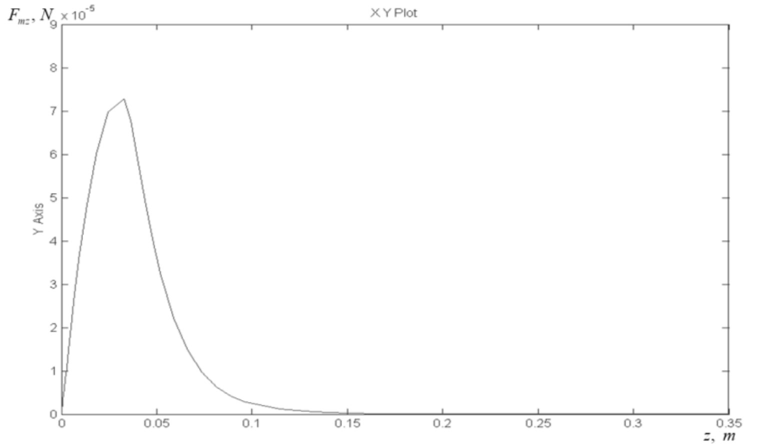

Fig. 3. Dependence of the longitudinal component of the ponderomotive force on the *z* coordinate

The presence of the extremum of the longitudinal component of the ponderomotive force determines its expression, which was obtained earlier.

The nature of the change in the longitudinal component of the Stokes force [4] can be explained as follows.

At first, before the particle reaches the side wall, the magnitude of the ponderomotive force increases insignificantly; therefore, the speed of movement of the pollution particle under the action of this force also does not increase very quickly. When the particle reaches the lateral surface and begins to move along it, the ponderomotive force acting on it, and, accordingly, the particle velocity increase sharply. Further movement is accompanied by a decrease in the strength of the magnetic field, and hence the speed of the particle, therefore, the force of resistance to the movement of this particle also decreases.

Tables 1-6 show the dependence of the time of attraction of the particle to the outer wall t_ρ and its movement from one coil to another t_z on the above parameters (the results are obtained for the following parameters: the radius of the particle is 10×10^{-6} m, the viscosity of the liquid (water) is 0.001 $kg/m\cdot s$, the flow rate is 5 l/min, the height of the gap is 4×10^{-3}m, the distance between the coils is 1×10^{-2}m, the radius of the inner pipe is 5×10^{-2}m.

The analysis of the data from Tables 1-2 showed that the increase in the current strength and particle diameter leads to the increase in the speed of the purifier (Figures 4 and 5), which is explained by the increase in the ponderomotive force, which depends on the square of the current and on the cube of the radius. The Stokes resistance force also increases with increasing particle size, but only to the first degree, so this factor has not decisive importance when analyzing the operation of the purifier.

Table 1. Dependence of the speed of the cleaner on the magnetizing force

I, A	2.5	5	7.5	10	15	20
t_z, s	0.025	0.006	0.0024	0.0015	0.00067	0.00035
t_ρ, s	0.0029	0.00075	0.00035	0.0002	0.00009	0.000054

Table 2. Dependence of the speed of the purifier on the particle diameter

$r,\times10^{-6},m$	10	15	20	25	30	40	45	50
$t_z\times10^{-3}, s$	1.5	0.7	0.4	0.25	0.15	0.1	0.074	0.06
$t_\rho\times10^{-3}, s$	0.2	0.088	0.05	0.033	0.023	0.013	0.01	0.009

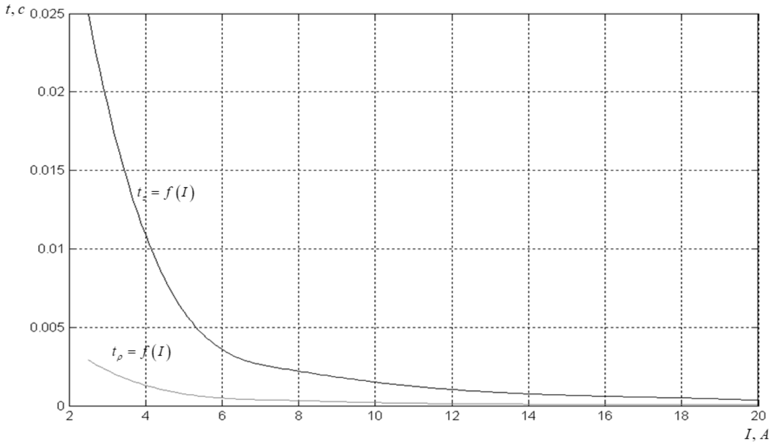

Figure 4. Dependence of the time of reaching the side wall and the transition from one coil to another of the particle on the magnitude of the current

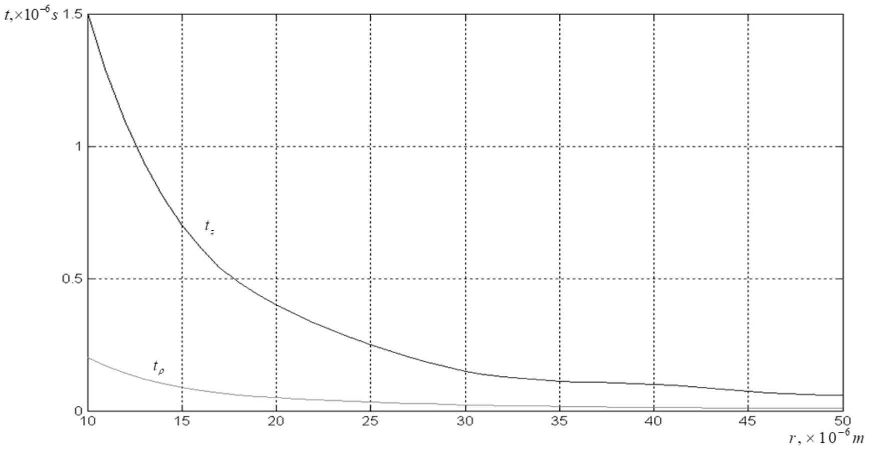

Figure 5. Dependence of the time to reach the side wall and the transition from one coil to another on the radius of the pollution particle

The dependence (Figure 6) showed that the speed of the purifier depends almost linearly on the temperature of the liquid [5]. This can be explained by the linear dependence of the Stokes force on the viscosity of the liquid. The calculations showed that at the amperage of 10 A, the particle covers the distance of 1 cm in 3 seconds during water treatment, which clearly cannot meet the technological requirements for purifiers that are used for water treatment.

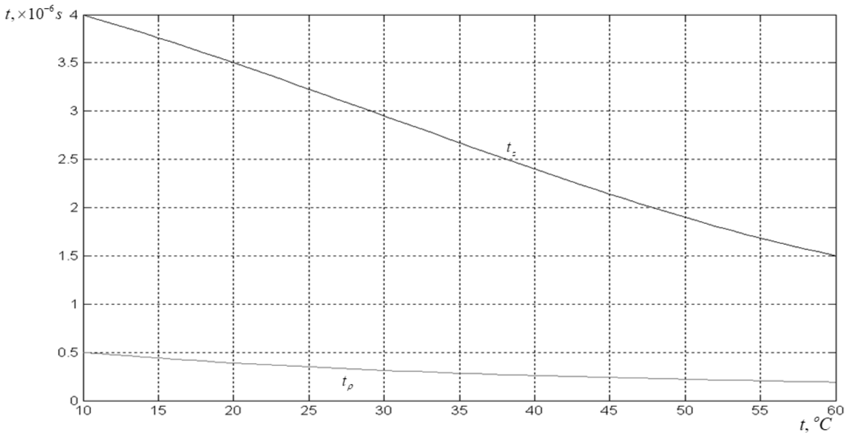

Figure 6. Dependence of the time of reaching the side wall and the transition from one coil to another by the particle on the water temperature

Tables 3 to 8 show the calculated dependences of the response speed on the hydrodynamic parameters of the liquid - its temperature, i.e. viscosity (in the case of water and oil) and flow rate (Figure 6). As expected, the increase in viscosity with decreasing temperature, which increases the Stokes drag force, lowers the particle velocity, and the significant increase in viscosity on going from water to oil (by about two orders of magnitude) necessitates the significant increase in the magnetizing force.

Table 3. Dependence of the speed of the purifier on the water temperature

$t, {}^oC$	10	20	40	60
$t_z \times 10^{-3}, c$	4	3.5	2.4	1.5
$t_p \times 10^{-3}, c$	0.5	0.39	0.26	0.19

Table 4. Dependence of the speed of the purifier on the water temperature

$t, {}^oC$	10	20	40	60
$t_z \times 10^{-3}, c$	4	3.5	2.4	1.5
$t_\upsilon \times 10^{-3}, c$	0.5	0.39	0.26	0.19

The dependence (Figure 6) showed that the speed of the purifier depends almost linearly on the temperature of the liquid. This can be explained by the linear dependence of the Stokes force on the viscosity of the liquid.

According to the calculated data from Tables 4 and 5, it can be concluded that it is advisable to use the purifier with the traveling magnetic field for water treatment and other low-viscosity liquids (emulsions, etc.). This limitation is due to the fact that viscous liquids require large values of the magnetizing force, for the creation of which it is necessary to use a copper bus with a cross section of about 300 mm^2 for the practical implementation of the electromagnetic filter system.

When using for the purification of viscous liquids, purifiers with the complex configuration of the magnetic field, as shown by the calculations, this problem does not exist.

Table 5. Dependence of the speed of the cleaner on the oil temperature at a magnetizing force of 700 A

$t, {}^oC$	20	40	60
$t_z \times 10^{-3}, s$	75	6.2	1.7
$t_\rho \times 10^{-3}, s$	2.8	0.69	0.2

Table 6. Dependence of the speed of the purifier on the liquid consumption

$q, 1/\min$	0	5	10	15	20
$t_z \times 10^{-3}, c$	3.3	3.4	4	5	9
$t_\rho \times 10^{-3}, c$			0.39		

The analysis of the data obtained in Table 6 showed that the time for the particle to reach the wall does not depend on the flow rate of the liquid, as follows from our mathematical model - with a laminar flow of liquid, the transverse component of the liquid velocity is zero. Tables 7 and 8 show the dependence of the speed on the geometric parameters of the filter - the distance between the coils and the height of the gap.

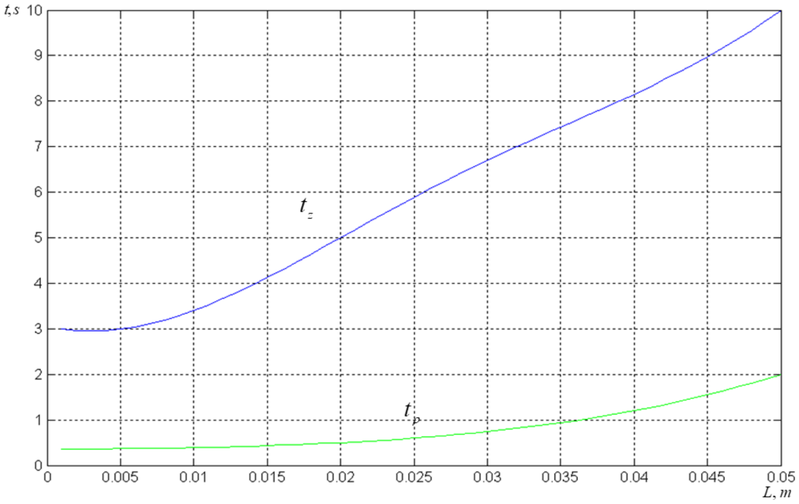

Figure 7. Dependence of the time of reaching the side wall and the transition from one coil to another by the particle on the distance between the coils

Table 7. Dependence of the speed of the purifier on the distance between the coils

$z_{нач}$, m	0.001	0.01	0.02	0.03	0.04	0.05
$t_z \times 10^{-3}$, s	3	3.4	5	7	8	10
$t_\rho \times 10^{-3}$, s	0.36	0.39	0.5	0.74	1.2	2

Table 8. Dependence of the speed of the purifier on the height of the gap

h, m	0.002	0.003	0.004
$t_z \times 10^{-3}$, s	2.5	6	9
$t_\rho \times 10^{-3}$, s	3.52	3.62	8.4

3. Conclusion

According to the study, the dependences showed that the longitudinal component of the particle movement during cleaning depends more on the geometric parameters of the filter than the transverse one (Figure 7). This once again confirmed the correctness of the theoretical studies.

References

1. Berdishev A, Taslimov A, Meliqo'ziyev B, Bijanov A 2020 Reliability indicators of 10 kV cable lines in rural areas *IOP conference Series: Materials Science and Engineering* **869** 022005.
2. Chen L, Bonaccurso E 2014 Effects of surface wettability and liquid viscosity on the dynamic wetting of individual drops *Physical Review E* **90**(2) 022401.
3. Abbasov T 2007 Magnetic filtration with magnetized granular beds: Basic principles and filter performance *China Particuology* **5**(1-2) 71-83.
4. Berdishev A, Eshpulatov N, Matchonov O, Yusupov Sh 2020 Methodology for conducting an optimization experiment for harvesting dry short-stalked grain crops *IOP Conf. Ser.: Earth Environ. Sci*. **614** 012118.
5. Berdishev A, Djumaboyeva Z 2020 Evaluation of the effectiveness of electromagnetic treatment of well water *E3S Web of Conferences* **209** 07016.
6. Taslimov AD, Berdishev AS, Rakhimov FM, Yuldashev AA 2020 Economic load intervals for selecting 10 kv cable cross-sections for agricultural consumers *IOP Conf. Series: Materials Science and Engineering* **883** 012102.
7. Rakhmonov I, Berdishev A, Niyozov N, Muratov A, Khaliknazarov U 2020 Development of a scheme for generating the predicted value of specific electricity consumption *IOP Conf. Series: Materials Science and Engineering* **883** 012102.
8. Taslimov AD, Berdishev AS, Rakhimov FM, Yuldashev AA 2020 Optimal tendency of selecting cable cross-sections for agricultural electrical networks *Journal of Physics: Conference Series* **1515** 022050.
9. Bayzakova JS, Abdildin NK, Shynybay ZhS, Chingenzhinova ZhS, Berdishev AS, Eshpulatov NM, Matchonov OQ, Yusupov ShB 2020 Methodology for conducting an optimization experiment for harvesting dry short-stalked grain crops *IOP Conf. Series: Earth and Environmental Science* **614** 012118.