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## **CALCULATION OF MAGNETIC OIL CLARIFIER**

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*Technology of oil cleaning from iron-containing impurities that shows the feasibility of magnetic cleaners applying was investigated. Comparative analysis of the types of magnetic clarifier was carried out. Procedure of calculating the dimension type of oil clarifier, which makes it possible to obtain high purity grade oil, was offered.*

**Problem statement.** One of the main problems of scientific and technical progress in many areas is increasing the purity of the oils. Therefore, in many cases, the effective cleaning of oils at various stages of the process is necessary to be provided. First of all it concerns those branches where the formation of an iron-containing additive, the sources of which can be corrosion progressing over time and wear of components, including the friction pairs, is possible. In general, iron-containing additives significantly and in some cases decisively influence not only on the quality and grade of products, but also on the behavior of technological processes, reducing the potential level of production and reliability and durability of aircraft equipment. Thus, the refining of oils from the iron-containing impurities is gaining relevance as it is a good reserve for improving their quality and improvement of technological processes in various industries. Since the vast majority of those impurities, usually has ferromagnetic properties, the real prospect of applying the methods and devices for magnetic removal of them from oil appears. It is important that in the process of magnetic deposition iron-containing additives, particularly of magnetite, also serve as the accompanying "transportation" function, capturing other particles of impurities during the deposition that leads to their thorough cleaning, even from those impurities, which are not deposited in a magnetic field.

At fine magnetic cleaning process implementation the magnetized nozzles that are directly exposed to fluid flow play a major role.

Thus, it is advisable to release oil from iron-containing impurities by magnetic cleaners.

**Comparative analysis of the magnetic cleaners.** The design feature of the magnetic cleaners with cores is the presence of relatively small coils made with steel cores beyond the working area of the magnetic deposition.

This type magnetic cleaners' structures should meet following requirements:

- rational layout of the magnetizing systems using a direct whole cores and minimizing the areas of magnetic circuit outside the working areas;
- creation of deposition working areas of required length;
- ability to work under pressure.

These basic requirements most appropriate to the design of magnetic cleaners which magnetizing system together with the working channel is assembled on a toroidal pattern (Fig. 1) [2; 3].

However, it can be attributed to the disadvantages of the magnetic cleaners with cores the unevenness of volume magnetization of the nozzle in the working channel, especially near the poles and away from them to the periphery of the nozzle (at  $90^\circ$  to the line between the poles).

The use of permanent magnets in magnetic cleaners is promising. This gives economically profitable solving of number of oils purification problems, to exclude or limit the use of coils and power consumption. Besides, that will help using special devices, such as hazardous conditions that require special production of electric equipment. Therefore, magnetic cleaners with nozzles-sorbents in the form of contact ferromagnetic deposition elements and the permanent magnets are more promising (Fig. 2).

However, the implementation of devices with permanent magnets, usually there are additional complexities associated with their periodic regeneration.

Especially it concerns widespread designs in which permanent magnets are used as deposition elements, i.e. as a kind of nozzle of different sizes, configurations and options for the location of the magnets.

The characteristic feature of magnetic purifiers those do not contain coils with steel cores is that the magnetic deposition of particles is carried out in a ferromagnetic filter nozzle located in the cavity of the magnetized coils.

In such designs nozzle itself is a kind of core. The most common design of this type is a solenoid magnet purifier (Fig. 3).

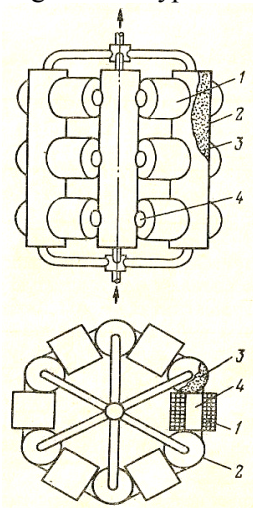


Fig. 1. Toroidal multichannel electromagnetic cleaner with the core: 1 – Coil; 2 – channel (body); 3 – nozzle; 4 – core

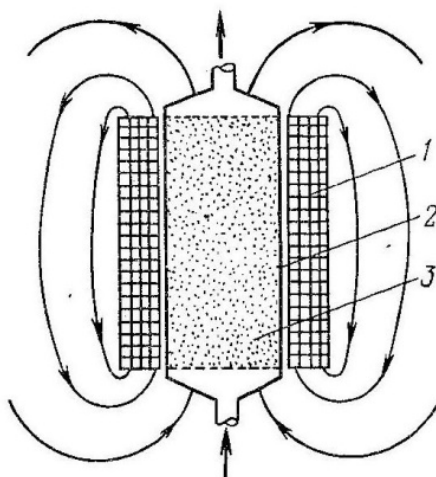


Fig. 2. Magnetic purifier with internal magnetizing system from permanent magnets: 1 – package of permanent magnets; 2 – channel (body); 3 – nozzle; 4 – magnetic elements.

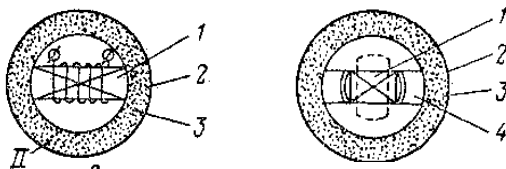
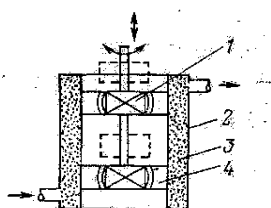


Fig. 3. Solenoid magnetic purifier: 1 – solenoid; 2 – body; 3 – nozzle.

Thus, a comparative analysis of the magnetic purifiers allows to conclude that the most promising design is with cores nozzles.

**Definition of magnetic purifiers dimension type with cores-nozzles.** Based on the above data it can be argued that it is appropriate to create a device with fixed length and relatively large solenoid diameter, as in this case the specific mass  $M$  of copper (aluminum) per unit of consumption  $Q$  or volume of oil is reduced, about  $M/Q \sim 1/D$ , but it must

be meant that with increasing  $D$  (and the constancy of  $L$ ) the relative length of the solenoid is reduced, which leads to more intense losses of the force field to the environment, it reduces the intensity of the field, especially in the axial and the end zones, and reduced the average intensity in the cavity of the solenoid  $H_L$ . These disadvantages are theoretically absent only in case when  $L \gg D$ . In the actual structures of electromagnetic gravitation filters of high performance solenoid length  $L$ , as a rule, is comparable to  $D$ , then obviously solenoids are "short", so the neglect of losses of the magnetic field can lead to gross errors in calculations of structural and operational characteristics of gravitation filters.

The value of  $HL$  in real not thin (multilayer) solenoid of finite length  $L$  (where  $D$  is the average solinoid diameter) can be determined by using the known expressions of the multilayer solenoid magnetic field energy. Writing the ratio of these energies and using the known expressions for the inductance of a finite length solenoid and the same section of an infinitely long solenoid we obtain

$$\frac{H_L}{H_\infty} = \frac{\sqrt{\mu_L / \mu_{cp}}}{1 + \frac{1}{3L/D} + 10\delta_H / 9L} \quad (1)$$

Where  $H_L$  and  $H_\infty$ ,  $\mu_L$  and  $\mu_{av}$  – are correspondingly field intensity and magnetic capacity;  $\delta_H$  – the width of solenoid coil.

When the solenoid is empty ( $\mu_L = \mu_{av} = 1$ ), the dependence (1) at value of  $\frac{\delta_H}{L} = 0,1$ ; that is close to practical one, shows that at conditionally allowable decreasing of  $H_L/H$  (not more than on 10%), the criterion must be value of  $L/D \geq 2-4$  (fig. 4, 1<sup>st</sup> line).

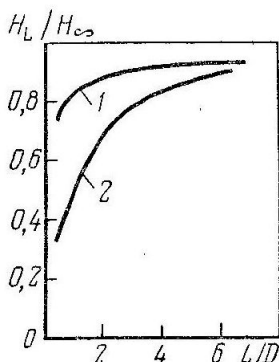


Fig.4. Dependence of relative field intensity in the volume of the empty solenoid (1) and solenoid filled with nozzle (2) from  $LD$

During the filling the solenoid with ferromagnetic nozzle the purposive value of  $L/D$  is not consistent with that for the empty solenoid, which is due to the negative influence of the demagnetizing factor of the nozzle. Thus, for the ball nozzles this factor virtually disappears only when the ratio of the length of the nozzle to its diameter  $L/D \geq 8-10$ , but with decreasing of  $L/D$  its influence on the magnetic properties of the nozzle increases. For solenoid with nozzle the dependence (1) for the same  $\frac{\delta_H}{L} = 0,1$  is shown in Fig. 4 (line 2), is significantly different from the "related" dependence obtained for the empty solenoid (line 1). If we take in order that  $HL/H$  was lowered no more than 10%, so  $L/D$  for the completed solenoid should be much higher than for the empty, namely:  $L/D \geq 6$ . At less severe requirement, for example at  $HL/H \geq (0,7-0,8)$ , i.e. when lowering of  $HL/H$  is for not more than 20-30%, criterion value  $L/D$  should be

$$L/D \geq 2-3, \quad (2)$$

Therefore, when designing gravitation filter type of solenoid the main criterion that determines their efficiency is a dimensionless parameter  $L/D$ , on which depend the specific consumption, the share of losses of the magnetic field and the actual strength of the magnetizing field. Neglecting the condition (2) reduces the device efficiency, a substantial decrease in the intensity of the magnetizing field, the degree of magnetization of the very nozzles, and performance.

If the solenoid device (see Fig. 3) is calculated by the principle consumption-diameter-length, then the relatively high consumption 0,2–1 m<sup>3</sup>/hour and the required diameter  $D = 0,05-0,2$  m (sectional) solenoid length  $L = 0,1-0,6$  m.

**Conclusions.** It is established that oil treatment from iron-containing impurities is advisable to provide with magnetic cleaners.

A comparative analysis of magnetic cleaners found that the most promising design is the design of the core-packing.

Method for determination of sizes of the magnetic cleaner of above mentioned configuration was given.

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*Пузик С.О., Шевчук В.С., Баранівський Є.О., Михайленко О.О.* **Розрахунок магнітного очисника масел** // Проблеми тертя та зношування: наук.-техн. зб. – К.: НАУ, 2011. – Вип. 56. – С.259–264.

Досліджено технології очищення масел від залізовмісних домішок, що показує доцільність застосування магнітних очисників. Проведено порівняльний аналіз типів магнітних очисників масел. Запропонована методика розрахунку типорозмірів очисника масел, яка дає можливість отримати масло високого ступеня чистоти.

Рис. 4, список літ.: 3 найм.

*Пузик С.О., Шевчук В.С., Барановский Є.О., Михайленко О.О.* **Расчет магнитного очистителя масел**

Исследованы технологии очистки масел от железосодержащих примесей, показывает целесообразность применения магнитных очистителей. Проведен сравнительный анализ типов магнитных очистителей масел. Предложенная методика расчета типоразмеров очистителя масел, которая позволяет получить масло высокой степени чистоты.

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