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DESIGN AND MANUFACTURING OF A MAGNETIC SWITCH BY USING OIL-BASED FERROFLUID AND OIL-BASED FERROFLUID DOPED WITH COPPER NANOPARTICLES

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Abstract:

In this work , design and manufacturing of the magnetic switch was prepared from the pure oil-based ferrofluid and froma Ferro fluid doped with 0.012mg copper nanoparticles. The properties and applications of ferrofluid were studied, and the effect of laser light on these samples were studied .The main parameters of the magnetic switch by using oil-based pure ferrofluid were studied such as rise time ,fall time and response time where, (Rise Time = 6.451 ms.)(Fall Time = 75ms) (Response time =12.09ms). The same parameters for the magnetic switch by using oil-based ferrofluid doped with copper nanoparticles were studied , where, the (Rise Time=4.261 ms.)(Fall time= 58.52ms) and (Response Time=7.95ms). also in this work ,a magnetic hysterical loop in different forms, according to the type of material used in making the magnetic switch sample, and the properties of these materials were identified by stud

Key word: magnetic switch, oil-based ferrofluid, Copper nanoparticles.

Introduction:

The compact starters or motor starter combinations are very important in industrial automation. It consumes lower power, higher current, high functionality, and has high performance [1]. Magnetic fluids can be classified as ferrous liquids[2]. Ferrofluid have novel properties and their behavior in the magnetic field leads to a lot of interesting applications[3]. Production of magnetic fluid, commonly called a ferrofluid, presents a challenge that initially started with efforts Gowan Knight in 1779 [4]. Ferrofluid is one of the most beautiful applications of ferromagnetic materials and they are suspensions of microscopic magnetic particles in organic solvents such as water or oil. The materials used in magnetic key manufacturing are magnetic liquids, this is called (Ferrofluid) [5]. In 1997, D. L. Meier et, al. they studied a magnetized disk model that could apply in the systems astrophysical jets, and provide the relativistic flows in the quasars. They report time-dependent numerical simulations of jet formation that exhibited speed and character of the jets based on the type of magnetic forces. This magnetic switch is not predicted by steady-state, self-similar disk models, or by relativistic wind theory that does not calculate the gravitational field [6]. In 2000, P.C. Fannin et al, were studied low-temperature investigations were provided on the power of the dilute magnetic liquid containing ultra-fine $CoFe_2O_4$ molecules. It shows the thermal evolution of cobalt ferrite molecules from the desired state magnetically to the super magnetic state with a blocking temperature at about 80K [7]. In 2002 Olga B. Kuznetsova et al, they were studied the statistical model that has been developed to study the magnetic properties of dense ferrous liquids. The model is based on the relationship between magnetization and the conjugation function of a spatially homogeneous system of dipole molecules. This approach permits the calculation of ferrofluid magnetization in a form of expansion on both the concentration of particle expressions obtained for magnetization and the initial formation and that magnetic sensitivity with precision d describes well experimental data. The effective field was calculated as a function of magnetism [8]. In 2003 Thomas A. Franklin, an analysis of ferrofluid experiments was listed in parts: the ferrofluid properties, the ferrofluid flow in piping and piping systems, and a study of fluoride-free surface plate flow. Characterization of the ferrofluid samples is completed by analyzing the magnetic curves measured with a magnetic scale of a vibrating sample. Determination of the size range of ferrofluid iron particles, low-field magnetic permeability, saturation magnetization, and magnetic volume portion Experimental results are found [9]. In 2018 Elena Castro-Hernández et al, They studied the Ferrofluid is suspensions consist of magnetic nanoparticles in the liquid. The Ferrofluid used for research purposes in the space (microgravity). The microgravity is an unexplored field because it is expensive and the access is limited. The surface displacement of the ferrofluid was calculated in microgravity conditions [10]. In 2019 Dominik L. Michels et al, They found simulation of ferrofluids is similar to the simulation of the complex dynamics of ferrous. The magnetic particles of ferrofluids react with the external magnetic. The employ smooth magnets are activating the ferrous in depending on the point magnets. The magnetization is using the analytical solution of the smooth magnets [11].

The experimental work:

The homemade ferrofluid is oil-based with a molecule of ($Fe3O4$) nanoparticles with diameter (5nm), that is dissolved in olive oil. The properties of these materials are:-

1- Oil-based. 2- Magneticity super. 3- Molecule diameter 5nm. 4- Concentration is 0.5g / ml.I

In this work, the preparation of ferrofluid is done in the lab by using the volume ratio 1:2 by dissolving (1 g) of ($Fe3O4$) nanoparticles in(2ml) of olive oil. Then the mixture (oil +$Fe3O4$) is put in Ultrasonic device for (1 hour). The manufactured material (ferrofluid) is used for production magnetic switch.

The production of the magnetic switch cell :

The first step for the production of the magnetic switch cell is the preparation of the indium tin oxide (ITO) slides. The most common material for the fabrication of the conducting layer is the indium tin oxide. [12]. With dimensions (2cm-3cm). The slide is deposited by (PVA) (4mm) the magnetic stirrer is used for this purpose. The slid is remained to dry up and the PVA to be deposited on it. Then rubbed the PVA layer with a cloth for 25 times for obtaining grooves on its surface. The angle of the shredding direction should be 90. Then the two slides are applied to each other, With a distance between them with a circular or square hole with a diameter (0.5cm) from isolation material in order to hold out the high temp. The ferrofluid liquid material is put between the two slides with a thickness of (20ml). Finally, The two slides are provisions tight to gather by using super glow in order to prevent the leaking the ferrofluid liquid material from the tow slides from all these steps the magnetic switch is manufactured.

Figure (1) represents the final prepared sample of the magnetic switch.

Figure(1) the final prepared sample of magnetic switch

The Doping of Ferrofluid With Copper Nanoparticles:-

Copper is considered to be a good magnetic conductive material, so it was selected as an inlaid material to obtain the ferrofluid nanomaterial. In this work (0.012mg) of copper, nanoparticles were mixed with ferrofluid material manufactured in the laboratory. By using these steps, the doped ferrofluid withe copper nanoparticles are obtained. Finally, the magnetic switch is obtained by manufactured ferrofluid doped with copper nanoparticles.

Figure (2) represents the final sample obtained.

Figure (2) represent the final sample from manufactured ferrofluid doped with copper nanoparticles

Finally, the experimental setup of the magnetic switch consists of light source (lasers), Polarizer, and analyzer made in Japan. The polarizer could be considered as a polarizer and/analyzer when these polarizers are set perpendicular to each other. A polarizer and Analyzer is an optical filter that passes light of a specific polarization and blocks waves of other polarizations, Coil wire(copper), the value of the current (1A), the diameter of the wire (1mm), a number of turns (6500), magnetic field (200 mT), DC power supply made in Japan which supply (9V) DC voltage to the coil. Power meter: Made by Mobiken laser power meter LP1), a device used to measure the laser beam after it passes through the cell. Magnetic switch cell was placed between a pair of perpendicular polarizers and illuminated by laser He-Ne Laser (2mW,635.8nm) and The light source as shown in figure (3), Gauss meter supply voltage(9V), made in China.

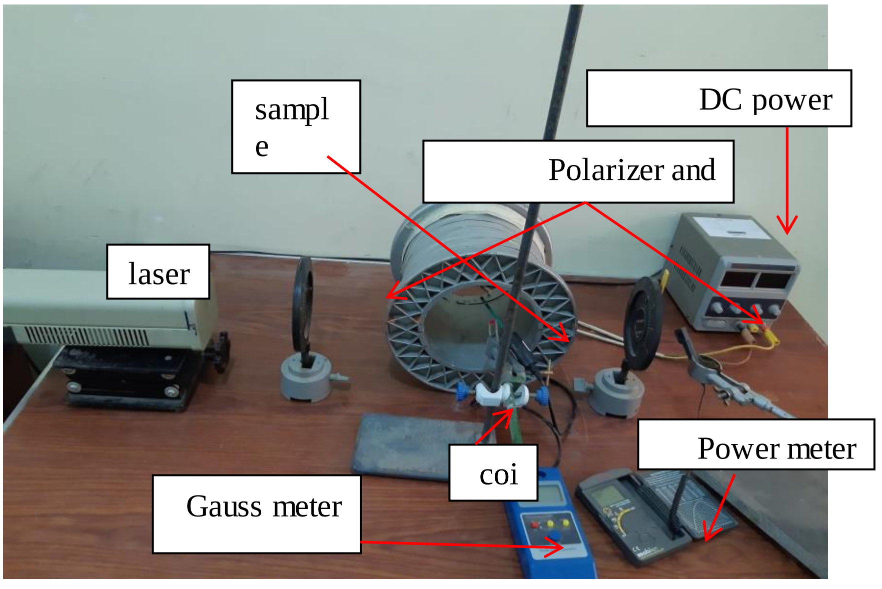


Fig. (3) The experimental set up of the magnetic switch work

Results and Discussions

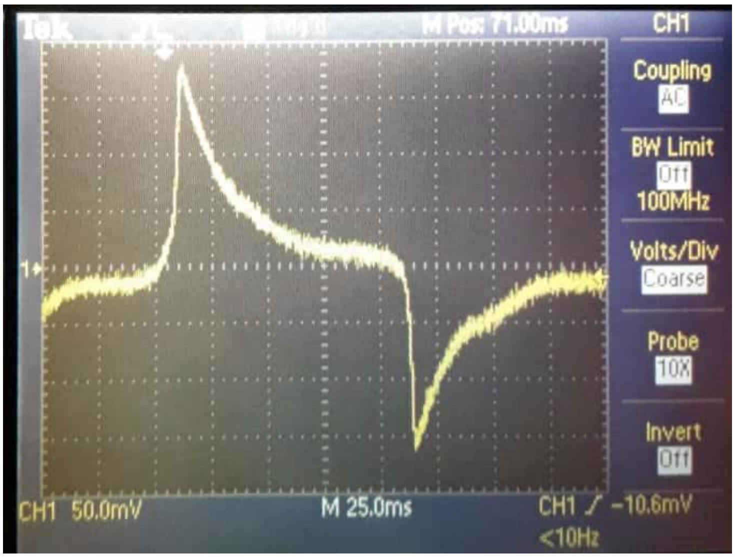
The He-Ne Laser (2mW, 635.8nm)

1-When highlighting the He-Ne laser on a pure magnetic magnetic switch sample, the following parameters will be get:-

1- 1-Rise Time:- When calculating the rise time as a signal of the fluoroid response rises from 10% to 90% Figure (4), its value was 6.451 ms.

1- 2- Fall Time : The fall time is as the steady state signal falls from 90% to 10% , which was 75 ms **.**

1-3-Response Time :- The response time is 0% - 62.5% of the steady state of the signal , which was 12.09 ms .



Figure(4) : The response signal ferro fluid pure

1-4- Hysteresis Loop

The hysteresis loop is the curve that represents the relationship between the applied voltages to the coil and the magnetic field strength as shown in Fig(5) An increasing in the applied voltages to the coil generates an electric magnetic field that affects the magnetic key sample of ferrofluid when the applied voltages increase. The intensity of the magnetic field increases until it reaches the area where the magnetic field stabilizes when the voltages increase. When the voltage applied to the coil is reduced, the magnetic field begins to decrease gradually, resulting in a hysterical curve.

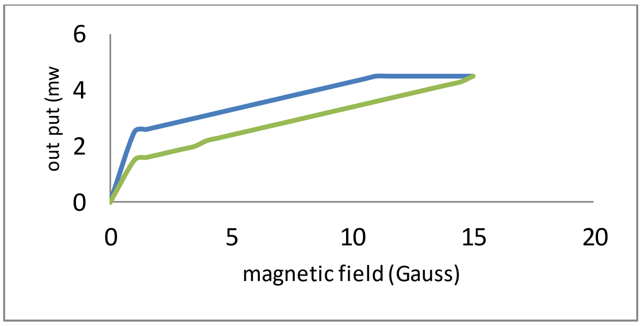


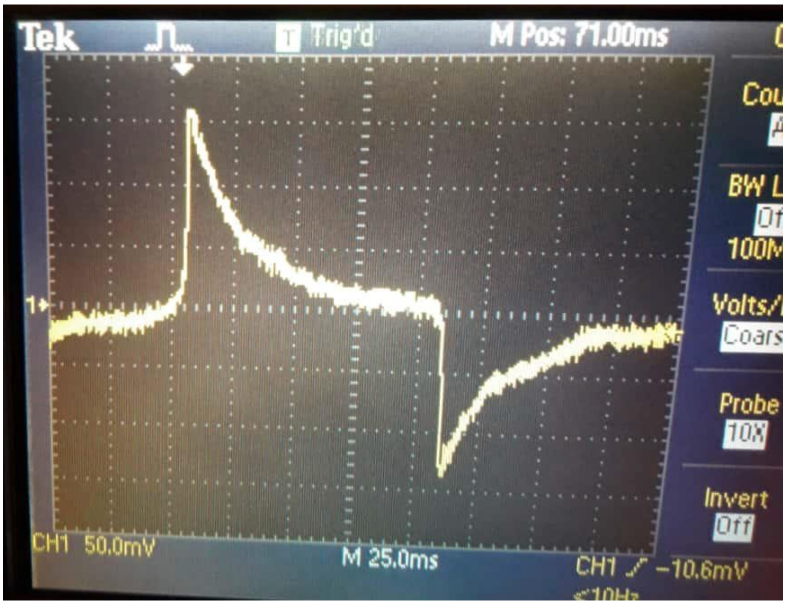
Fig. (5) the hysteresis loop of ferrofluid Pure magnetic switch

2- When highlighting the He-Ne laser on ferrofluid doped with copper nanoparticles, the following parameters will be get:-

2- **1- 1-Rise Time:-** When calculating the rise time as a signal of the fluoroid response response rises from 10% to 90% Figure (5), its value was 4.216 ms.

1- 2- Fall Time -: The fall time is as the steady state signal falls from 90% to 10% , which was 58.52 ms **.**

1-3-Response Time :- The response time is 0% - 62.5% of the steady state of the signal , which was 7.95 ms .



Figure(6) : The response signal ferroflui ferrofluid doped with copper nanoparticles

2-4- **Hysteresis Loop** :-

when the ferrofluid is doped with copper nanoparticles, another hysterical loop will be gaited, but the area within the curve will be less than that in the pure material hysteresis curve. As in Fig (7).

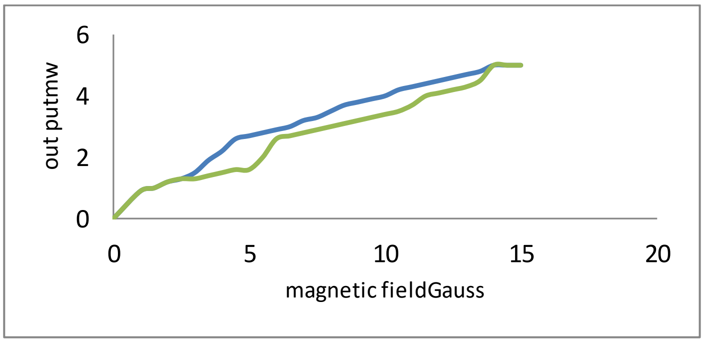


Fig. (7) The hysteres loop of ferrofluid that is doped with copper nanoparticles

Conclusions:

1-The difference in the values of (Rise Time, Fall Time, and Response Time) according to the difference in the purity of the material, where the values decrease as the material becomes more deformed.

2- The hysteresis loop differs according to the purity of the material, the larger the ring area, the more pure the material will be.

3- The longer the projected laser light falls on the material, the greater the material's response to the magnetic field.

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