INTENSELY SPONTANEOUS MAGNETIZATION OF A DRILL STEM FOR OIL AND GAS FIELD

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Abstract: The objective of this study was a theoretical explanation of the reason causing a new phenomenon in NDT. When some drill stems for oil and gas field operated through a long period of time were maintained, NDT personnel discovered that the magnetic particle inspection could be carried out on them without magnetization, and only had to apply suspension upon them.

An item analysis was conducted on this concrete condition, on the basis of geomagnetic induction effect and the unsymmetrical result of the magnetization－demagnetization process of the ferromagnetic materials.

The principal finding of this item analysis was that a ferromagnetic object rotating in the geomagnetic field had to be magnetized intensely.

On the basis of this finding, a drill stem for oil and gas field after its operation for a long time must be magnetized intensely and spontaneously.

In May, 2002, Mr. David Yan, at The Forging & Casting Factory for Heavy-Duty, Chong-Qing, China, asked by telephone the author the reason causing a new phenomenon (When the drill stem for oil and gas field are maintained after a long period service, all one has to do is to apply the magnetic suspension directly upon the stems, the magnetic particle testing on them will be carried on, because they are already magnetized intensely). Present paper is specially written for answering this difficult problem.

1. The rotating of an object made of ferromagnetic material perpendicular to the geomagnetic field

A rotating object with any shape of transversal section is composed of countless thin pieces through the rotating axis (Figure 1.a). And each thin piece may be considered as a composition of infinite closed coils in frame shape (Figure 1.b). When an object with electric conductivity is whirling around axis ω perpendicular to the geomagnetic field H_e (Figure 1.c, for simplicity suppose the object is in the shape of a cylinder, and its central axis coincides with axis ω), these closed coils all cut the magnetic lines of force of H_e. According to Faraday's Law on electromagnetic induction [1-3], the electro-motive force E and induced electric current i must be induced in these closed coils, and E, i change directions twice in one cycle of the object rotation (Figure 1.c). In other words, each closed coil is a alternating current generator, but the generated electric current flows only within themselves, and these are Foucault (eddy) currents [1-3]. If the rotating object is made of ferromagnetic material, it must be magnetized and demagnetized respectively once in every cycle of rotation by the magnetic field H yielded from current i, that is, at an arbitrary point of a ferromagnetic rotating object there will be magnetization and demagnetization once in every cycle of whirl.

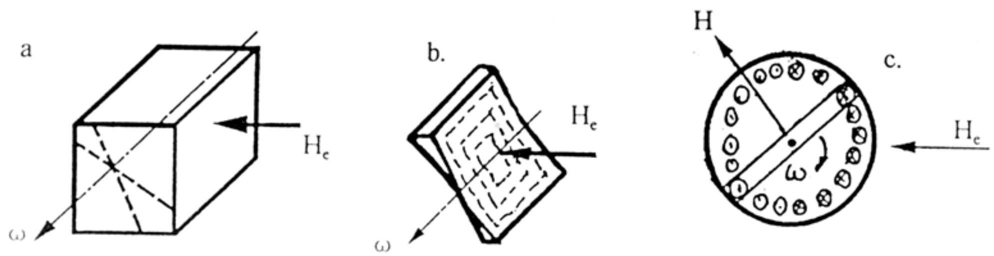


Figure 1 Rotating object in geomagnetic field

2. The unsymmetrical magnetization□demagnetization process of ferromagnetic materials.

On the basis of the traditional conception, the magnetization□demagnetization process of ferromagnetic materials are described by the original magnetization curve (Figure 2 .□), the main magnetic hysteresis loop (Figure 2.□) and secondary magnetic hystersis loop (Figure 2.□) of these materials[1□4]. But the practice and theory of metal magnetic memory testing and diagnostic technique[5] have proved that the magnetization□demagnetization process of ferromagnetic materials in geomagnetic field by mechanical strain should be shown in Figure 3 [6,7].The author has proved that an unit volume of ferromagnetic material will accumulate an amount of magnetic potential energy equal to the area of its secondary magnetic hysteresis loop after each cycle of this magnetization□demagnetization process. This magnetic potential energy must heighten the residual magnetic induction of this material itself with an increment □B (Figure 3)[8]. But as □B is very small, so everybody misunderstood in the past that point c in the Figure 3 returned back to point a to form the secondary magnetic hysteresis loop. And when the cycle index of the magnetization□demagnetization process is very large, the □B will be accumulated in considerable amounts. This is just the physical fundamental, on which the metal magnetic memory testing and diagnostic technique depends for emergence and development [5]. Judging from this, strictly speaking, the ferromagnetic materials don't have the real secondary magnetic hytsteresis loops, but have the winding whirling curves very approaching to the loops (Figure 3).

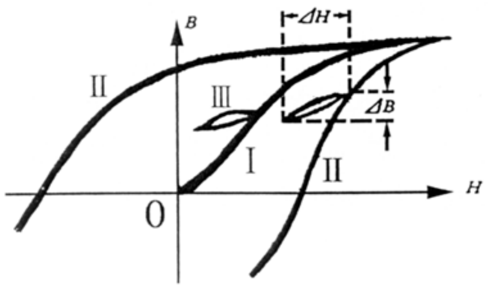


Figure 2 Magnetization□demagnetization process of ferromagnetic materials

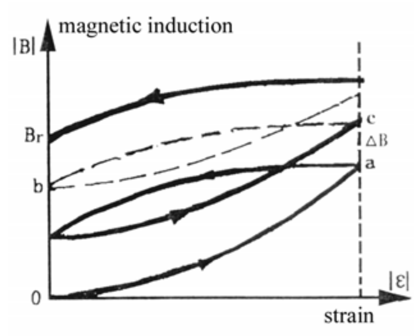
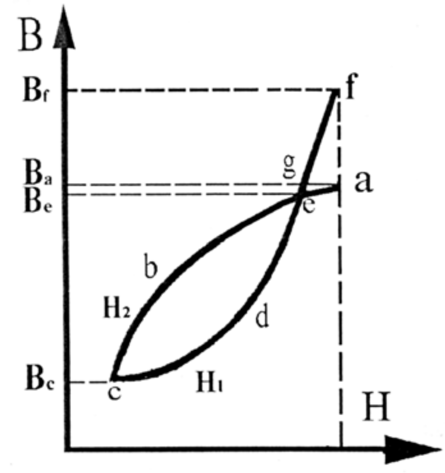


Figure 3 Magnetization□demagnetization process of ferromagnetic materials in geomagnetic field by mechanical strain

Since in practice there is no the secondary magnetic hysteresis loop, the magnetic potential energy W accumulated after every cycle of magnetization□demagnetization process in an unit volume of ferromagnetic material should be (see Figure 4)[3,8]:

$$W = \int_{B_c}^{B_f} H_1 dB - \int_{B_c}^{B_a} H_2 dB \quad (1)$$



tht is

$$W = \int_{B_c}^{B_e} H_1 dB + \int_{B_e}^{B_a} H_1 dB + \int_{B_a}^{B_f} H_1 dB - \int_{B_c}^{B_e} H_2 dB - \int_{B_e}^{B_a} H_2 dB$$

$$W = \int_{B_c}^{B_e} (H_1 - H_2) dB + \int_{B_e}^{B_a} (H_1 - H_2) dB + \int_{B_a}^{B_f} H_1 dB \quad (2)$$

Obviously, W is equivalent to the area surrounded by loop bcde adding area surrounded by curve fB_fB_ag and decreasing the area surrounded by curve eag. From Figure 4 it is thus clear that.

$W>0$ (3)

Hence, an unit volume of ferromagnetic material will increase magnetic potential energy in amount W after every cycle of magnetization□demagnetization process, that is, its residual magnetic induction may be increased with an increment □B. So an object made of ferromagnetic material must be spontaneously magnetized after its rotating in geomagnetic field for a long period of time.

Figure 4 Magnetic potential energy accumulated in every magnetization□demagnetization cycle

3. Conclusion:

3.1 The rotating of any shape object made of ferromagnetic material perpendicular to the geomagnetic field will lead to the spontaneous magnetization of this object, the more the revolutions, the stronger the degree of its magnetization.

3.2 In the magnetization□demagnetization process of ferromagnetic materials, there is no rigid secondary magnetic hysteresis loop, but winding curves very approaching to the loop.

3.3 The intensely spontaneous magnetization phenomenon of a drill stem for oil and gas field after a long time service is an inevitable outcome of the geomagnetic induction effect, and it belongs under"magnetization through operation"[9].

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