# Effects of a Remanent Magnetization on the Detection Signals of the Metal Loss in MFL type NDT by using M-B Variable Preisach Model

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**Abstract — Because of a strong magnetic field in magnetic flux type NDT system, the object is magnetized during the sensing so that it shows the hysteresis characteristics, which causes the distortion of the defect signals. In this paper, the effects of a magnetic hysteresis of a pipeline on the sensing signals are analyzed. The reason of decrease of a sensing signals' magnitude, as an increase of pigging numbers, is turned out to be remnant magnetization of gas pipeline. The measurements of the remnant flux density supported the computational results well and the compensating data as a number of pigging are successfully obtained.**

## I. Introduction

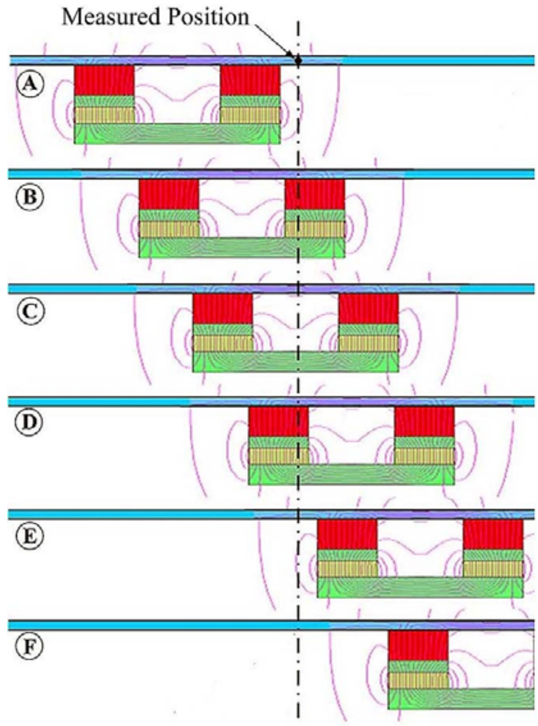
The magnetic flux leakage (MFL) type non-destructive testing (NDT) system is widely used to detect metal losses of the underground pipe in gas pipelines [1]. This pipeline inspection gauge (PIG) system, as shown in Fig. 1, consists of permanent magnet, magnetic yoke and Hall sensors to detect the metal loss, corrosion defect and any other damages of the gas pipeline. The pipeline is magnetically saturated by a magnetic system with permanent magnet and yokes during the sensing so that the Hall sensors could detect the stray leakage fields in the metal loss region.

In the system, a magnetization level is designed to be high enough to saturate the pipeline in order to increase the leakage fields [2]-[3]. So, after the pigging, the pipeline has remanent magnetization which distorts the sensing signals to reveal the metal losses [4]-[6]. To detect the defects precisely, the sensing signals need to be compensated to eliminate the distortions coming from the media hysteresis. In this paper, the magnetizations of the pipeline in MFL type NDT are analyzed by 3 dimensional finite element analysis with suggested M-B Variable Preisach model and the distortions of the sensing signals are compared with measurement.

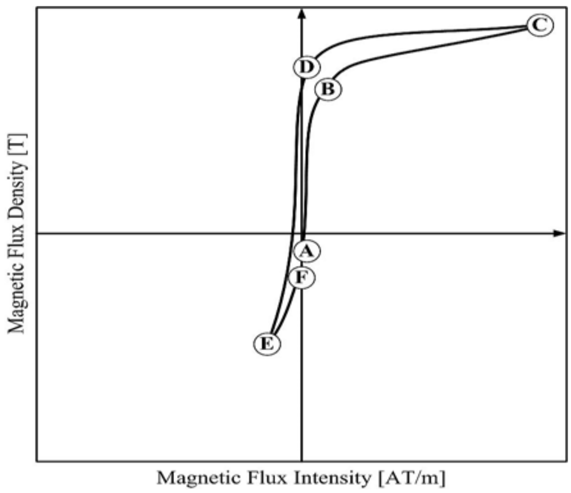
## II. Remanent Magnetization of the Pipeline

In MFL type NDT system, a magnetization level is designed to be high enough to saturate the pipeline in order to increase the leakage field under the defect region. So, in most cases, pipeline is to have remanent magnetizations according to the movement of the PIG so that the sensing signals are distorted to reveal the metal losses.

Fig. 1 (a) shows the variations of magnetic field according to the movement of the PIG at measured point. As the PIG passes, the magnitude and direction of the magnetic field at the measured point is changed in ⓐ−ⓑ−ⓒ−ⓓ−ⓔ−ⓕ order. The changes of magnetization of the pipeline at the measured point could be displayed as in Fig. 1. (b). So, the final remanent magnetization after a first pigging event is ⓕ

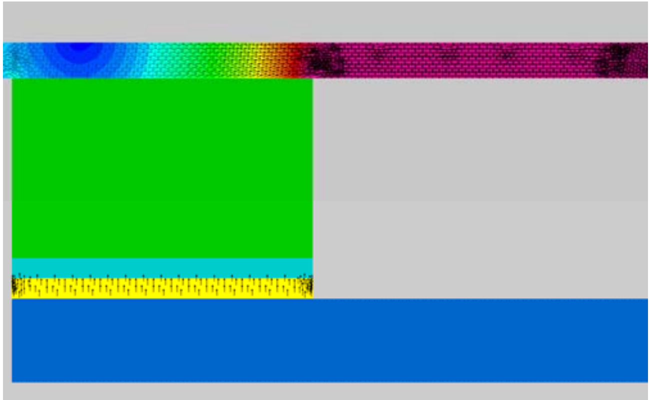



(a) Magnetic fields according to the position of MFL PIG

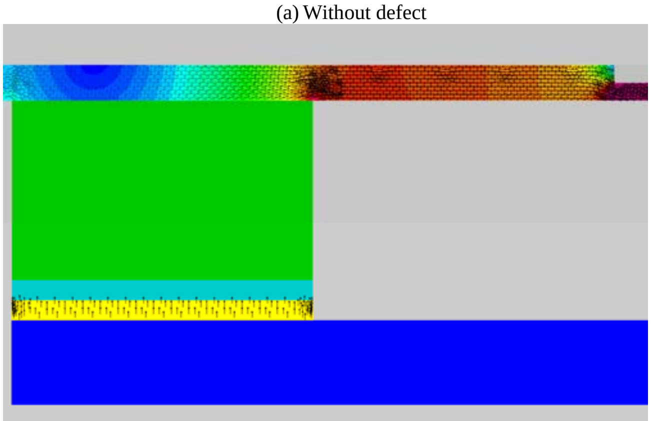



(b) Magnetic hysteresis loop of the pipeline

Fig. 1. Magnetization process of the pipeline.



(a) Without defect



(b) With edfect

Fig. 2 Distributed magnetization in the pipe by MFL system.

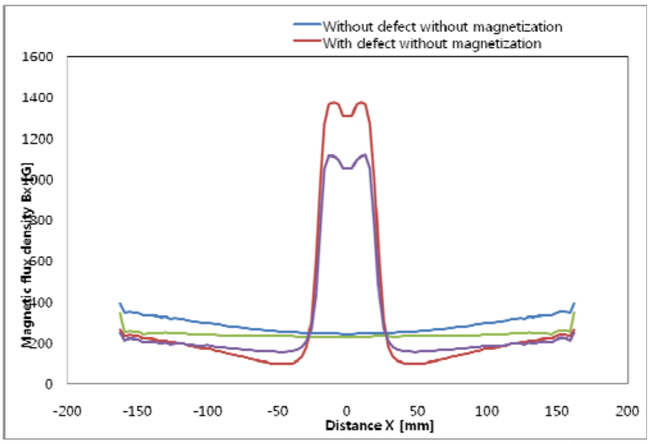
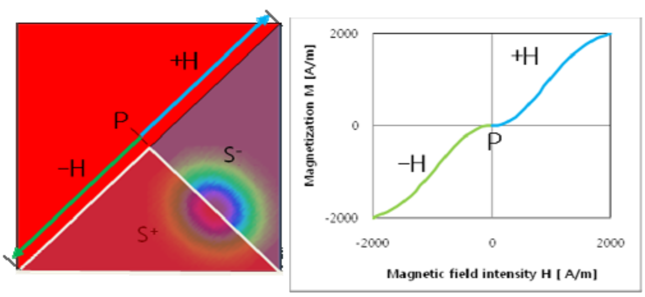



Fig. 3 Comparison sensing signal (Bx component) by defect and magnetization




(a) (b)

Fig. 4 Initial tracing curve definition. (a) Preisach plane. (b) M-H curve.

## III. Results and Discuss

In MFL type NDT system, pipe is magnetized by generated magnetic field intensity from ND Magnet contained in the MFL system. Therefore, the measured magnetic field signals generated in the pipe are included. Fig. 2, if there is a defect in the pipe and in the absence of magnetization distributions are shown. The general Preisach model exploits the variation of output magnetization, M, versus the input magnetic field strength, H. However, as plotted in Fig. 4, if the M-H curve is used, the output magnetization, M, rapidly varies against the input magnetic field strength, H, leading to instability when applied to the hysteresis model. If the M-B curve is used instead, as shown in Fig. 4, the variation of output magnetization, M, as a function of the input magnetic flux density, B, is evenly distributed to a great extent, resolving the numerical instability problem.

## IV. Conclusion

For the precise detection of a defect in MFL type NDT, it is necessary to compensate these distortions. In this research, the dynamic characteristics of magnetization in MFL type NDT system are analyzed. Effects of a remanent magnetization is computed by using 2 dimensional finite element analysis including hysteresis characteristics. The reason of decrease of a sensing signals' magnitude is turned out to be remnant magnetization of an object. The measurements of the remnant flux density supported the computational results well so that the compensating data as a number of pigging are successfully obtained.

## V. Acknowledgment

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