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A new measurement system using magnetic flux leakage method in pipeline inspection

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ABSTRACT

Today, natural gas and oil, called main energy sources, are transported by pipelines at long distances. Defects (corrosion, cracks, dents) in the buried pipelines can cause loss of life, environmental pollution and economic loss. Recently, devices called "Pipeline Inspection Gauge (PIG)" are used for non-destructive evaluation (NDE) of defects in pipelines. In these devices, the magnetic flux leakage (MFL) technique comes into prominence as the inspection method. However, when the literature is examined, a study that examines the speed variable for defect detection has not been found. In this study, two new PIGs which can be used to investigate the speed variable while determining defects in pipelines are designed. For these new designs, a new magnetic measurement system with KMZ51 AMR sensors is developed. The voltage values of the sensors in the measurement system are saved to the computer by using LabVIEW-based software in sequential order via the NI USB-6210 data acquisition card. This data is also displayed on LCD screens by using MyRIO 1900. In the article, the mechanics of the developed system, its electronics and its software are examined in detail. Moreover, the usability of these new designs in determining pipeline defects are examined through an example experiment result with the Origin analysis program.

1. Introduction

Pipelines are widely used to transport natural gas and petroleum products between countries or at long distances [1,2]. In most of these buried pipelines, external factors such as corrosion pressure or displacement can cause defects [3]. These defects can result in economic losses, environmental pollution and fatal accidents if they are not detected on time. It is necessary to inspect the pipelines regularly in order to avoid these problems [4].

Devices called "Pipeline Inspection Gauge (PIG)", designed in accordance with non-destructive testing (NDE) techniques, can perform the inspection without damaging the pipeline. Only one or few of the several different techniques can be used together in the design of the PIGs that are used in the pipeline inspection. These techniques are mainly ultrasonic [5,6], magnetic flux leakage [7–10] and eddy currents [11]. Also metal magnetic memory [12–14], magnetic Barkhausen noise [15,16], magneto acoustic emission [17] and magnetic tomography [18] methods are used for defect detection. Among these techniques, which have advantages and disadvantages relative to each other, the magnetic flux leakage method (MFL) has been considerably used in the design of PIG in recent years. This method, which is used in the inspection of ferromagnetic materials, focuses on the detection of defects on the magnetized sample by detecting magnetic anomalies in magnetic flux lines with using magnetic sensors. Parallel to the developments in magnetic sensor technology, the types of sensors used in the magnetic flux leakage technique is also considerably increased. In recent years, the crack detection studies which uses the MFL method have frequently used Giant Magneto Resistive (GMR) [19], Anisotropic Magneto Resistive (AMR) [7], Giant Magneto Impedance (GMI) [20] and Magneto Optical (MO) [21] sensors as well as Hall sensors [22,23] and search coils [24].

In the magnetic flux leakage technique, magnets or coils are used to magnetize the samples. Two different magnetization types are used in this PIGs; circumferential magnetization and axial magnetization. Axial MFL devices that axially magnetize the pipe sample are used to determine circumferential defects. Circumferential MFL (CMFL) devices which circumferentially magnetize the sample are used in determining axial defects [25,26]. Also the usage of Pulsed Magnetic Field Leakage (PMFL) technique is increasing last years [19]. With pulsed MFL, the probe is driven with a square waveform and the frequency components can provide information from different depths [27]. Also, PMFL technique is used for measuring stress in ferromagnetic metals [28].

When the studies that use the MFL method are reviewed in the literature, it is seen that they are generally focused on different sensor

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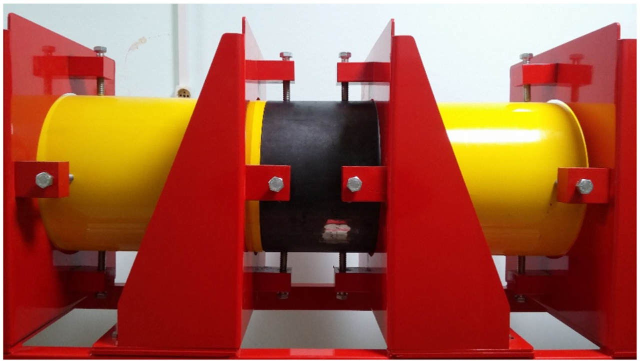

Fig. 1. View of defective pipe.

Fig. 2. General view of the system.

usage. No study has been found to examine the change in magnetic sensor output voltages for PIGs with different speeds. For this purpose, two different PIGs are developed in this study and they can magnetize the pipeline axially and circumferentially. KMZ 51 AMR sensors are installed on the developed PIGs. In addition, coils with iron-carbon alloy cores containing more than 2% carbon are used to magnetize the pipe sample. The movement of the PIG in the pipe is provided by a three-phase AC motor with a trigger belt. The AC motor is driven by a frequency inverter (speed controller) so that the speed of the PIG is changed.

The developed PIGs are moved in the steel pipes, produced as High Frequency Welding with a length of 5.25 m. The defected pipe is placed

Table 1
Technical data of motor and reductor.

Motor						
Full Load					Starting	
Power (kW)	Rev. per minute (rpm)	Current (A)	Moment (N m)	Power Factor (cos φ)	Current (I/INA)	Moment (MA/MN)
1.50	1440	3.40	9.95	0.77	6.00	2.30
Reductor						
Power (kW)				Revolutions per minute (rpm)		
1.50				106		

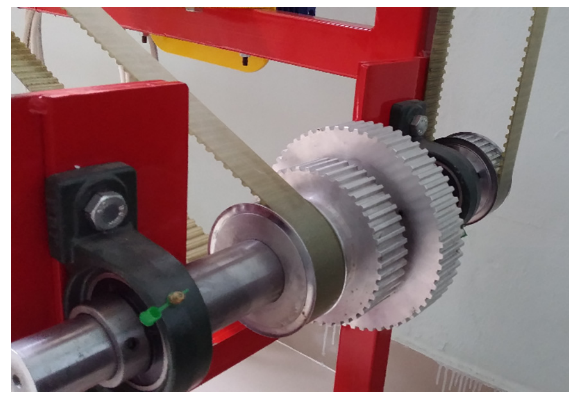

Fig. 4. Timing belts, gears and ball bearing units.

in the middle of the movement area (Fig. 1).

The programs, which are written by using the LabVIEW programming language, are used to save the data to the computer and display them on the control panel. The NI USB-6210 data acquisition card and My-RIO 1900 card are also used in the system. In other parts of the manuscript, the PIGs and the components and the design of the developed system are explained in detail.

2. Components and design of the system

A general view of the measuring system, developed within the scope of the study and used for identifying the defects in pipelines at different speeds, is given in Fig. 2. The developed system consists of three parts as mechanical, electronic and software. The sub-systems of the

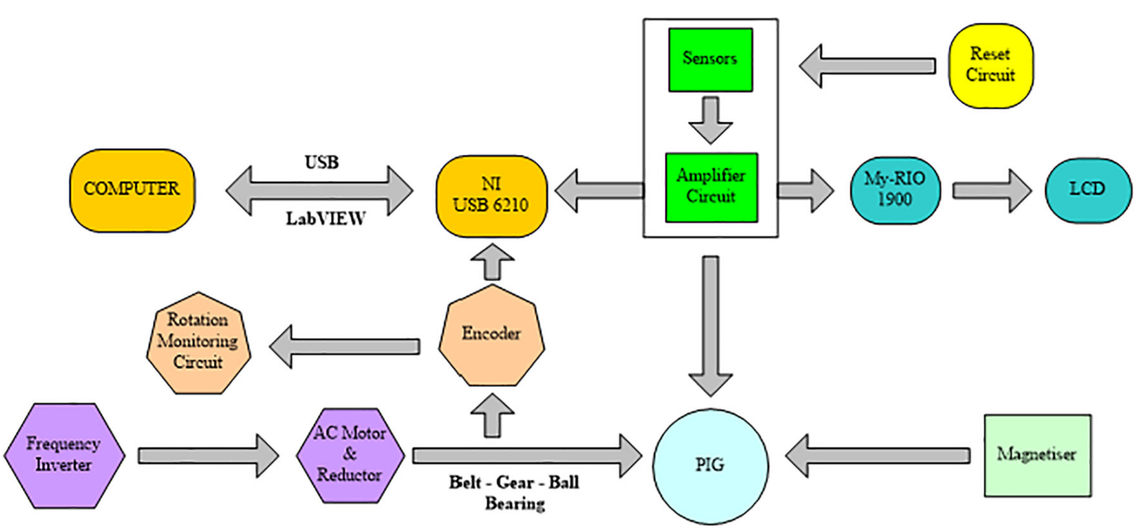

Fig. 3. Schematic representation of system components interactions with each other.