CHAPTER 7

SMART CONTROL FOR PIPELINE INSPECTION ROBOT

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7.1 INTRODUCTION

The concept of "Industry 5.0" represents a significant milestone in the evolution of manufacturing, where machines reach a level of intelligence that enables them to autonomously execute complex tasks. These advanced machines harness cutting-edge technologies and computational capabilities to collaborate seamlessly with human counterparts, resulting in increased efficiency and productivity across industries. However, challenges persist in various sectors, necessitating innovative solutions and the integration of machinery and inventive products to simplify daily operations. Notably, the oil and gas industry continue to employ conventional methods, presenting an opportunity to transition toward the transformative paradigm of Industrial Revolution 5.0.

Pipelines play a pivotal role in the transportation of natural gas and crude oil within the oil and gas industry. Ensuring the structural integrity, both internally and externally, of these pipelines constitutes a formidable challenge for technicians and engineers. Frequently employed for the conveyance of oil, gas, or other fluids from production sources to distribution centres, pipelines endure harsh environmental conditions on the ocean floor, including extreme temperatures, pressures, humidity, sea currents, vibrations, salt exposure, dust, and more.

These adversities can lead to corrosion, cracking, joint failures, stress loading, and leaks. As such, pipeline inspection assumes paramount significance in preserving their integrity and mitigating the risk of ruptures and environmental disasters. Consequently, early detection of potential hazards, corrosion, blockages (Figure 7.1), and other anomalies is imperative. Thus, the regular inspection, monitoring, and maintenance of transportation pipelines are strongly recommended for safe and reliable operations.

Figure 7.1 The condition inside of the pipeline: Corrosion and blockages

Conventional pipeline monitoring and inspection methods involve the utilization of surface vessels and remotely operated underwater vehicles, resulting in protracted reaction times and mobilization periods (Allibert et al., 2019). To circumvent these limitations, most entities in the oil and gas industry employ specialized tools and techniques such as pipeline inspection gauges (PIGs), remotely operated vehicles (ROVs), and autonomous underwater vehicles (AUVs). Among these, PIGs are a notable mode of transportation within pipelines, and visual inspection represents a vital technique therein.

Visual inspection constitutes a cost-effective method for the detection of pipeline leaks and ruptures. This method involves the capture of images of the pipeline's interior using a camera to facilitate sample collection. Systematic monitoring and subsequent digitalization afford a straightforward and highly efficient means of managing extensive pipeline networks. The implementation of pipeline inspections significantly enhances the identification of potential hazards and obstructions within pipeline systems. However, it is worth noting that inspecting pipelines poses inherent challenges, and therefore, there is a pressing need for a convenient and technologically advanced mode of transportation for inspection purposes.

The requisite transportation device, capable of traversing the pipeline, may take the form of a small robot crawler, an autonomous underwater vehicle (AUV), a remotely operated vehicle (ROV), or employ pushrod equipment. Notably, common pipeline inspection techniques and tools encompass pipeline camera inspection, pipeline quality verification (QV) inspection, and pipeline sonar inspection.

Existing PIGs and ROVs suffer from certain limitations. PIGs are designed to systematically inspect pipeline systems by sequentially releasing high-pressure water flow for flushing, cleaning, and gauging (refer Figure 7.2). However, a significant drawback arises when blockages occur, particularly in the flushing or other phases, within the pipeline. In such instances, operators are compelled to manually identify the obstructed pipeline section, incurring substantial operational costs. Additionally, PIGs are characterized by their unwieldy and heavyweight nature, which compromises their convenience and practicality

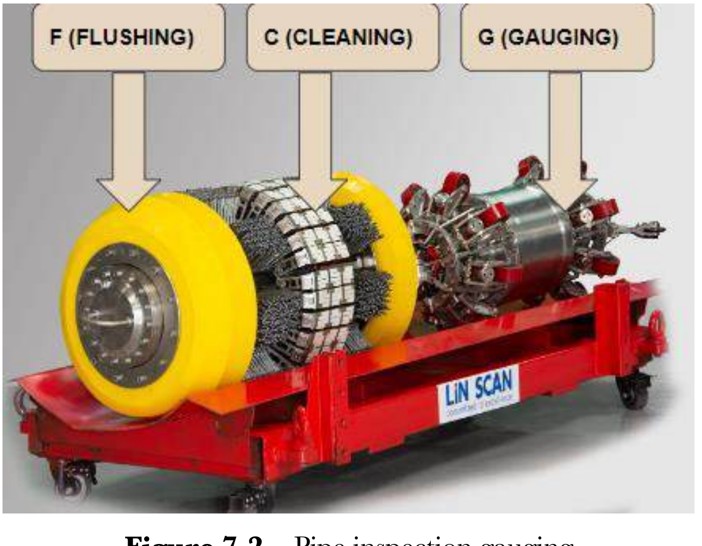

Figure 7.2 Pipe inspection gauging