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Next-Generation MFL Technology

A TALE OF TWO SYSTEMS

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NEXT-GENERATION MFL TECHNOLOGY

Mike Niosi, Onstream Pipeline Inspection, Canada, explains how the future of magnetic flux leakage technology is a tale of two systems: data acquisition and data processing.

Magnetic flux leakage (MFL) is a reliable inline inspection (ILI) tool that is utilised across the pipeline industry, helping to ensure pipelines around the world can continue to operate safely and economically. During the past ten years, there have been significant advances in MFL tool technology, as the miniaturisation of electronics and sensors has allowed MFL tool designers to pack many more sensors onto tools as well as increase the frequency of data sampling. These technology advancements have led us from the era of high-resolution MFL, to the age of ultra-high resolution MFL.

These advances in data hardware only tell half the MFL story, however. MFL inspection data is a product of a two-component, interdependent system. While advancements to data acquisition tools have led to ultra-high resolution data, the question now becomes: what do we do with it?

The answer: advancements to the second essential system – data processing software and algorithms.

In addition to building hardware set to compete in today's ultra-high resolution marketplace, Onstream Pipeline Inspection – a member of MISTRAS Group, a leading, global, OneSource provider of asset protection solutions – is taking the lead in finding new avenues to continue to advance MFL technology. In particular, the company is focused on evolutions in neural networking and self-learning artificial intelligence (AI) data processing software, and the potential these advancements can offer to provide pipeline operators improved solutions to manage difficult defects.

A brief history of MFL

Initially used to find defects in cannons back in 1868, MFL was first applied to pipeline inspections in the 1970s and has evolved exponentially since that time. In the beginning, MFL tools were simple devices that provided minimal data storage capacity and had limited inspection ranges. Initially referred to as 'thing finders,' MFL systems would provide operators with the coarse locations of where defects might be. Despite being very expensive to operate, the first tools were low-resolution and they struggled to differentiate severe corrosion defects from non-injurious mill anomalies.

Since the inception of MFL ILI technology, continuous innovation has allowed MFL tools to effectively inspect more pipelines, in a variety of conditions. These innovations include advances in electronics, data storage, magnetic materials and, more recently, the introduction of triaxial Hall effect sensors and low-drag mechanical designs to improve run profiles. Increasingly, MFL inspection providers have focused on maximising the number of sensors a tool can carry, with conventional thinking saying that higher and higher sensor quantities enhance defect detection capability, and ultimately sizing performance.

Today, an MFL inspection provides pipeline operators with the precise location, as well as the relatively accurate severity assessment, of metal loss defects in a pipeline. Today's advanced MFL systems are used as crucial components of pipeline integrity programmes across the world, offering the capability of collecting terabytes of data while inspecting hundreds of miles of pipeline in a single run.

System I: The data acquisition system

As we enter the ultra-high resolution era, the industry is buzzing with the arms race to determine whose inspection tool can claim the highest sensor density and lowest sample interval. However, MFL is not a direct measurement technique. MFL is an inferred measurement whereby signal responses are compared to models to determine the dimensions and severity of defects. Given that MFL is not a direct measurement, a 1 mm decrease in sensor spacing

Figure 1. Onstream provides data-driven inline inspection (ILI) services and data analysis for assessing challenging corrosion defects.

does not directly equate to a 1 mm improvement in detection capability or in sizing accuracy. While the addition of more sensors and increased sampling frequency certainly increases the quantity of data collected, these improvements do not necessarily ensure an improved pipeline inspection report overall.

Onstream's new generation of ultra-high resolution inspection tools – the TriStream MFL™ – focuses on more than just increasing resolution. According to Dr. Stephen Westwood, Onstream's Vice President of Technology, "MFL inspection service is about more than just the tool. Although the tool and the resolution are essential, the industry is already very high on the curve of diminishing returns when it comes to sensor spacing."

System II: The data processing system

While sensors and tools are an important part of the process, there is additional information to consider in regards to a pipeline inspection report. As stated, MFL technology is most effective when utilising the interdependent two-system philosophy, with data analysis being given as much weight as the data acquisition tool. While the data component often gets overlooked, it ultimately has the biggest potential upside for pipeline operators.

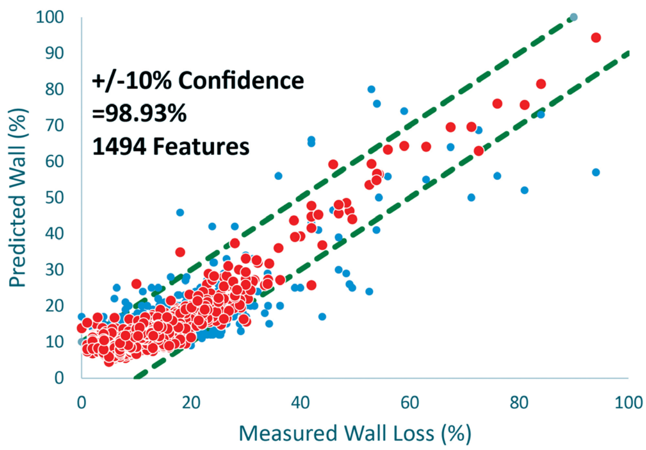

Figure 2. Chart shows the improvement that can be made by training neural networks on real data as opposed to training neural networks on just pull through data. Original model in blue; improved data in red.

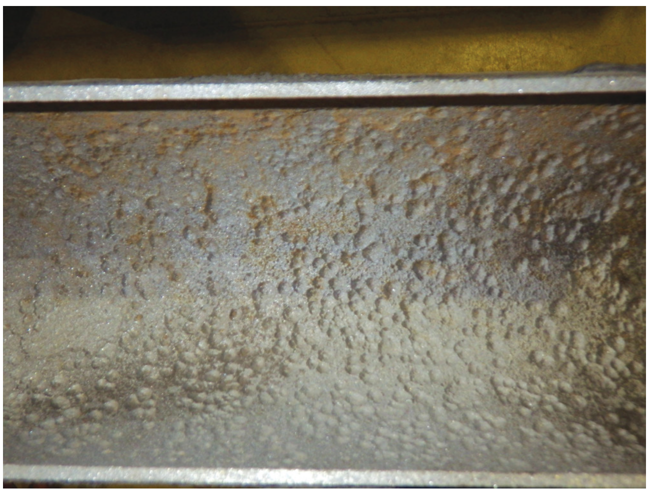

Figure 3. Neural networks can be trained to recognise and size thousands of real-life anomaly types, including pitting and corrosion.

Dr. Stephen Westwood and his team believe that the next breakthroughs for MFL are now being realised in how the data is processed, rather than collected. "Breakthroughs in data science present exciting new possibilities for interpretation of the data," says Westwood.

Advancements in AI and data analysis algorithms, in particular, are generating exciting new potential for ILI. Some of these new developments include machine learning where neural networks offer continuous improvements in accuracy, data speed, and even breakthroughs on how MFL anomalies are reported.

Self-training neural networks

In the last 15 to 20 years, there has been a massive increase in the computational power of neural networks. This is evident in all areas of life, ranging from face detection, outlier detection used in identifying fraudulent credit card activity, and with the recognition of injurious cells in X-rays.

These advancements in neural networks are now being actively used in pipeline inspections. The original neural networks used for pipeline inspection had a limited number of neurons, and while these were effective for specific problems, their capabilities were limited.

It is easiest to think of the neurons in the neural network as cells in a brain. The more cells in the brain, the more it can do. These early neural networks – which were developed for specific tools, pipelines, and types of corrosion – had limited processing ability. Now, with the increase in the number of neurons available in neural networks, today's technology can choose the optimal solution for a particular problem without any prior project-specific information.

By increasing the number of neurons in a neural network, and through advances in intelligent machine learning, neural networks are able to be 'trained' to correctly recognise and size thousands of real-life features that are cross-correlated to laser data. This allows the neural network to experience microbial corrosion (MIC), defects within defects, slab erosion, and a wide range of other anomaly types.

These neural networks are trained on thousands of defects across a range of diameters. The performance of the neural network is then assessed on data that the network has not previously seen. This is an important step to ensure that the network is not only robust, but that it is not simply recognising the training data and is capable of recognising new damages that it previously has not been exposed to. The increase in the use of laser scan and automated ultrasonics (AUT) – and the support of MISTRAS' expertise in advanced non-destructive testing (ANDT) – ensures that the feedback loop is not only closed, but that it is done so correctly.

MFL's next frontier

When it comes to MFL and its future technology advancements, it is not about where it has been, but where it is going. MFL tool technology has grown significantly over the years. However, it is the next-generation advancements in neural networking, software algorithms, and data processing that are set to offer the biggest benefit. These advanced platforms will allow operators to gain unique and important insight into the condition of their pipeline, more than ever before.

"The next arms race in our industry will be around the data and what you do with the data," said Westwood. "Questions won't be about the number of sensors, operators will be asking about the number of neurons."


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