Digital Maturity in Alumina Refining

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Abstract

The rapid advancement of digital technologies and methods promises to have significant impact on the alumina and processing industry. Modern tools in machine learning, internet of things (IoT), cloud computing and real-time mathematical optimization are becoming more accessible and commonplace. These tools are being used to transform the refinery design process, improve productivity of operations, reduce maintenance cost, and offer the opportunity to redefine business processes and business models. Having knowledge of these rapidly developing digital technologies combined with deep domain expertise is key to unlocking value and delivering on the business case. This paper introduces the concept of digital maturity and provides a structured approach for considering digital transformation of complex processing plants. Moving through stages of digital maturity, process data is first used to provide visibility of the operation and generate process insights. Insights provide a ground truth to allow the development of predictive models. Predictive models then allow scenario evaluation and optimization to assist in making the right decisions from a facility to refinery-wide level. This may be by way of determining process targets, optimizing maintenance activities, or other means. An example of this approach to digital maturity is presented for the digestion facility of an alumina refinery. Here, modern software systems provide an interactive and intuitive means to assess current plant performance and provide real-time process insights and diagnostics of operational issues. Predictive asset reliability information is also generated to assist in maintenance planning by highlighting at-risk equipment and providing estimates of residual equipment life.

Keywords: asset reliability, predictive maintenance, digestion, digital transformation, digital twin.

1. Introduction

This paper demonstrates how modern digital technologies and methods may be applied to help tackle significant or poorly understood challenges in the refinery operations setting. One approach, as currently being undertaken by Hatch, is presented for such a challenge in the pressure letdown area of an alumina Digestion facility. Here, certain operating modes may lead to widespread and aggressive rates of erosive wear throughout the asset, representing a significant impact to operating costs. Further, under some operating modes erosive wear may be so severe that piping components can fail unexpectedly resulting in significant safety and environmental incidents through release of high pressure caustic slurry.

Supporting the above objective, the concept of digital maturity is introduced to provide a structured approach for the application of digital tools. Focus is firstly placed on providing a framework for consolidating all relevant information and data on an asset-centric basis. Secondly, live digital tools are progressively applied to support operations and maintenance decision making. Central to achieving this aim, complex multi-phase hydraulic models are deployed to provide live insights into current operation as well as predictive information for future asset condition, and to enable simulation across a variety of process and mechanical variables.

2. Digital Maturity

The concept of digital maturity is complex, can take on many forms, and represents a continually evolving journey [1]. The digital maturity of an organization or operation could be measured by its digital strategy or vision, by its governance or change management practices, or even by its culture. A challenge facing many organizations is the internal collection, management and use of data and information; particularly information regarding the design, operation, maintenance, planning and performance of their key assets. Because of this, it is useful to think of digital maturity in terms of the management of data and information.

Digital maturity is often a difficult balance between functionality, complexity and value. 'Big bang' approaches to highly integrated, smart and automated systems can be costly and face significant change management challenges. Overcoming legacy aspects associated with established brownfield systems also make this approach impractical. A more desirable approach is one which gains incremental functionality, complexity and most importantly value. Focus is placed on demonstrating value at each stage of digital maturity by realizing specific and measurable business cases.

Figure 1 shows one such trajectory through various levels of digital maturity. It shows how an operation might progress from being reactive in nature, through to fully understanding the present, and ultimately being able to predict and avoid undesirable events.

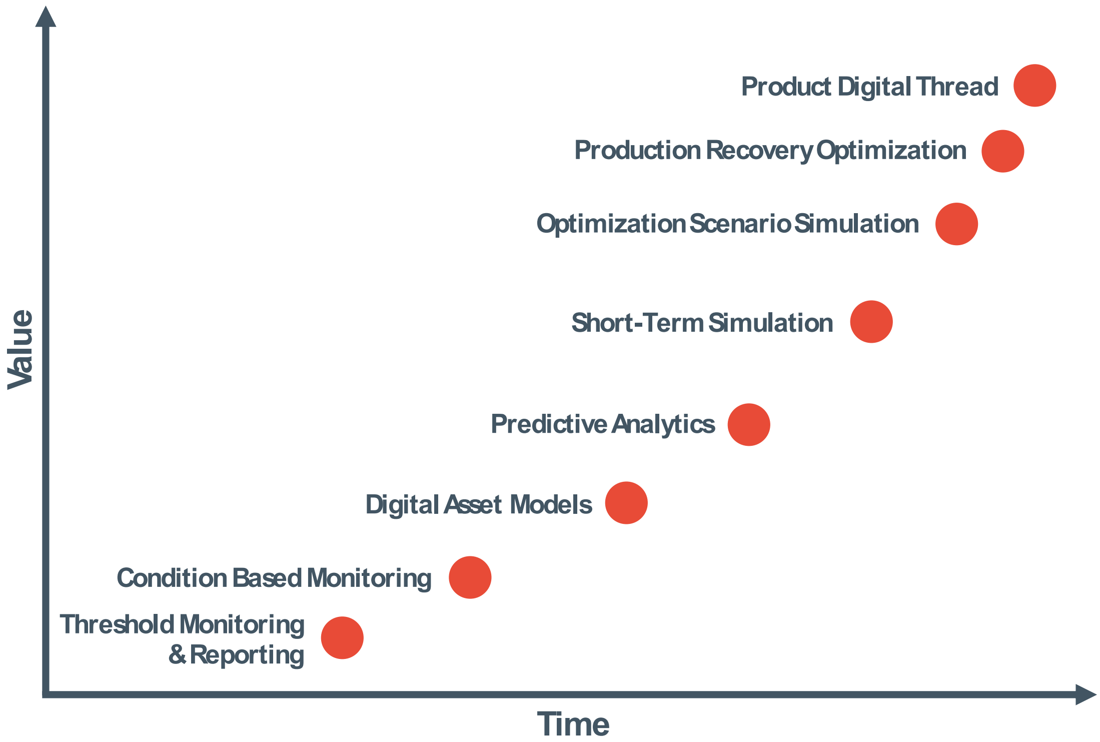

Figure 1. Digital maturity curve.

Moving up the steps presented in Figure 1, we progressively become better at contextualizing, communicating and drawing value from data and information. Further, each step draws on the

- Shipping and logistics channels from mine to refinery
- Conditions during refining, such as general plant configuration, stockpile blending, equipment status and condition, equipment mode of operation during refining (vs. design operating envelope), final alumina quality attained, etc.
- Key aspects of smelting, including energy supply and auditing details
- Shipping logistics to final customer, including customer contract and market conditions during time of sale.

Ultimately, all attributes of the final product (source, quality, quantity, etc.) are linked to all aspects of its production, enabling macro-scale visibility, analytics and decision-making.

4. Conclusion

An array of modern digital technologies and methods are currently available to help transform the refinery design process, improve productivity of operations, reduce maintenance cost and offer the opportunity to redefine business processes and business models. This paper has introduced the concept of digital maturity to provide a structured approach for considering the application of these tools to assist in the digital transformation of complex processing plants.

The various stages of the Digital Maturity Curve were presented and applied to tackle a common challenge in the pressure letdown area of an alumina Digestion facility. A digital twin was created to centralize the various sources of asset information including live plant data, maintenance & NDT information, design documents, as well as digital tools such as analytics and simulation. Complex two-phase flashing slurry flow models were deployed to provide live instantaneous velocities for each piping component and fitting throughout the slurry piping system. Velocities were shown graphically within the digital twin to provide a simple and intuitive means assessing current asset performance and to help fill a major knowledge gap linking process dynamics and mechanical integrity of the Digestion slurry piping. This information supplemented NDT data to provide live indications of asset health via remaining pipe thickness approximations. Analytics were also applied to produce residual life predictions for each piping component. Finally, simulation capabilities were introduced to enable spin-off “what-if” analyses.

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6. References

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