# ESSENTIAL DIGITAL TWINS IN UPSTREAM OIL & GAS PRODUCTION OPERATIONS

Honeywell

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# MANAGEMENT SUMMARY

**Oil & gas producing companies face a number of key challenges today. Oversupply of oil and gas in the short term coupled with the need to reduce greenhouse gas emissions and the loss of valuable industry experience puts a great deal of pressure on the industry's existing staff.**

Additionally, we are currently facing an unprecedented environment amidst Covid-19 where oil & gas companies have to keep producing while minimally manning their operations. In this background, we expect more operators to consider remote operations as a means to de-risk their business and improve operational efficiency.

Increased field automation, remote operations, reduced costs of sensors, Digital Twins, Machine Learning, and improved computational speed are all addressing these challenges.

This article provides insights into essential Digital Twins in upstream oil & gas production operations using industry examples.

# INTRODUCING DIGITAL TWINS

> If you are reading this article, chances are that you have come across the term "Digital Twin". Put simply, a Digital Twin is a virtual representation of a piece of equipment or production process while in operation and can be composed of one or more underlying technologies.

Process Digital Twins can pertain to the reservoir / subsurface e.g., optimization of an inflow control valve to reduce water-cut or on the surface e.g., adjusting the separator pressure or routing the flow of wells from a high-pressure separator to a medium/low-pressure separator. Ultimately, when the process and assets are connected, they result in an Integrated or Digital Twin of the entire asset or plant.

The fundamental technology behind a Digital Twin are various models – first principles models, machine learning models, or dynamic process response models. Often the term used for a combination of first principles and machine learning models is hybrid model.

### DIGITAL TWINS CAN APPLY TO

- Assets/Equipment e.g., Compressor, Well, Electrical submersible pump, etc.
- Process within Upstream Production Operations e.g., Gas lift optimization, ESP optimization, Compressor optimization, Corrosion monitoring, etc.

| DIGITAL TWIN TYPE | DESCRIPTION / APPLICATION | DIGITAL TWIN TECHNOLOGY |
|---|---|---|
| Equipment Digital Twin | Running the steady-state simulation model of the equipment connected to real-time data allows continuous improvement / calibration of the model and is used for understanding if there is a deterioration in performance of equipment | • Steady-state simulation (Simulation model of equipment)<br>• Nodal Analysis (Production Engineering) |
| Process Digital Twin | Process simulation - CO2 Membrane separation, Water Treatment plant, Gas Treatment and Gas Processing plants | Steady-state simulation |
| | Simulation of the production or injection network. An Integrated Digital Twin can include Subsurface – Surface Integrated Reservoir and Production Model | Integrated Production Model / Integrated Asset Model |
| | Operator training simulators commonly used to train operators on the operations of process facilities / topsides in Upstream | Dynamic simulation |
| | Stabilization and Optimization of the operation of an individual equipment / unit or process and closed- loop process control (e.g., Compressor control, Gas Lift optimization, ESP optimization, Inflow Control Valve optimization | Advanced Process Control / Model Predictive Control |
| | Real-time detection of corrosion along with surveillance data used for understanding internal corrosion risk in oilfield production – onshore and offshore, in wells and pipelines | • Top of line corrosion model<br>• General corrosion model |

# DIGITAL TWIN FIRST PRINCIPLES AND MACHINE LEARNING MODELS

**Both First Principles and Machine Learning models have been used in the Upstream Oil & Gas industry. While technology and computing power has certainly transformed the power of Machine Learning models, First Principles models continue to have their advantages. They include:**

- Often models are available from the engineering phase of the project – especially in greenfield projects
- Better trust in the models as operating conditions change – since First Principles models are built on laws of physics, fluid flow, thermodynamics, and chemistry, they can determine the expected equipment or process performance when process conditions change with time
- Compare the current operating condition vs. the design envelope of the equipment / process honoring all constraints related to reservoir management and flow assurance
- Consider opportunities to optimize the operation of the equipment and / or process
- Soft sensors / virtual sensors to estimate operating parameters that are not measured or compare theoretical parameters vs. measured parameters from sensors and use this data to detect any faulty sensors
- Analyze impact of transient operating conditions (e.g., well start-up, subsea well / pipeline cooldown during production shut-ins)

A Digital Twin solution that combines both First Principles and Machine Learning models is expected to provide a far greater benefit than each of these solutions on their own, and this is where decades of experience in modeling, simulation and operations becomes very important.

# DIGITAL TWINS FOR THE AUTONOMOUS OILFIELD

**Much has been written about the promise of digital technology in the Upstream industry. Increased amounts of sensors, clever engineering using smartphone capabilities, and Machine Learning applied to the autonomous car application have given rise to terminology such as "autonomous well," "autonomous oilfield" and various other terms used to describe wells and process equipment whose operating parameters are changed autonomously to optimize production.**

The technology to automatically adjust operating conditions of wells and process equipment i.e., closed-loop process control has existed for decades. Honeywell's Advanced Process Control (APC) technology has been used by a major offshore operator in their Ula - North Sea, and Marlin - Gulf of Mexico, offshore assets. Other industry examples of APC implementation in artificial lift is the usage of APC technology for adjusting set- points of Electrical submersible pumps to optimize production while minimizing electrical power consumption. APC goes one-step beyond Integrated Production Modeling in closing the loop, also known as closed-loop process control. Those who understand this subject also know this technology is routinely applied in the oil & gas downstream and process industries.

The obvious question then is what limits the Upstream industry from adopting this technology?

Listed below are various challenges that we come across – some of them are common across industries, while others are unique to Upstream Oil & Gas.

1. Difficult to sustain APC implementation as it needs maintenance / tuning
2. More emphasis on the well / subsurface and less on the process facilities
3. Low oil prices / cyclical industry, loss of experienced personnel
4. Lack of motor-operated valves / wellhead instrumentation and generally poor instrumentation in many assets
5. Constantly changing fluid conditions as the reservoir depletes
6. Wells are constantly being added (new wells coming online)
7. Monitoring and service of equipment such as ESPs is an outsourced service, or ESP is a rented equipment
8. Changing lift type over life of well in Unconventional field development
9. Concerns on IT security resulting in sabotage attacks that can shut down a field

Because Honeywell has worked on a number of such projects across multiple industries, our solutions have evolved to address the above challenges. As an example, Honeywell's Control Performance Analytics (CPA) software is used to address the challenge of APC benefits being lost over time because of a lack of maintenance.CPA allows visibility into this loss by quantifying the opportunity lost with time and enabling operators to take pro-active action in re-tuning the APC model.

# CONNECTED OR COMPOSITE DIGITAL TWIN

**In a world inundated with an increasing number of Digital Twins and AI/ ML vendors, what differentiates the leaders from the rest? Deep domain knowledge, industry experience and a track record in building Digital Twins and connected solutions are what distinguish technology leaders. A Connected or Composite Digital Twin connects one or more Digital Twins to represent the performance of equipment or the process.**

This is because various simulation models are available that are purpose-built / best-in- class for specific type of equipment or processes. However, in Upstream Oil & Gas, fluids move from the reservoir through downhole completions into the wellbore, and through manifolds into the production separator, and may also go back (injected) into the reservoir. This is one reason for connecting or integrating the Digital Twins. Wells can have a combination of advanced completions such as inflow control valves and electrical submersible pumps. Chemical inhibitors may also be injected into the well for flow assurance.

Let's review an industry example for a better understanding of the Connected Digital Twin. Here, we have ESP producer wells flowing into the gathering network. Using algorithms that look for patterns in data, it is possible to predict a likely ESP failure a few days before the actual event occurs. This is hardly a differentiator from an integrated solution standpoint, since a large number of service providers can provide a Predictive Analytics point solution. Knowing an ESP is going to fail is important, as operators can prepare for pulling out the ESP before failure and/ or plan for a replacement ESP. More important is the ability to keep running the ESP within its operating envelope to extend the equipment's run life. What are the additional things that can be done beyond just raising alarms when important ESP parameters go out of range? Continuous optimization is one such important action where the ESP is operated to remain as close to possible to its ideal condition.

Now let's understand possible linkages between the ESP, Chemical injection and Pipeline integrity as a "Connected" example. Since ESPs are driven by motors, thermal energy released by the motors raise the temperature of the production fluids. Corrosion inhibition chemicals are often injected to minimize corrosion in the production pipeline network but lose their effectiveness above a certain temperature. The corrosion inhibitor also loses effectiveness in certain flow regimes that require an understanding of the flow conditions within the production network. If a Digital Twin were to be built to monitor this process, we would need to connect the data from the ESP (i.e., Equipment Digital Twin) and the production system, including fluid flow, fluid temperature, concentrations of chemical inhibitor, and corrosion rate (i.e., Process Digital Twin). In this example, the ESP motor temperature could have an adverse impact on pipeline integrity. This is where a Connected Digital Twin and domain knowledge come in to realize Integrated Operations or integration across disciplines. The Process Digital Twin can also provide useful information on whether chemicals are being over- or under-injected when combined with surveillance data. This capability has the potential for huge savings from reduced chemicals usage while mitigating asset integrity risks.

# INDUSTRY ADOPTION

**Honeywell has been delivering Digital Twin technology for the Oil & Gas industry for over 20 years. Adoption of this technology is increasing as oil prices remain low, along with reduced demand and increased regulatory pressure related to greenhouse gas emissions.**

As a result, we see greater interest in Digital Twins that can enable operators to improve their performance through Asset and Enterprise Performance Management. More specifically, this includes solutions that improve equipment efficiency, reduce downtime and enable condition-based maintenance and energy efficiency of equipment and processes.

Typical benefits as a result of using Honeywell technology include increasing production by four percent, reducing energy costs, and saving $1 Million USD per year in taxes due to CO2 reductions. Additional benefits coming from improved equipment condition and process and corrosion monitoring can result in an estimated $8-10 Million in savings.

Last year, Honeywell signed a 10-year partnership agreement with ADNOC Group for one of the world's largest predictive maintenance projects in the Oil and Gas industry.

# CONCLUSION

**The back-bone of Digital Twins are various modeling technologies, which continue to undergo improvements as the industry has always done. Advances in computing power, Big Data, Machine Learning and sensors, combined with lower technology costs, are driving increased adoption of Digital Twins.**

Domain knowledge and industry experience are the key ingredients to success and maximization of benefits from this technology.

The Oil and Gas industry will continue to see increased adoption of remote Asset and Enterprise Performance Management solutions enabled by Digital Twin technology. Newer fields with the required instrumentation and control hardware for remote operations will provide opportunities for closed-loop control. As technology advances and engineers become more comfortable with these technologies, we expect to see increased adoption rates in Upstream operations.

References

1. ADNOC, Honeywell embark on one of the industry's largest predictive maintenance projects – World Oil, Nov 2019
2. Use of Advanced Process Control for Automating Conventional Oilfield Operations, Society of Petroleum Engineers paper SPE-192393-MS, April 2018
3. Honeywell Brings Energy Accounting to Remote Offshore Oil and Gas Production: Case study, Aug 2019
4. Shell Deepwater taming Big Data Whale - Exception-based Surveillance Helps Manage Hundreds of Millions of Daily Data Points, Control Global – June 2013
5. The online use of first-principles models in process operations: Review, current status and future needs – Computers & Chemical Engineering, Vol 51, pages 136-138, April 2013
6. Control optimization on Ula cuts $1 Million / year in CO2 taxes – Offshore Magazine, July 1999

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Vineet's strengths include a deep domain understanding of Upstream production operational challenges, production optimization / artificial lift optimization and Integrated Operations. He has consulted with major clients internationally, including the US, UK, Italy, UAE, Saudi Arabia, Qatar,Kuwait.

Vineet is a frequent speaker at Society of Petroleum Engineers (SPE) events and has several technical papers authored in Digital Fields. He is a core member of Honeywell's Oil & Gas Technical Solutions Consulting group based in Houston. Prior to joining Honeywell, Vineet was Global Industry Solutions Advisor – Production & Reservoir Management for Halliburton.

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