Digital Chemistry – Our path to Versalis Smart Plant

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Abstract

Versalis has always considered the adoption of IT technology in industrial plants in synergy with OT technologies as a fundamental factor to ensure effectiveness, efficiency, safety and sustainability in the production processes of its industrial plants. Historically Versalis plants have always been operated with the support of advanced control systems and field data collection systems which are boundary between process systems and management systems. However, in the last 10 years, thanks to the maturity reached by advanced analysis algorithms, AI, IoT systems and integrated collaborative platforms, the design of the "Smart Plant" has been progressively defined. The recent push towards a complete review of the maintenance model, shared with all Eni downstream business, has also further evolved the ambitious reference target.

In Versalis the "Smart Plant" embraces all site and Head Quarter operations processes, and IT and Business functions are working together along our transformation roadmap.

Operation area:

* full operation production systems replatforming with introduction of a single centralized cross-site Industrial Platform:
* modeling and monitoring of the production process for all different types of production lines both liquid and solid products by integration with field data collection systems and laboratory data system
* centralized HUB for access to industrial data to support monitoring of production efficiency and plant management, circular economy, CO2, energy management
* machine learning models for advanced analysis of field sensors (recognize faults and operational deviations on critical assets in advance, optimize the process quality parameters, emission monitoring)
* use of High-Performance Computer and specific package for fluid dynamic simulation
* digitalization of on-site logistics processes, warehouses and tanks
* planning support system (production planning and scheduling, turnaround and day by day ordinary maintenance activity planning scheduling and execution)
* digitalization of processes from a paperless perspective (information flows with external government entities such as “ARPA” and “Customs and Monopolies Agency”)
* Digitalization of field operators' activities by mobile devices for remote information and documents access and for manual data collection

Safety area:

* Real-time health and PPE monitoring of operators on field and in confined spaces and digitalization of work permits preparation and authorization process
* Machine learning models for risks predictive alerting

Cyber Security Area: network segregation, system access control enforcement and network traffic continuous monitoring

**Keywords**: artificial intelligence, machine learning, industrial platform, process digitalization, real-time data, safety, cyber security

* 1. Digital Chemistry

Our path towards the smart plant is fundamentally based on data valorization to increase productivity, reduce risk and increase plant uptime, process digitalization to ensure operation efficiency, iot technologies to increase safety and best practices adoption to increase cyber resiliency.

* + 1. Artificial Intelligence

Versalis has always believed in the potential of data and always considered the adoption of IT technology and artificial intelligence in industrial plants in synergy with OT technologies as a fundamental factor to ensure effectiveness, efficiency, safety and sustainability in the production processes. Historically Versalis plants have always been operated with the support of advanced control systems and field data collection systems which are boundary between process systems and management systems. However, in the last 10 years, thanks to the maturity reached by advanced analysis algorithms, AI, IoT systems and integrated collaborative platforms, the design of the "Smart Plant" has been progressively defined.

Focusing on AI, Versalis journey through machine learning and deep learning models can benefit on Eni AI center of excellence with strong internal skills that oversees market technologies, tests them, and engineers them to encourage agile and at the same time conscious use.

Versalis started with the development, through internal resources of data scientists, of specific use cases and now has a set of engineered environments to develop its own or package-based models [1]. The first machine-learning models were targeted to intercept and predict degradation phenomena in asset performance to increase production capacity and optimize maintenance activities (for example the prediction of cracking furnaces’ coking and runlength for next decoking activity simulation, prediction of furnace vaporizers fouling, root causes analysis of plate fouling and formation of agglomerates phenomena in polythene’s reactor, compressor failure prediction). Over the years it has been put in place a cloud platform environment as hub for machine learning, first for R&D [5], then extended to any use cases that leverage field sensors data, with the aim of speeding up and engineering the ingestion, modeling, notification and results sharing phases. At the same time, market solutions, with physical or data driven approaches, were evaluated, and adopted to increase the speed of diffusion by exploiting the knowledge gained in non-specific application areas [3]. The recent emphasis on generative AI has been also treated with a structured approach, starting from understanding the potential of technology, testing it in experimental contexts and conducting assessment sessions of potential application areas from which use cases emerged in terms of training support, maintenance activity on filed support, plant image evaluation, automatic report generation and process trouble shooting support.

* + 1. Industrial Platform

The main factors that inspired the rethinking of the industrial operations application portfolio were systems capacity for scalability and flexibility with respect to the corporate structure evolution needs, and the opportunities to improve collaboration and the valorization of data that the new platforms and market solutions can guarantee together with consolidation of some application components geographically distributed.

We designed our model by capitalizing and consolidating features and processes on a centralized, modern and flexible collaborative platform that we recently introduced into our application portfolio, the Dassault Systeme platform (collaborative operation platform COP) by integrating it into a composite architecture with specific domain package and where necessary custom packages developed with a platform as a service perspective. The mantra that guided our choices can be summed up in three words: modernize, centralize and share. In this context, the target model that we have defined and the project streams that we have activated provide:

* implementation in COP of recipes management and production budget, tracking and accounting by consolidating geographically distributed components in the local data rooms
* implementation and consolidation in COP of industrial reporting for production efficiency calculation on a monthly and daily based, extension to energy management and CO2 calculation and near-real-time monitoring of the main plant phenomena
* implementation of an environment for simulation integrated with recipe and margin calculation models to support what-if analyses
* implementation of a custom cloud solution to support tank farm management and digitizing the integration flow with “Customs and Monopolies Agency”
* implementation of a mobile app integrated with COP to support field operations digitalizing data collection and reporting unsafe conditions

The program is very ambitious due to the breadth and relevance of the processes involved and the industrial sites impacted on an international level. It is currently underway and is expected to be completed by 2025 [2].

* + 1. New Maintenance model

In the Maintenance area, has been activated a program that aims to increase operational effectiveness and optimize costs through the simplification and digitalization of processes and the introduction of artificial intelligence capabilities. The scope of the program cuts across the various downstream oil, chemical and power generation businesses and is related to warehouses technical materials optimization and maintenance processes optimization (predictive and prescriptive maintenance, ordinary maintenance, turnaround management). The program consists of 7 project streams to leverage, evolve and share solutions that have proven effective in different businesses and 1 project stream which involves the introduction of a new platform. All the project streams are underway and expected to be completed by the end of 2026 [3].

* + - 1. Maintenance

In the maintenance area the main streams are:

* smart ​maintenance ​worker: creation of an integrated maintenance platform that leverages and integrates existing asset integrity systems, field data acquisition systems and ERP system, digitalizing field activities and enabling collaboration between skills
* paperless office: implementation of a custom cloud solution for workflows and documentation digitalization along the maintenance orders creation and accounting process flow​ ​
* turnaround coworking tool: preparation of a common multi-business repository for sharing multi-year shutdown plan to intercept potential synergies or related risks
* integrated operation windows: implementation in COP of a sensor monitoring solution for critical assets to intercept operational conditions that can accelerate degradation phenomena and compromise the assumptions underlying the Risk Based Inspection analyzes​​
* asset ​performance monitoring​: adoption of an artificial intelligence solution for the advanced monitoring of critical static and rotating assets for predictive e prescriptive recognition of failure patterns (failure agent) and deviations from reference operating conditions (anomaly detection agent); the adoption of a market platform based on machine learning technologies allows us to accelerate the roll-out path on the main critical assets on different plants.

As an additional stream we started a study to identify a new platform in the maintenance management system area to support the planning, scheduling and execution processes of ordinary, extraordinary and turnaround maintenance activities.

* + - 1. Asset Performance monitoring focus

The identified solution for advanced asset performance monitoring is package based Aspentech MTELL that has already been successfully implemented in refinery context and deployed on a range of equipment such as furnace, heat exchangers, pumps, columns, compressors, reactors & boilers. The package that combines physical and data driven approach and offers different type of agent that allow you to choose the right one based on your maintenance strategy:

* rules based, best for simple monitoring: monitor sensor and calculated sensor data in real time to trigger alerts when data points are out of bounds
* conditions based, best for rapid response: correlate sensor and calculated sensor data with usage to trigger alerts for degradation that is occurring
* first principle based, best for assessing degradation: physics-driven calculations to assess asset degradation based on pre-defined criteria
* machine learning, best for predicting degradation: proven, pre-selected pattern recognition algorithms to predict asset degradation based on embedded domain knowledge
* brind your own model, best for unique use cases: custom-created algorithms by citizen data scientists for advanced / unique use cases

We are in a roadmap to deploy the solution on the main Versalis over the next 2 years starting from the main critical asset and process, based on a value map with measurable critical success factors that covers production gain, environmental gain, maintenance and inspection planning optimization.

* + - 1. Material and spare parts warehouses

In the warehouse management area, the main streams are:

* warehouse dashboard: implementation of a shared monitoring environment for the technical materials and spare parts warehouse stock to improve single business control and enable cross-business synergies in the use of surplus materials
* warehouse automation: adoption of a market package specialized in the automation of inbound, outbound and inventory processes of technical materials and spare parts using RFID, BARCODE, QRCODE technology integrated with the company ERP
  + 1. ​ Digital Safety

The safety of operators on field has always been a priority for Eni and Versalis and therefore over the years different technologies have been tested and adopted to support the prevention and mitigation of risks connected to the activities carried out by internal and third-party personnel at our plants. Also, in this area, the interventions are divided into different streams:

* electronic work permit: we developed an Eni application, to support the process of compiling, managing and archiving work permits with the aim of increasing control and monitoring of all the risks connected to the process, prevent interference between different maintenance teams operating in the same area, digitize work permit documentation, with easier archiving, retrieval and tracking of information
* smart safety: use of wearable devices and algorithms able to detect dangerous situations in real time through specific use cases for monitoring the use of personal protective equipment, monitoring access to restricted areas, automatic "man down" notification, SOS requests, management of system emergencies with automatic counting at the safe point and geolocation in the plant
* safety pre-sense: application of natural language processing and machine learning models to predict possible risk situations through advanced analysis of the amount of security events recorded in the central Eni repository to generate alerts from weak signals or recurring situations of danger and enable a new approach to incident prevention and improvement of recording and analyzing safety data and the possibility of increasing prevention through targeted actions; in this context, an experiment is underway to extend the scope of analysis also to process data to correlate them with incidents (e.g. maintenance interventions in the plant)

The roll-out program in Versalis plants is underway and specific KPIs are calculated to ensure the maximum possible benefit in terms of safety of personnel in the field [4].

* + 1. Machine Learning HUB

The potential that arises from the use of advanced analytics models in operations, R&D and HSE has pushed us to set up a cloud environment on which to quickly and easily implement models for different use cases [5].

The characteristics of the environment we have implemented are:

* enhance the representative and collaborative capacity of analyzes between functions through advanced, real-time and mobile data visualization tools
* design an enterprise solution for the ingestion, modeling, notification and sharing phases of plant monitoring via machine learning
* already opened near-real-time field and laboratory data integration and further data sources ready to set up ensuring scalability

More specifically, in the hub we created models based on machine learning technology:

* models for optimizing the quality of production processes through real-time data monitoring from process data, laboratory data and other unstructured data sources
* ARMA models predicting the value of the main emission parameters for cracking furnace and polymer plant to be capable to monitor these parameters even in case of dedicated sensor fault.
  + 1. Cyber Security OT

The growing threat represented by cyber risks led us to activate a broad enforcement program across all industrial sites aimed to enforce the resilience of OT systems.

An assessment study completed in the past have allowed us to set up a program with a risk-based approach which is divided into the following intervention guidelines applied according to a model consistent with the mapped risk cluster:

* business continuity system enforcement and cyber active monitoring probes
* network segregation enforcement between process network connected with industrial control system and office network connected to filed data acquisition system
* data acquisition system hardening and continuous lifecycle management of industrial control system
  1. References in the text
  2. Conclusions

The digital chemistry vision contributes and aligns with Versalis’s strategy aimed at maintaining technological and industrial leadership to maintain a positioning in the market of high added value applications, be a completely sustainable and diversified company and contribute to achieving the goal of carbon neutrality.

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