PharosN Use Case: Integrated holistic operational control of manufacturing processes in metal production plant

Manufacturing process overview

The fabricated metal production is one of the largest industrial sectors in the developed countries. It is traditionally conservative and resource consuming especially in raw materials, energy, water and has various environmental impacts in many forms including solid waste and wastewater, gases and particles matter, noise, traffic, etc. As the employment in the industry decreases significantly over the last 50 years the sustainability of the enterprises has significant impact on many jobs in their relevant locations.

We present the practical use case of metal pipes manufacturing plant in Europe to analyse its typical processes and identify the ways how manufacturing efficiency and sustainability of such large scale manufacturing can be improved along with the decrease its negative environmental impacts by enabling AI-driven integrated manufacturing processes automation in compliance with Industry 4.0 concepts.

Use case: Metal pipes manufacturing plant

The typical workshop for the metal pipes manufacturing supports the complete production cycle of the seam pipe from the raw material - the roll. A schematic depiction of the workshop is shown in the Figure 1.

The operation: Rolls with the help of motor vehicles are brought to the warehouse, where they are unloaded and entered into the database of the shop. The rolls, with the help of a crane, are loaded onto a slitting unit, where the roll is cut along — into strips of a given width — strips, from which, subsequently, a pipe is made. The strips are reloaded to the semi-finished product warehouse, which is also sold, if there are orders for this product. From the warehouse, strips, with the help of a forklift, are transported to a hopper that provides stock for the continuous operation of the rolling line.

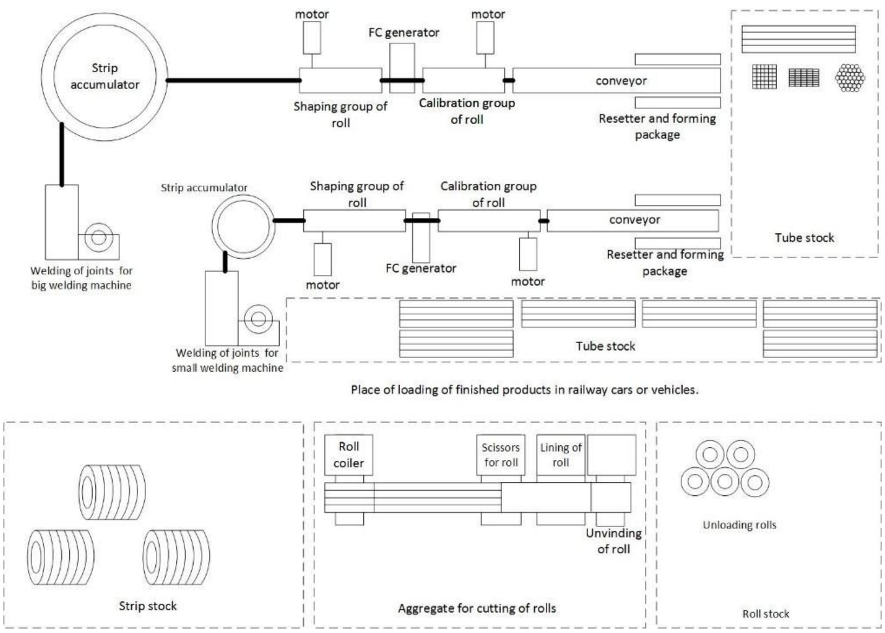

Figure SEQ Figure * ARABIC 1 Schematic depiction of typical metal tube manufacturing facility

Before loading into the drive, the joints of the strips are welded; a continuous strip is produced for the production of the pipe. The strip is fed to the rollers of the rough (forming a round profile) stand, where the initial shape is given to the blank. After the roughing stand, a welding machine is installed - a high-frequency generator. When passing through the HF generator, the pipe is welded, and then the round pipe passes through the refrigerator to the finishing (calibrating) group of stands.

After the calibrating group of stands, the pipe is cut into fragments of a given length and sent by conveyor to a reset device, which drops the pipe into one of two pockets. When the pocket is full, the packers overtighten the finished package with steel tape and send it to the warehouse with a crane.

In stock, storekeepers attach a tag with package parameters and with the help of cars, or railway cars, send a pipe to the customer. In this specific use case the workshop uses water from own well after its filleting by the filtration station located on the workshop territory. For cooling inductors, pipes, rolls, chemical emulsion is used to prevent equipment and pipes from rusting. The emulsion content in water is controlled by the operator.

Systemic inefficiencies in metal pipes manufacturing and its roots

When designing and modelling a shop management system, one need to cope with a number of difficulties such as distance between buildings and manufacturing structures spread over large territory and diversity of various sensor interfaces, and complex mathematical models for describing the technological process and the lack of communication between the subsystems. There are many factors also implicitly influencing the manufacturing process flow.

A significant part of those is beyond the technology. For example, the speed of production is influenced by the speed of cars delivering rolls to the warehouse, the presence of an emulsion in stock used to eliminate rusting of pipes during production, the presence of an employee at the workplace who has the right to issue this reagent, the level of purified water in tanks, the speed of issuing permits on the entry of vehicles carrying rolls and many other factors.

Due to the inability to establish an optimal production process, there are multiple causes of losses in productivity and efficiency. For example, on average, an overrun of cooling water is statistically ~70-80 cubic meters / month, and an overrun of emulsion concentrate is ~ 0.4-0.6 cubic meters / month, and electricity ~ 900-1100 kW * h / month, unplanned stops due to for repair and changeover of equipment, 10-12 hours resulting in underproduction of ~ 90-105 tons of pipe products and losses of ~50,000 EUR per month as well as various waste components.

Figure SEQ Figure * ARABIC 2 Typical manufacturing assets in metal pipe plat operates independantly without real time management of the whole plant as a big system

Implementation of integrated manufacturing based on PharosN platform

The advanced functionalities provided by PharosN IoT software platform allow considering the manufacturing processes as a whole i.e. the plant as big system of multiple systems that shall operate together effectively and sustainably. PharosN tools allow designing the holistic model of the metal pipe production plant as cyber-physical system (CPS) presenting its digital twin linking various systems existing in physical and virtual worlds in compliance with the Industry 4.0 concepts.

Linked to all sensors, IoT and isolated control systems that realise different production sub-processes, the digital twin obtains real time information about all ongoing processes, analyses each of them individually using appropriate machine learning algorithms, calculates all process dependencies, monitors links between different manufacturing objects and introduce relevant controls to achieve main goal: Maximising efficient and sustainable system operation as whole.

The application can be perfectly integrated and customised for any specific production structure including legacy machinery. It has exceptional flexibility, adaptability and scalability in linking various subsystems (see Figure 3) and enabling real time digital transformation of big data.

The resulting intelligent manufacturing system allows calculation of the process results using custom indicators and its comparison to planned process data and its automatic correction upon the deviation from the specified course of actual manufacturing process results. The real time analysis and control of these complex technological processes is implemented with the distributed CPS model of the plant as the orchestrated set of collaborating digital twins. Each twin is set and running on local intelligent assets management modules using advanced machine learning methods and neural networks.

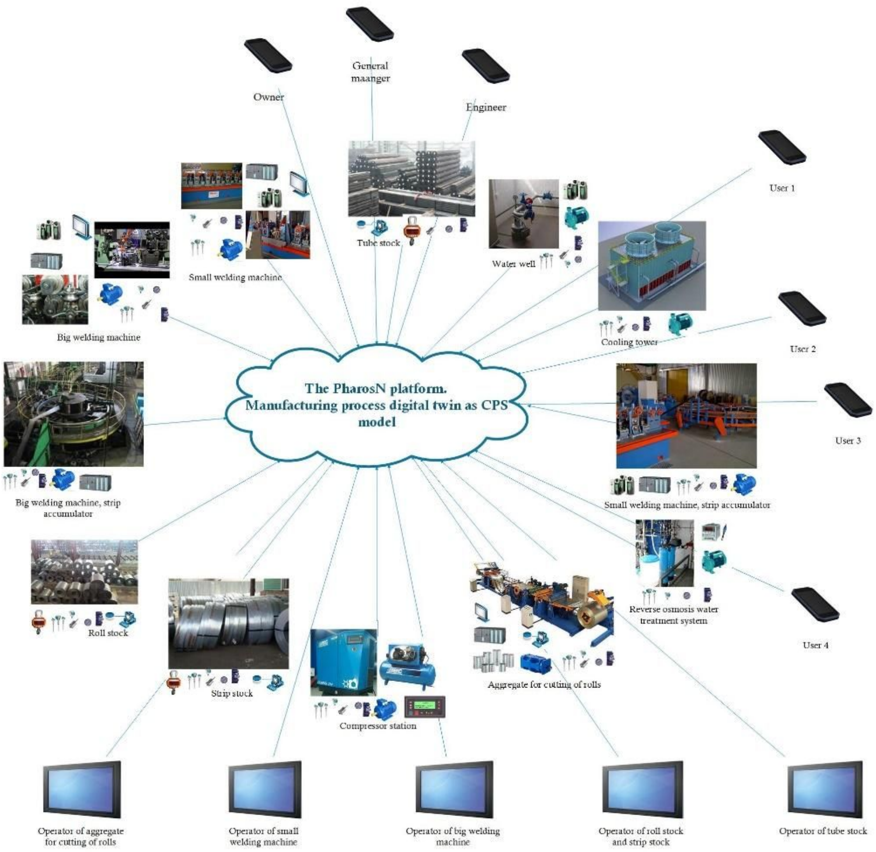

Figure SEQ Figure * ARABIC 3 Automatic real time monitoring and control of manufacturing processes using industrial CPS running at PharosN platform in cloud

Predicting each state of the production process, possible errors in the operation of the manufacturing assets based on the holistic vision of totality of all current states of the industrial system objects included in the model, allows operators and managers quickly and promptly troubleshoot having system support in prescriptions including condition monitoring and maintenance scheduling and make rational use of the time allotted for the planned repair of the units.

The AI-assistance significantly fosters the ability to manage and calculate the optimal work tasks for the components and assemblies, proving automatic calculation of all necessary technical and economic indicators, and optimising the production based on the selected optional parameters (minimum lead time, minimum cost of order fulfilment, special requirements for the quality of the seam, etc.).

The PharosN application implemented in the described use case allows holistic real time monitoring and analytics and control of all business and operational results of the metal pipe manufacturing plant for its management. Compared to the initial pre-project results there were many improvements including business sustainability, performance, quality of products, decreased waste and stoppages and maintenance costs.

The online demo of the Smart Enterprise Monitor application is available by the following link: http://pharosnavigator.com.

Contact for inquiries: info@golem.at