Challenges for the transition of legacy machine tools to Industry 4.0 compliant equipment

Modern manufacturing initiatives, such as Industry 4.0, are aiming to push the digital transformation of the manufacturing sector. **The usage of sensors in the machines**, which are interconnected with one another, as well as with other levels of the product lifecycle, such as the design and operating life of the product will be introduced to a wide audience.

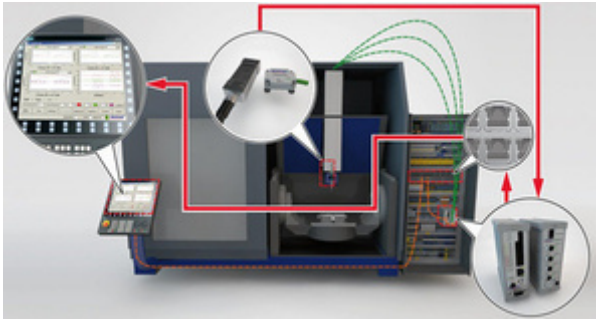
Therefore, technologies that provide the ability to manage this amplitude of data and process them are key elements of this era. As such, manufacturers are called to **update their shop floor assets, including their machine tools, among other equipment**, into Industry 4.0 compliant equipment that fulfills the aforementioned characteristics. Machine tool builders are also aware of this trend. Most new machine tools come with a set of added functionalities, such as connectivity with other digital systems of the factory, sensorization, etc. that are as important and seeked for, as improvements in their performance (accuracy, productivity, etc.).

However, overhauling the whole shop floor with modern machine tools is not the answer for most end users. Instead, there is an effort assigned to **updating legacy assets to adhere to Industry 4.0 principles.**

Why does one consider updating legacy assets instead of purchasing new equipment?

A logical question that is raised is why would one assign effort into updating an older machine, which always requires custom solutions and adaptions, instead of buying a new, fully equipped machine tool from an OEM, without the hassle of integration of external systems. First and foremost, **the investment** cost to overhaul an entire factory can be unfeasible for most manufacturing companies. Even if that is not the case, decommissioning a machine before its end of life does not make economic sense. Additionally, it is important to note that in most sectors, **machine tools that are 5–10 years old are not Industry 4.0 compliant.**

Sectors, such as machining, Additive Manufacturing and injection molding, have made some steps forward, but full connectivity is usually limited to brand new, flagship machinery. In that sense, fairly modern, perfectly good machines that do not have compromised performance would need to be replaced with newer ones. Considering also the sustainability aspect, it is a bad practice to throw away good equipment instead of retrofitting it and make it aligned with modern standards. To this end, digital retrofitting of legacy equipment seems promising. Nevertheless, it also brings a set of challenges that need to be surpassed.

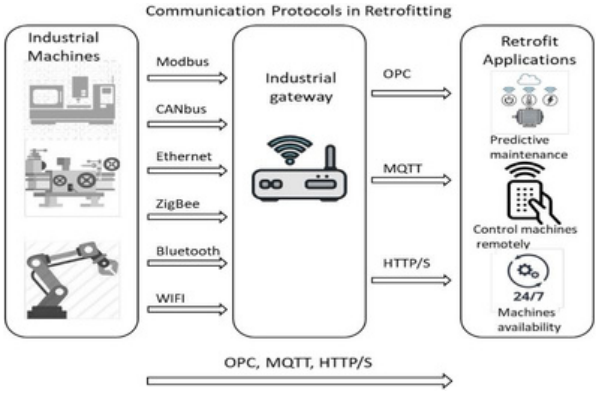


Challenges of hardware integration

The first step towards digitalization of manufacturing assets is **the addition of suitable sensors** that can harvest the data required for each final application. However, integration of such sensors needs to be **non-invasive.** Additional sensors that might be installed should not interfere with machine operation or alter its structural behavior, while being close enough to the manufacturing process, so that they can effectively capture process-related data.

To achieve this effort, **miniaturization of sensors and electronics** enables deep integration in tooling. Such examples include integration of sensors in machining tooling (vise, tool-holder, etc.), or tooling of forming processes (injection molds, forming dies, etc.). Wireless communications help in installation of sensors in movable parts of the machine tool. Additionally, utilization of internal sensors of the machine used for its operation (e.g. sensors positioning system) can be utilized to capture information in a non-invasive fashion.

Challenges of software integration



Next in the line is the challenge of **software integration.** Controllers that are more than 10 years old usually rely in older communication protocols that are either proprietary per brand or are not fully standardized among different manufacturers. A typical example of that is the OPC-DA communication protocol (also known as OPC Classic), which has been an effort towards an open communication protocol that could be standardized among PLC manufacturers. Nevertheless, setup of OPC-DA communication is still not a straightforward task, compared to its modern version (OPC-UA), which has become an industry standard for industrial IoT.

In that sense, there is a need for connectors to be built to enable communication between legacy machines and new Industry 4.0 applications.

Furthermore, diverse sets of sensors and heterogeneous data (monitoring, QA, etc.) need to be registered and linked to CAD and simulation data. This calls for standardized data formats and data modelling approaches to support handling of large datasets from diverse data sources.

Business-related challenges and opportunities

Digitalization of manufacturing assets can disrupt the way manufacturers set up their business models, turning product-oriented enterprises to service-oriented ones. Connected machines manufacture products that are enhanced with traceability aspects. This enables manufacturer end users to create additional value for their products, by leveraging the process-generated data, which can be utilized for certification of a component in highly regulated sectors (e.g. medical, aerospace) or correlation with defects or failures that might emerge during its operating life. It is evident that data are now valuable, so this brings new challenges in protecting generated data from a factory.

Data privacy aspects need to be ensured, which requires the reinforcement of existing networks of companies. Additionally, IP between manufacturer end users and providers of technological solutions (sensor and monitoring systems) providers need to be clearly distributed, as it comes to process-generated data

How does R3GROUP contribute to this transition?

R3GROUP is a project that is heavily focused on **supporting and advancing the digital retrofitting of existing manufacturing assets**. 3 out of the 5 pilot lines of the project are based on 100% preservation of their legacy equipment, advanced through digital retrofitting.

R3GROUP will develop solutions for digitalization of existing manufacturing assets, through non-invasive integration of sensors and use of internal machine data to enable applications ranging from predictive maintenance to advanced process monitoring. Additionally, a secure and robust data exchange platform, based on the Asset Administration Shell, utilizing connectors with many modern communication protocols (OPC-UA, MQTT among others) will enable seamless data exchange between manufacturing assets and software tools. These solutions will be available for testing through the R3GROUP open calls.

Written by **Thanassis Souflas** - Research Engineer at Laboratory for Manufacturing Systems and Automation