Article

4.0 Technology for machine tools of the future

Aitor Alzaga, Coordinator of Industry 4.0 and Javier Arzamendi, Coordinator of the Machine Tool sector at IK4-TEKNIKER

Digital technology linked to the so-called fourth industrial revolution has caused heightened expectations in the machine tool and advanced manufacturing sector. Interconnected equipment, fully automated lines, robots which work with people, smart factories. Ultimately, new business models have been ushered in by technological advances which will transform industrial plants.

But, in order to better understand the current situation and to prepare ourselves for the challenges of the future, it is important to take a look back and analyse what has happened since the third industrial revolution.

The 1980s saw the incorporation of electronics and the arrival of numerical control (CNC) for machine tools, the consequence of these factors being the obsolescence of previous equipment.

Later on came the introduction of flexible production lines which had the overall effect of creating manufacturing cells containing, on the whole, just one machine, which made them more profitable and more reliable.

From the moment CNC was incorporated into the machines, factories starting working to achieve higher levels of precision in the manufacture of parts. To this effect, optical rulers were integrated alongside systems for machine-based measuring and calibration.

Once the precision that such machine tools could achieve had been demonstrated, the next step was to improve productivity and thereby increase profitability. For this to happen, new tools were developed as well as machines with higher mechanical capacity (higher velocity, power, torque, rigidity etc.). Furthermore, systems were created which reduced down time (automatic loading and unloading, quick tool and head change, using robots for multiple tasks, etc.).

The introduction of open loop controls also permitted real time monitoring and processing of external sensors and internal propulsion signals, which in turn made it possible to track the status of the tool, vibrations, collisions, etc. In this way, the level of autonomy and reliability was increased.

In recent years, advances have been made in the production of multifunctional machines which combine various different processes in such a way that a larger number of actions can be carried out in a single clamping, thereby removing the need to manipulate the part.

One aspect that has only been taken into consideration in recent years is the energy efficiency of the machines. Machines have to be designed and sized so as to provide the greatest reduction in life cycle costing and to be as environmentally friendly as possible. To achieve this, great strides have been made in the use of new materials, the reduction of coolants, recycling, the use of higher performance components and in the reduction of space occupied in the plant, amongst other factors.

All this progress has brought us to our current situation, the fourth industrial revolution: a setting which poses big challenges for the machine tool sector.

What will this new paradigm bring?

From a technological point of view, 4.0 concepts present many possibilities to the machine tool sector. However, the question raised by many buyers and users of the equipment is how to make the best use of it.

In order to structure an analysis of the elements which can make a business more competitive and the service that we need to demand from the machines, it is useful to have a benchmark.

In the diagram shown below you will find a detailed breakdown of the Industry 4.0 general model for machine tools developed by IK4-TEKNIKER for diagnosing and identifying opportunities.

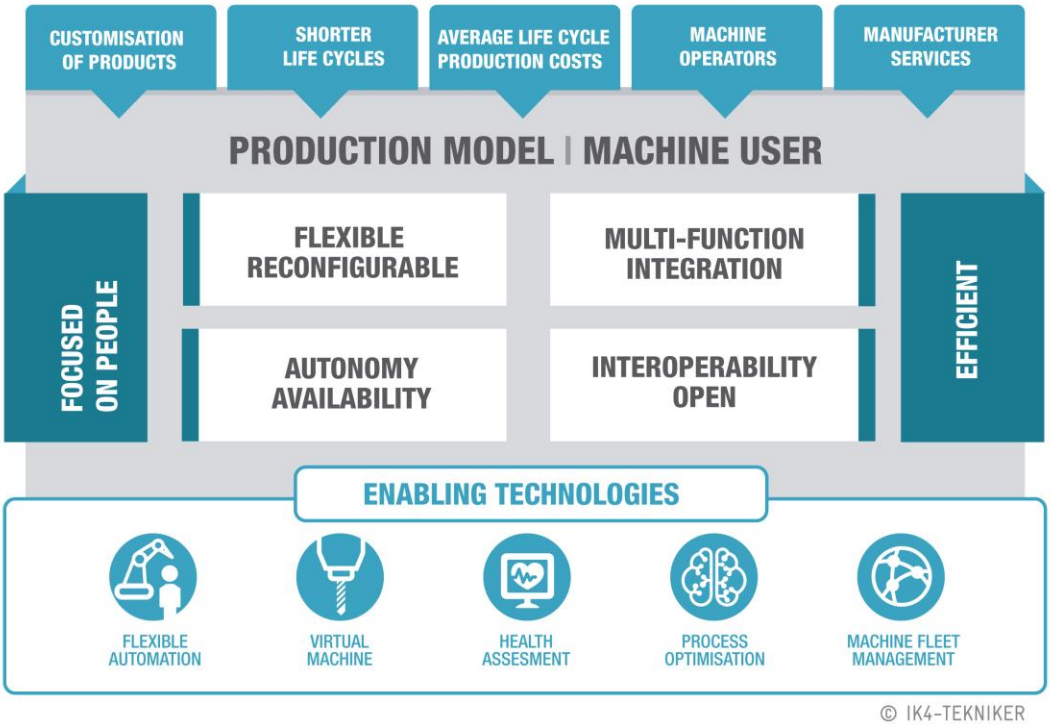


Diagram 1. Enabling technologies from IK4-TEKNIKER

This model aims to guide the buyer and user of the machine through the evaluation of technological aspects which are of specific interest, depending on each individual case. Purchasing criteria are not homogenous, and they will vary according to the business strategy of each situation and to the production model which would best serve that strategy.

As a starting point, the company will have to bear in mind the drivers, trends and business factors of the market in which they compete. Some fundamental aspects include:

- The tailoring of products or the need to tailor the product to the end user.
- Shorter life spans, which will be linked to the need to launch new products in ever reduced time limits.
- The life cycle cost of the production resources.
- The availability of technicians and training focused on the use of information technology.
- The characteristics of the manufacturing resource providers, who are increasingly offering more services linked to the predictive maintenance of their machines.

The advanced manufacturing production model to adopt in each case will have, generally speaking, attributes such as:

- **Flexibility** meaning the capacity to offer personalised production and reconfigurability denoting the ability to adapt quickly and economically to product changes.

- **Multifunctionality** or the ability to carry out the greatest number of processes on an item by the same machine, including auxiliary processes such as the loading/unloading of items and in-situ measuring.

- **Intelligence built in to the machine** to provide autonomous confirmation that the process is manufacturing defect-free items, to track the status of the machine and to be able to predict whether a component is going to fail or cause a quality-related issue.

- Connecting capacity and **interoperability** through machines which integrate easily into the company's **digitalisation** process and allow third party utilities to be incorporated.

- **Efficiency** which will be achieved though process optimisation, with high machine availability and 'zero defect' manufacturing.

- **Guidance for personnel**, since it is these people who operate manufacturing systems and make them work.

As well as these attributes it is fundamentally important to define the technologies which we can rely on, such as those which are aimed at **flexible automation** and are easy to reconfigure allowing, for example, the loading and unloading of parts in situations where production dictates frequent changing of components in machines.

"Virtual machines" will also play an important role, enabling modelling and simulation of the process-machine interactio.

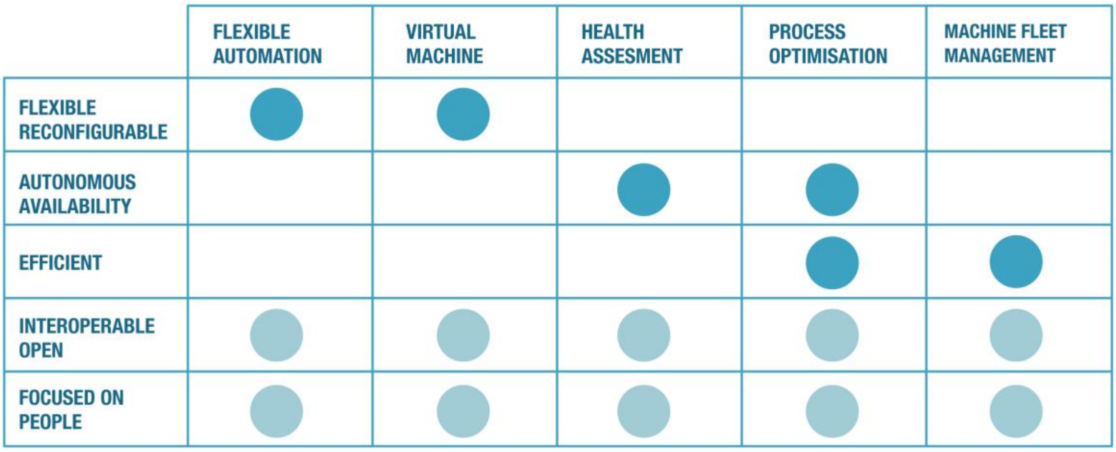
"Health assessments" for machines represent another significant element since, through a series of characterisation tests, they make it possible to access almost continuous, real-time information regarding the status of the various critical components of the machine. A further enhancement could be the addition of machine tool **autocalibration** mechanisms which, in a matter of minutes, enable the machine to undergo an autonomous error check and, if found to be outside the range of tolerance, to be automatically calibrated so that it can keep working at the highest level of precision.

Process optimisation through **simulation models** which integrate with the machine controls will be useful for taking autonomous and intelligent decisions regarding the parameters of the process and the dynamic conditions of the various mechanical components.

Furthermore, it could help the user investigate the root causes of efficiency loss through a search of correlations between the OEE and the different variables which can have an effect on its components (efficiency, availability and quality) using statistical tools and data mining.

A machine's state of health, which can be monitored locally, and associated data which can be exchanged with the manufacturer of the machine, mean that value-added services such as predictive maintenance can be offered.

Furthermore, analysis can be carried out regarding how these technologies contribute to the attributes of the productive model and, ultimately, how they align with drivers in any given enterprise. Not all technologies impact in the same way, as is reflected in the following diagram.



So, for example, a business in the **automotive sector** will prioritise autonomy and efficiency, whereby the machines should be equipped with sufficient levels of sensorisation so as to allow autonomy and high availability.

If the business belongs to the **aeronautic sector**, it will require production solutions which enable it to create and produce new components without errors right from the start.

Concepts such as **"virtual machines"** could be of great assistance. Furthermore, concepts such as **"flexible automation"** could mean that automations which were unthinkable in the past are now becoming more feasible.

It is important to point out that there are two characteristics, “Interoperable/Open” and “People-centred”, which should be taken into account in some way when considering any technological solution.

Finally, we should also consider another concept, namely technological maturity, since it affects both technological supply and demand. Currently, and faced with the potential opportunities which appear to exist, multiple new agents are entering the market in addition to the more traditional supply. But, it must be borne in mind that not all will survive.

On the other hand, and from the perspective of the buyer and machine operator, the organisation must be prepared to take advantage of some or much of the technology that is on offer.

Concerning IK4-TEKNIKER

With more than 35 years of experience in applied technology research that has been be transferred to companies, IK4-TEKNIKER has achieved a high degree of specialisation in four major areas (Advanced Manufacturing, Surface Engineering, Product Engineering and ICTs). This means that its cutting edge know-how has been made available to customers to meet their requirements.

Further information

////////////////////////////

IK4-TEKNIKER | Itziar Cenoz

Itziar.cenoz@tekniker.es | Tel. (34) 943 256 929

////////////////////////////

GUK | Eider Lazkano

eider@guk.es | Tel. (34) 620 807 344

////////////////////////////