

Agile Manufacturing – a (Small) Step in the Direction of Industry 4.0?

Dr.-Ing. Edgar Dietrich, Stephan Sprink
Q-DAS® GmbH & Co. KG

Flexible manufacturing, another term for agile manufacturing, is an alternative to part-specific transfer lines for mass production. The advantage is a high flexibility of parts which makes it easier to react to changes in the production processes and allows for the manufacturing of several product variants virtually at the same time. Additionally, it raises equipment availability and the interchangeability of machines.

The following engine manufacturing example (here: cylinder head) illustrates the exponentially increasing data traffic caused by the flexibility and variety of components in agile manufacturing, but it also explains how data traffic still remains controllable. Especially the different perceptions of these data provide a deep insight into machine behavior and help you assess product quality.

Classical engine manufacturing performs the single operations by means of a clocked transfer line. Changes caused by new characteristic specifications are hard and time-consuming to implement. Besides, there are only few product variants that can be produced in the same production line.

Agile manufacturing performs the same operations as the classical manufacturing, indeed, but the flexibility is much higher (see Figure 1). There are several identical machines for certain operations and some of them possibly include more than 50 tools. So the same machine performs several operations. The equipment availability controls, as needed, which type of machine performs which operation with the cylinder head. A machine park is thus able to process different types of cylinders and variants of a cylinder type.

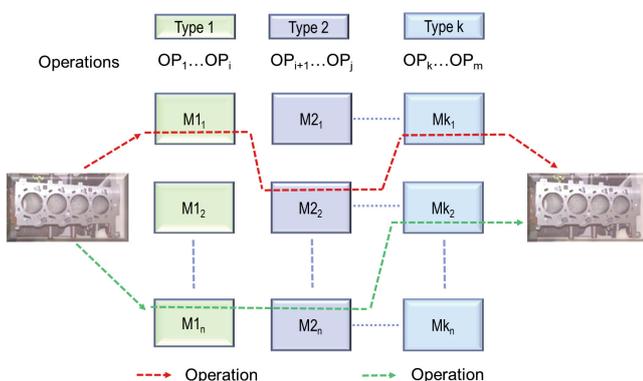


Figure 1: Agile Manufacturing of a cylinder block (diagram)

This highly flexible processing of parts leads to two essential questions:

1. The question alone as to whether a machine or all machines of a machine park are capable or suitable seems to be a problem that can hardly be solved. Compared to a transfer line, you cannot produce e.g. 50 parts, measure the characteristics and analyze capability. Indeed, you can produce 50 parts in agile manufacturing; however, you may only reach a small fraction of all available operations. Otherwise, this situation would require a massive effort to perform the respective options 50 times and this effort is not justifiable for reasons of time and for financial reasons.
2. How can you monitor agile manufacturing in order to ensure that all characteristics are processed correctly at any time?

You may answer these questions due to the right perception of the products to be manufactured and the respective process steps. As the conclusion reached in many projects for the implementation of the Q-DAS CAMERA® Concept indicates, there tend to be two perceptions of the manufacturing processes. There is

- a product-related and
- a process-related

approach. The product-related approach evaluates the quality of the product and the process-related approach analyzes the capability of the entire production line and its components (tools, spindles, etc.).

Product-related Approach

The product-related approach (see Figure 2) assesses whether the processed characteristics meet the required specifications. You cannot only have a closer look at the single characteristics but you may combine different elements (characteristics of a component or characteristics of a type of product) and evaluate them as a separate unit. Test planning, measuring programs and part identification define with which level a characteristic is associated. The number of levels you should observe

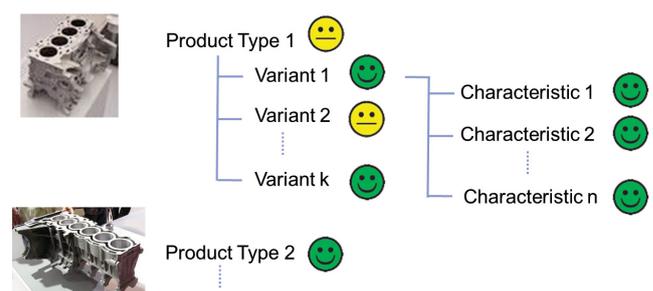


Figure 2: Hierarchy of products

depends on the respective situation and must be determined accordingly.

This helps you assess the characteristics and the higher levels as an own unit.

You just have to use coordinate measuring machines or SPC stations to measure the characteristics and evaluate the measured values statistically. Corporate guidelines and process instructions specify the type of evaluations which are also referred to as capability analyses. The system shows on each level whether the single characteristics are o.k. or n.o.k., i.e. it shows a clear summary graphic with e.g. smileys (😊, 😐, 😞). You have to define the criteria for displaying the single smileys individually.

Moreover, the system processes the same types of characteristics in an operation over and over again even though they belong to different parts or components (e.g. a borehole with defined specifications). You may combine all comparable characteristics into a virtual characteristic. Regarding the virtual characteristic, this procedure quickly leads to a data volume sufficient to make the desired machine capability analysis possible.

Process-related Approach

In terms of the process-related approach (see Figure 3), the people responsible for the manufacturing process are rather interested in the behavior of machines, their spindles and tools, independent of the characteristics that are currently processed. In order to observe this behavior, you have to combine the characteristics, too, and create different levels. Here are some examples of levels.

- Entire machine park
- All machines performing the same operations
- A single machine
- A tool / spindle of a machine

Since you are able to identify the processing of a characteristic clearly, you will always know which machine and tool perform which operation on a part. This is the requirement for structuring the data according to the cri-

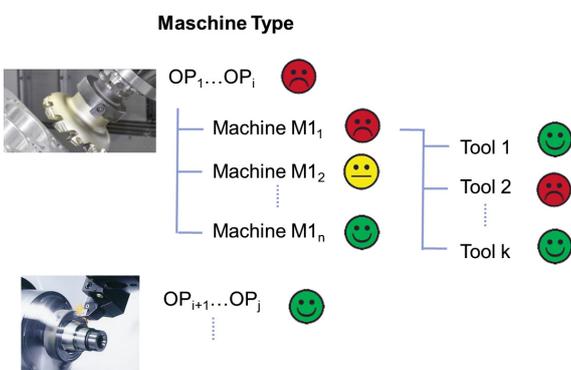


Figure 3: Hierarchy of the process

teria mentioned above. The number of levels specified based on this approach also depends on the desired allocation of characteristics to the respective levels.

Even the process-related approach measures characteristics, as described above, and evaluates the measurement results statistically based on the process levels. You have to define the criteria for displaying a certain smiley on a certain level individually. In the end you create a status overview always indicating whether all process steps are taken correctly or whether there are some deviations. In case of problems in a sequence of operations, the process responsible will quickly identify the manufacturing machine and tool concerned. The drill-down function shows increasingly more details, i.e. it presents a summary of tools including the respective status display (see Figure 4). You have to define task-specific criteria for displaying a green, yellow or red bar. Additionally, you may show further details about the characteristics corresponding to the respective tool, such as charts, statistics, reports, etc.

The process-related summary allows for an ongoing analysis of production facilities. This analysis helps detecting deviations from target conditions or exceeded limit criteria quickly in order to take respective corrective action.

Conclusion

The processed product and the manufacturing facility can both be provided continuously with these types of information. So they are able to control themselves. Agile manufacturing based on the principles mentioned in this article takes a first step towards the basic idea of Industry 4.0.



Figure 4: Process-related summary including a drill-down function