IGS GeboJagema

Model Based Definition:

Nice-to-have or must-have for an automated, flawless industry 4.0 production environment?

By Rob Doorakkers, Chief Innovation Officer, IGS GeboJagema, February, 2019

From Precision to Perfection

Model Based Definition: Nice-to-have or must-have for an automated, flawless industry 4.0 production environment?

At first glance, the main advantage of Model Based Definition (MBD) seems to be the time saved in the design department. But while it's true that Model Based Definition removes the time-consuming need to create 2D drawings, this is just one of the many advantages of using MBD. In fact, MBD is the cornerstone of a new way of working that improves product quality and allows for a leaner workflow throughout the production process. And that should be the main driver to switch to Model Based Definition.

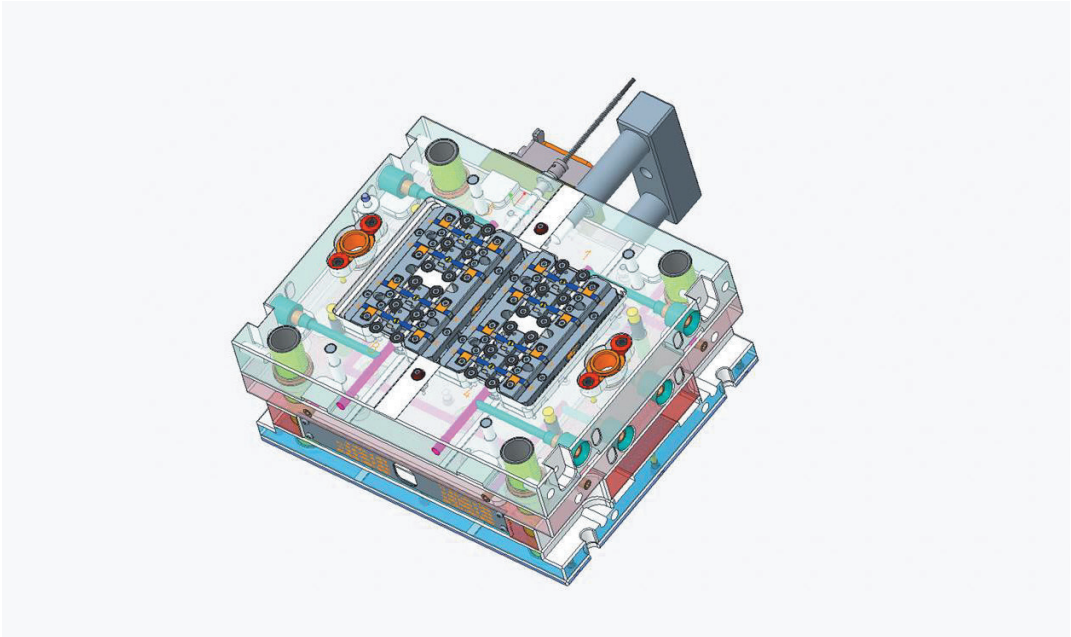
For decades, the manufacturing industry has used 2D drawings and wrestled with interpretation and communication problems. Although processes based on 2D drawings are deeply rooted at most companies, these drawings must be interpreted by people, meaning errors are unavoidable.

With Model Based Definition, every step in the production process uses 3D data. It allows one to aim for as much automated programming as possible in CAM (MBM, Model Based Manufacturing) and metrology (MBI, Model Based Inspection). This not only minimizes human error, but also improves product quality and optimises every step of the production process. From design and manufacturing to programming and inspection. These should be the main drivers to develop a new way of working using MBD. It is integral to an Industry 4.0 strategy.

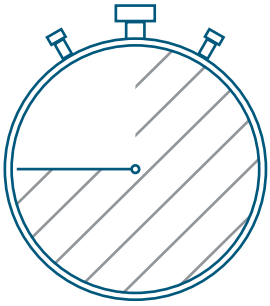
This whitepaper discusses how MBD changes the workflow in every step of the production process. From design and Logistic Technical Engineering (LTE) to Model Based Manufacturing , the tool shop and Model Based Inspection .

Design

Model Based Definition starts with the design department delivering an optimal 3D CAD file, called a Functional Engineering Model (FEM). The FEM needs to be a 100% accurate model of the actual steel part. Crucially, it should also include all the Product Manufacturing Information (PMI). All information necessary to build a tool should be added to the FEM, such as preload, venting gaps, mounting clearances and so on. The FEM should be 100% nominal, which means no unsymmetrical tolerances, but only +/- tolerances can be used.



Creating a perfect FEM starts with a model of the final plastic product. It is vital that this model is 100% accurate, as every other step in the production process depends on it. Any inaccuracies in this product model will result in inaccuracies in the final FEM. This means the product designer should invest sufficient time in preparing the model of the plastic product. This file should then be delivered in the tool maker's preferred settings or, if possible, as a native CAD file. The product designer can also add PMI data such as tolerances or surface finish information to this product model, which can then also be included in the FEM. Colour coding is one way of adding PMI data to the FEM, as is discussed below.

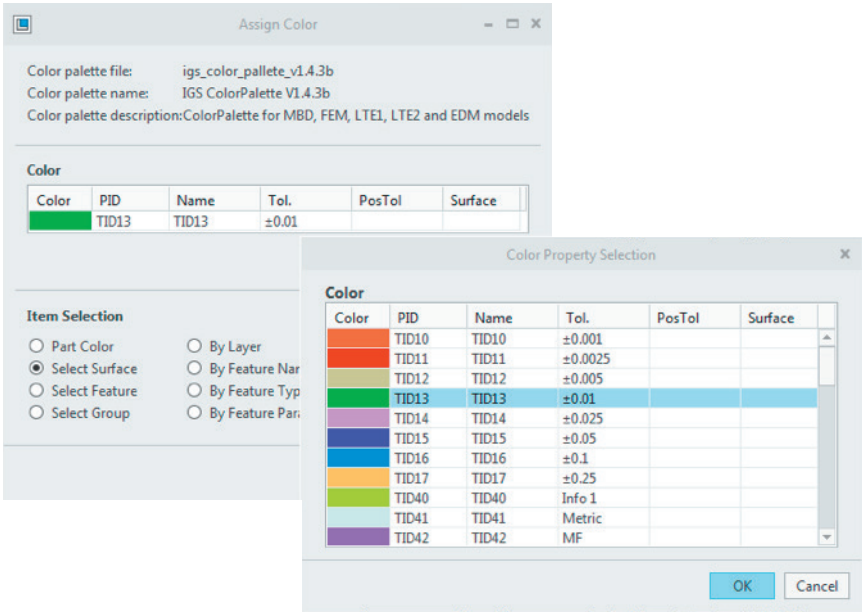


25% time reductionduring the design phase

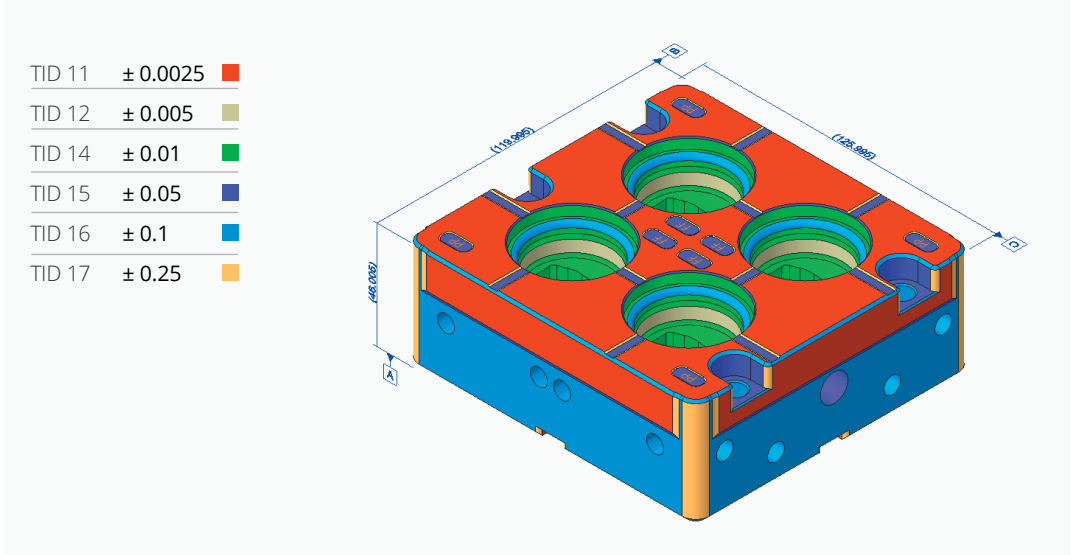
This new way of working requires a shift in mind set at the design department, as it changes the way it has operated for decades. It takes a little more time to add the PMI to the FEM, but because 2D drawings are no longer required, this change in approach results in a 20-25% time reduction during the design phase. Moreover, it lays the foundation for numerous advantages in subsequent stages of the production process, as will be discussed later in this whitepaper.

Adding PMI to the Functional Engineering Model

One way of adding Product Manufacturing Information to the FEM is to use a colour coding system.

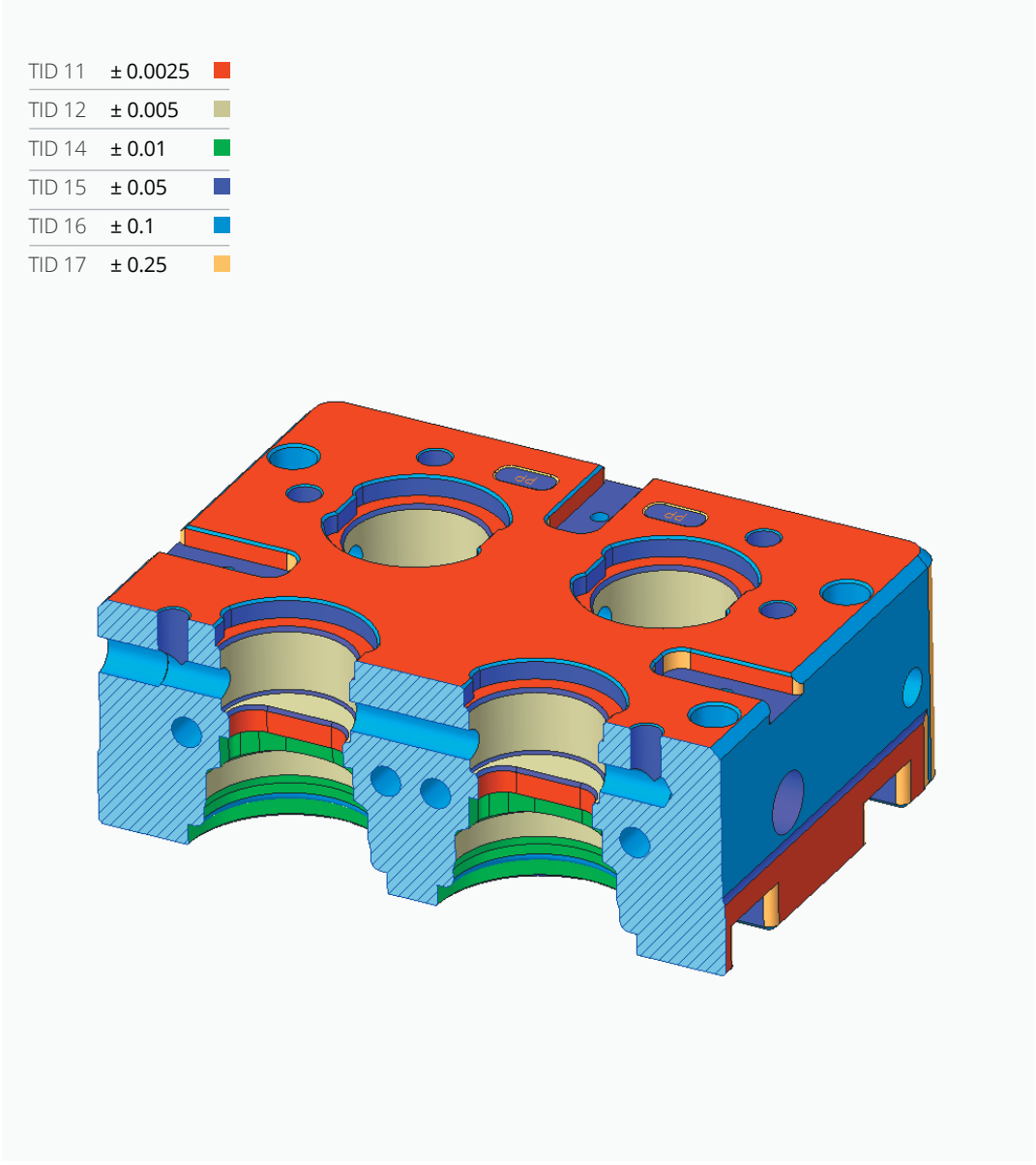


This colour coding system creates different appearance states (i.e. visualisations in the CAD application) for different types of information. One appearance state shows the colours indicating the required tolerances. Each surface area is assigned its own colour, which corresponds with the tolerance given to the surface. A second appearance state displays the assigned surface finishes such as EDM texture or SPI finish.



While designing the FEM, the tool designer can add the required colour (i.e. tolerance and/or surface finish) to the model right away. As it is today, this information is often processed days or weeks later when the 2D drawing is prepared. This can lead to errors if the tool designer misremembers the original idea or if the 2D drawing is created by a different member of the design team. Immediately adding the information during the tool design removes the risk of such errors. This reduces drawing failures by human error significantly.

Moreover, this change in approach makes it possible to start the manufacturing phase sooner. In the old approach, the CAM programmers had to wait until the 2D drawings had been prepared. In the new approach, the FEM has all the necessary information to start programming.



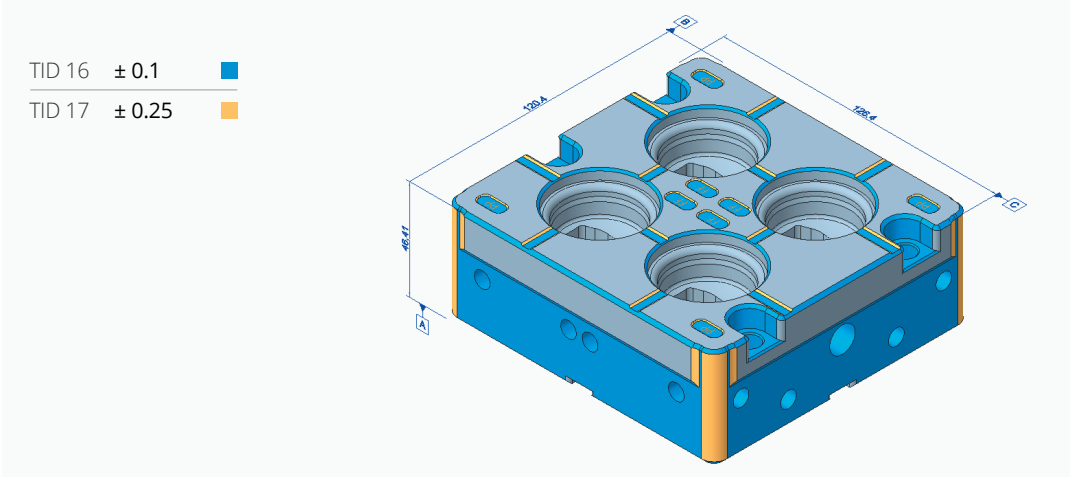
Logistic Technical Engineering with Model Based Definition

The LTE team prepares the workflow of the manufacturing departments. They determine the production steps necessary to manufacture the FEM, i.e. the actual steel components used for mould assembly. To do this, the LTE team also uses the MBD strategy and prepares 3D CAD manufacturing models. These manufacturing models are based on and linked to the FEM. Any modifications to the "parent" FEM will automatically be applied to "child" manufacturing models as well. The LTE team has full control over the manufacturing models, but cannot make any changes to the original FEM.

First, the LTE team creates a soft steel manufacturing model in which extra allowance is added, holes are closed, extra features can be included and so on. This means the department will create a 100% model of what will be manufactured in soft steel before it goes into heat treatment. This model can then be manufactured with an overall standard tolerance.

A second manufacturing model is used for hard part manufacturing. The area which should be finished in each of the manufacturing steps is highlighted in this model. It allows the team to add notes, additional dimensions, change tolerances if required for manufacturing purposes and more.

A big advantage of this working method is that the workflow is captured within the 3D CAD files and stored in the data management system covered by version management. This allows any replacement or repeat work to be started very quickly and ensures the exact same manufacturing strategy will be used to create identical parts.



Advantages in CAM programming through Model Based Manufacturing

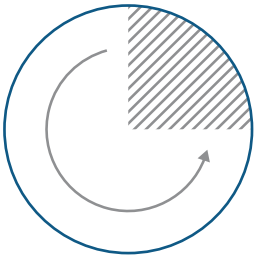
MDB saves the most time in CAM programming, through the Model Based Manufacturing (MBM) strategy. By aiming for 75% of automated programming, the skills of the program engineers are freed up to improve output. For example, they can optimize the programs in order to improve quality of the most critical parts in the tool and reduce runtime on high-volume production.

Automated programming is possible because the PMI data has been added to the FEM during the design phase. CAM programs cannot read PMI data on 2D drawings. But through colour recognition, CAM software can determine the tolerances that have been assigned to the holes, chambers, the outer boundary and other features in the FEM. Using that PMI, the software can determine the optimal standard strategy for tools to manufacture the cores and cavities.

By preparing standard strategies for milling and lathing, tool shops will be able to use automated programming for 75% of their workload. The main reason to do so is that human errors and deviations in strategy are minimised. These standardized strategies will create a recognized, standardized manufacturing method within the tool shop. All this will help to improve quality and output. Standardized ways of working create a better workflow and allow program engineers to put more effort in the non-standard and critical parts.

The goal of this new way of working is not to reduce the number of program engineers, but to create more CAM programs with the same number of people. Over the years, it has become clear that CAM capacity determines the output of the manufacturing departments. With MBD, it should be possible to increase output and create extra machine hours.

Automated programming can cover up to 75% of the workload

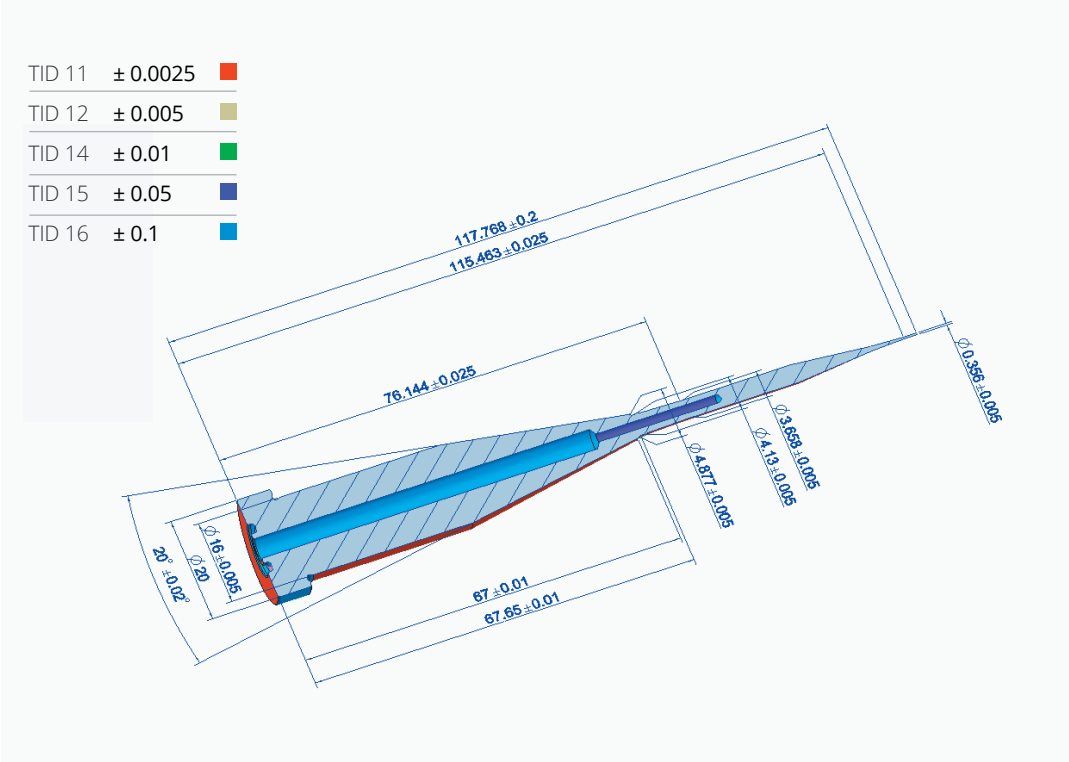


Model Based Definition (MBD) in the Tool Shop

As we get into the Industry 4.0 environment, we need to go paperless and supply digital information to all departments. This is true for both the fully automated and the non-automated activities in the tool shop. Viewable files can be created to present all PMI data from the FEM model.

For automated activities, one can work with minimally annotated files, meaning just a coloured 3D file showing the applied colours for tolerances and surface finishes as well as some specific notes. In the viewable file, buttons are created to highlight colours that indicate a tolerance or surface finish. This helps improve readability and reduces human error. The operator can measure real dimensions within the 3D file.

The second option is to create fully annotated files showing visual PMI data. This tends to be easier for non-automated activities as the operators are provided with dimensions and notes on the viewable file. This means the operators do not need to measure in the FEM to find the manufacturing information they need. Of course, these fully annotated files are more time-consuming to create than minimally annotated files and will require some extra work in the design or LTE departments.



Fast and easy programming and metrology using Model Based Inspection (MBI)

All the advantages of CAM programming apply to metrology as well, where automated programming also increases efficiency significantly. As in previous steps, a 3D CAD file is prepared: the MBI file. The MBI file is also a “child” of the FEM and it reuses the PMI data from the colour-coded FEM model. All metrology points are added to the MBI file and standard datum plans are used to align it with the actual steel components.

Because geometrical tolerances have been added to the FEM through colour coding, it is no longer necessary to apply Geometric Dimensioning and Tolerancing (GD&T) as notes. By staying within the boundaries of the geometrical tolerances, requirements in terms of parallelism or squareness will also be covered.

The metrology points required to measure the FEM are also added to the MBI file. Next, the coordinate measuring machine (CMM) uses these metrology points in the MBI file to generate the metrology reports. Because these metrology points are also part of the FEM, they are stored in the data management system and controlled with version management. This ensures identical metrology output for any repeat or replacement work in the future.

Model Based Definition: Nice-to-have or must-have for an automated, flawless industry 4.0 production environment?

If a company in the manufacturing industry wants to make a big step into Industry 4.0, MBD is a tool they **must have** to make the next step in improving the production workflow.

A number drivers are key in making the decision to start working in an MBD environment.

- ✔ Improving quality by removing the human error factor as much as possible.
  - This reduces the number of rejects
  - Less interruption in planning by rejects
- ✔ Only using 3D files for automated programming steps in CAM and QA.
  - More efficient use of programming software
  - More efficient use of manufacturing equipment
  - Optimized production processes
- ✔ The entire production process is stored within the FEM and ready for repeated production.

Of course, there are also downsides to implementing MBD.

- ✖ Preparing the FEM requires more time as the PMI needs to be added.
- ✖ More time required in the LTE department to prepare the 3D Manufacturing models.
- ✖ The risk of error when people on the shop floor need to measure directly in the FEM instead of having the dimension available on a drawing.

These few downsides do not outweigh the benefits of using MBD.

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