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Product Maturation Guide - a digital simulation outcome

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Abstract

The process of improving product performance by improving individual parts and tuning the assembly line fixtures to reach acceptable quality to start mass production is called Product Maturation. Often in new product development, product maturation affects the target date due to iterative process. Tolerance analysis tools, those optimizing the individual part tolerances at the time of design can generate a *product maturation guide* that eliminates many problem solving procedures and saves time on root cause analysis. Assume a first product built on a new assembly line was found to need improvements. To conclude the actions we need information about all the dimensions of child parts and processes involved and their influence. At the time of product design, the tolerance analysis system works with the same variables with a given range of variations virtually. For a practical build, instead of variation range, it has to consider one fixed value measured from initial parts. By adding information about process characteristics, like speed, cost, etc. to all the dimensions, the system can directly guide the manufacturing team, on which parameter to modify, which direction and how much. At the same time, it can predict the time required and cost involved. Product Maturation guide is one of the documents/tools that gets passed from design to manufacturing along with 3D models and drawings at the manufacturing kick-off gate. Tolerance analysis tools can make it possible to reduce product maturation time by 80%.

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1. Introduction

Once a product design is finalized, manufacturing starts developing parts and assembly line. A product goes through several phases, Proto, Pilot. Alpha, Beta, etc. before establishing mass production. This process of improving individual parts through modifying tools and tuning the assembly line fixtures to reach product quality acceptable to mass production is called Product Maturation. Each phase of maturation is defined with certain aspects of the product to be confirmed. Not meeting them in one iteration leads to stretching the phase, like alpha1, alpha2, alpha3, etc. This pushes the Start Of Production (SOP) date further past the launch date. The key intent of all these phases is to understand each part dimension and their behavior in assembly. Also assembly line fixtures are tuned with respect to individual parts to meet assembly dimensions over the phases. This research focuses on the process of improving parts and fixtures by understanding their design philosophy, allowing the manufacturing team to take all improvement actions together, and reduces maturation time to reach SOP.

Product design involves two aspects before kicking-off manufacturing.

1. Geometry: Size, shape and their control requirements to meet the product functions. Control requirements get communicated to manufacturing through, drawings and 3D math models. The designer’s assumption behind this specification system is that, when

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manufacturing meets all the part dimensions, the final product will meet the targets automatically.

2. Assembly process: The method of joining the parts for making sub-assemblies and final assembly. Process design communication to manufacturing specifies where to hold the parts and where and what kind of joint to apply. The assumption is that when manufacturing follows the process specification, final assembly will meet the functions automatically.

In this traditional way of passing the product from design to manufacturing, "how" all these dimensions are working together with the process and achieving the final target is not included. As manufacturing tries to follow all the specifications independently, with less understanding of their relationship, it leads to iterations. They need to learn the relationship over failures. Instead, design communication can include the philosophy behind all the dimensions, can speed up the maturation. Developing a maturation guide from the same variation analysis tool used for product design, can help the manufacturing team make all improvements in one go with predictable performance.

Researches in the past developed the tolerance analysis methods to predict product variations. Greenwood and Chase [1,2] suggested tolerance methods to analyse the assembly issues. Assembly tolerance optimization techniques have been derived by DeDoncker and Spencer [3]. Approaches of commercial software in tolerance analysis have been explained by Turner and Gangoiti [4]. An algorithm developed by XiongY and RongR [5] for predicting geometric variation in assembly. The process of identifying source of variation from assembly condition has been developed by Hu and Wu [6]. Ayne Cai [7] suggested a two-step approach for understanding part geometry and position variations in assembly. The research of Wenzhen and Zhenyu [8] included assembly fixture variations in the final product. This paper connecting assembly variations on product functional requirements also focused on dedicated outcome for product maturation.

2. Method

This research followed a method of understanding present industry practice, finding the motivations for iterations at maturation, identifying the gap, finding gap filling opportunities. Fig 1 shows the method followed.

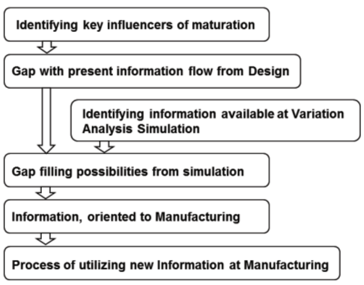

Fig 1. Research method to improve maturation process

2.1 Traditional Maturation Process

Once the parts are confirmed in their production process and dimensionally within tolerance from their drawings, the first batch of products gets built. When products are tested and some of the performance targets are not met, parts go for improvement. The order of priority for addressing targets is,

1. Performances out of quality limits
2. Performances near to the quality limits

When all the performances are reached within the acceptance range, the focus moves to high value performances to keep near to nominal. Traditional maturation processes look for easy and quick solutions to correct product performances. First, process and fixture parameters are adjusted according to parts. When that is not sufficient, part dimensions are changed. Due to the coupled conditions of design, changes to one product performance also influence other performances, which are not planned to change. This leads to the next cycle of iteration.

The top three motivations for iterative cycles noted from manufacturing records are analyzed to find gaps.

1. Not knowing the relationship of change in dimension to change in performance: Sometimes modification in one dimension gives less improvement in performance than expected. This leads to change in the same dimension again. Sensitivity of dimension is not considered while applying changes.
2. One dimension change influences multiple product performances in various degrees: While improving some performances, others go down, which demands changing the same dimensions again. The coupled condition of performances is not completely known to manufacturing.
3. Many final product specifications are not dimensions, for example, push button force, door closing efforts, uniformity across the product, etc. Unless products are tested, manufacturing will not know the exact performance achieved. Iterations go on to improve the product after testing. Mathematical relationships with dimensions to end product specifications are not applied at maturation.

All these gaps, sensitivity, coupling and mathematical relationships are part of product design philosophy. Variation analysis, performed at the design stage, generates the relationship of all dimensions in the product, including assembly fixtures. For complex products 3 Dimensional (3D) tolerance analysis tools are used. These digital tools build the transfer functions between each dimension and the corresponding final product performances. An outcome from these digital tools, in manufacturing understandable format, can enhance the maturation process.