Direct Manufacturing Design Rules 2.0

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As additive manufacturing processes create parts layer by layer without using formative tools, they have a great potential to provide new design freedoms to their users. To publish these freedoms and to support a suitable design for manufacturing, comprehensive design rules for additive manufacturing are required. Within the "Direct Manufacturing Design Rules" project (DMDR) design rules for additive manufacturing processes were developed. At time, the developed design rules apply only for boundary conditions that were considered within the DMDR project. Thus, the "Direct Manufacturing Design Rules 2.0" project has the aim to extend the range of validity for the developed design rules.

Design Rules given by the DMDR project

In order to develop design rules, standard elements were defined, first within the DMDR project. Standard elements are geometrical elements which often reoccur by designing technical products. Based on these elements a process independent method for the development of design rules was set up. Using this method, design rules were developed for the laser sintering, laser melting and fused deposition modeling processes (Figure 1). Therefore the machines Eosint P395 (laser sintering), SLM 250HL (laser melting) and Fortus 400mc (fused deposition modeling) were used. For each machine common parameter settings was considered with one material. So, for the laser sintering process the material PA2200, for the laser melting process stainless steel 316L and for the fused deposition modeling process Ultem were used.
How the material, the according parameter settings and the machine itself do influence the geometrical quality of the considered elements is unknown. Because of this, the developed design rules are only applicable for the described boundary conditions, which were considered within the DMDR project (Figure 2).

Objectives

In general, design rules for additive manufacturing technologies, which can be used for training and teaching, need to be applicable for different boundary conditions. Thus the research "Direct Manufacturing Design Rules 2.0" project (DMDR 2.0) has the objective to extend the range of validity for the developed design rules.

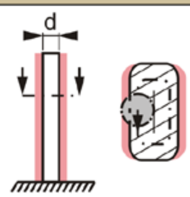
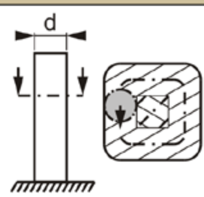
Group	Type	Attribute	Description: General / Process specific	Example: Not suitable for manufacturing	Example: Suitable for manufacturing	LS	LM	FDM
Basic Elements	Non-Curved	Thickness	Plates should be so thick that each layer can be structured of a contour with inscribed raster to minimize dimensional deviations and to avoid defects. LS: d > 1,0 mm LM: d > 0,6 mm FDM: d > 1,5 mm			x	x	x

Figure 1: Design rule, developed within the DMDR project.

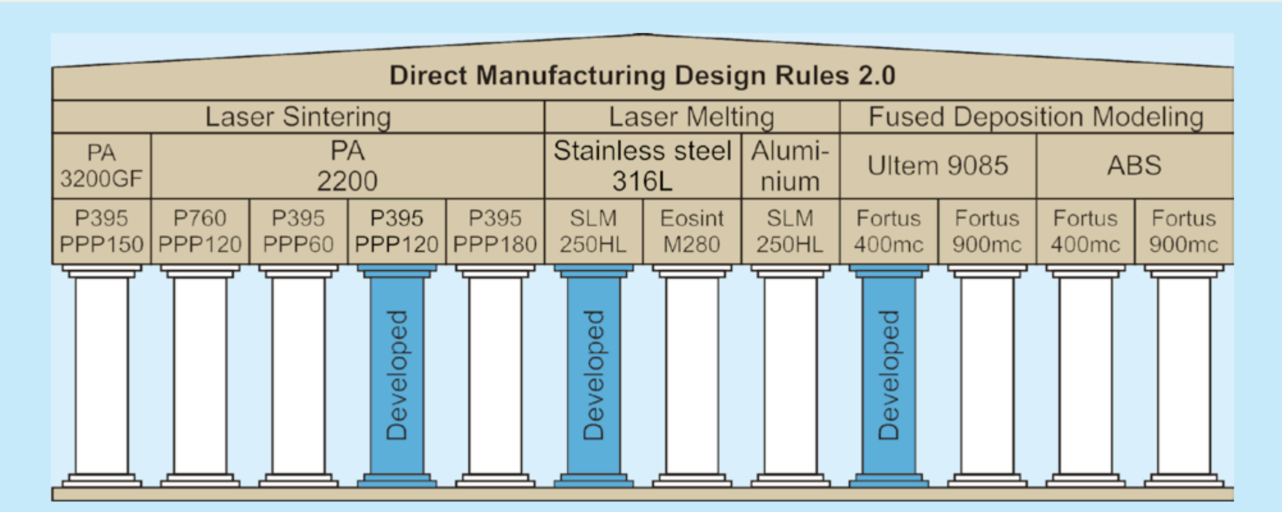


Figure 2: Range of validity for the developed design rules before (blue pillars) and after (white pillars) the DMDR 2.0 project.

Using the method given by the DMDR project, it shall be proven if the developed design rules apply for different boundary conditions, too. Different materials, manufacturing machines and parameter settings will be considered. As a result the validity range will be extended (Figure 2) and (in case of success) the transferability of the design rules to different boundary conditions is possible.

Adaption of the design rule catalogue

A main result will be the adaption of the design rule catalogue. The catalogue was developed within the DMDR project and will be adapted with the results of the DMDR 2.0 project. Therefore the results of both the DMDR project and the DMDR 2.0 project will be analyzed and compared. It will be analyzed if the design rules given by the DMDR project fit for all considered boundary conditions. The results will be interpreted and if necessary, the design rule catalogue will be extended with additional design rules.

Latest results

During this year the extension of the design rules was performed for laser sintering. The results clearly show that the general behavior and occurrence of geometrical deviations are independent from the considered boundary condition. Thus, in most cases the general descriptions of the prior developed design rules are applicable for different boundary conditions in laser sintering. However, varied boundary conditions lead to different numerical values for which the general descriptions become valid. These numerical values are stated within the specific descriptions of the design rules. Together, both descriptions provide the information that is required to design parts that shall be manufactured with certain boundary conditions.