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Direct Manufacturing Design Rules

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, design rules for additive manufacturing are required. But profound knowledge about such rules is not completely given at time. Thus the Direct Manufacturing Design Rules (DMDR) project had the objective to develop design rules for additive manufacturing. The basis for their development was given by Standard Elements.

Definition of Standard Elements

Parts consist of combined Standard Elements

Design rules shall be application-independent and easily transferable on individual part designs. Thus they were not developed for parts but for Standard Elements which often reoccur by designing technical parts. These elements were defined initially. Their spectrum contains elementary geometries like cylinders or plates as well as transitions between these elements and structures combined of these elements. In addition to this, each Standard Element owns different attributes. For instance the thickness, length, width, orientation, position and direction are attributes of a plate. By designing technical parts Standard Elements have to be combined. Thereby their attribute values need to be varied so that the part's function is fulfilled.

Development of Design Rules

Assuming that each part is designed of combined Standard Elements, its quality depends on the qualities of the involved elements. Using design measures, these element qualities can be influenced directly by varying the element's attribute values. So design rules need to recommend ranges for suitable attribute value variations.

To figure out those ranges, Standard Elements were manufactured with the laser sintering, laser melting and fused deposition modeling processes. Quality aspects like dimensional deviations, surface defects or the manufacturability itself were analyzed and compared with the used attribute value. Based on the results, design rules were derived which support a robust design for manufacturing.

Design Rule Catalogue

The design rules were summarized in a design rule catalogue. Also, additional information about additive manufacturing principles, terminology and backgrounds of the design rules were added. An extract of the catalogue is shown in picture 1-1.

More than 60 rules are contained at time

Outlook

Based on the design rule catalogue a seminar "Design for additive manufacturing" is planned. Participants will learn how additive manufacturing influences the part design. Therefore design rules, examples for their use as well as hints for given design freedoms and limitations will be provided.

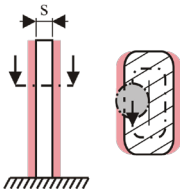
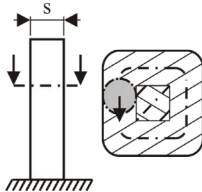


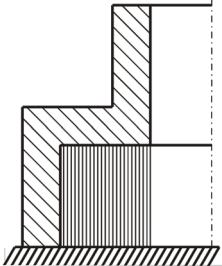
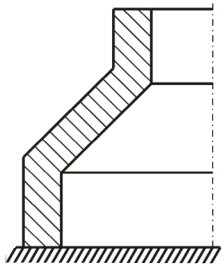
Element			Information	Examples		Techn.		
Group	Type	Attribute	Description	Not suitable for manufacturing	Suitable for manufacturing	LS	LM	FDM
Basic Elements	Plates	Thickness	Plates should be so thick that each layer can be structured of a contour with inscribed raster to minimize dimensional deviations and to avoid defects.			X	X	X
			LS: S > 1,0 mm LM: S > 0,6 mm FDM: S > 1,5 mm					
Element transitions	Firmly bonded	Inner cones	Interior corners should be rounded to remove disperse support material more easily.			X	X	
Aggregated structures	Overhangs	Length	The length of an overhang should be small enough to avoid solid support material. Otherwise overhangs should be designed with element orientations that don't require solid support material.				X	X

Figure 1: Extract of the design rule catalogue