Generative Manufacturing of Rocket Engine Thrust Chamber Components and Fluid Control Equipment

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At the time being generative manufacturing methods are thrusted in the production chains of almost every industrial branch. This is owed to numerous advantages of this technology, such as low material consumption, high design flexibility, short lead times and - in special cases - the opportunity to synthesize new materials using the effect of rapid cooling during processing.

Despite these clearly proven advantages it is mandatory to have a critical view onto the industrial application of the generative processes in terms of raw material procurement, material properties, reproducibility, finishing processes and NDI methods. ASTRIUM Space Transportation is working on generative manufacturing methods - comprising Additive Layer Manufacturing (ALM) as well as Sprayforming methods - for the application in the production chain of rocket engines for liquid propulsion.

On the basis of four very different examples the prospects of an application of generative manufacturing methods will be discussed:

The liner material for the Ariane 5 main thruster consists of a highly conductive Cu alloy. Work of NASA and others has shown that there is a CuCrNb alloy with increased live potential. Due to the material strengthening by fine dispersed particles a rapid solidification is necessary to achieve suitable material properties. This can be achieved by numerous ALM and Sprayforming methods, which were investigated for assessment. It will be shown that the material properties have a very strong link to the manufacturing conditions.

The injector head of a liquid propulsion combustion chamber is a complex part with a high number of single components manufactured by use of a lot of process steps. The evaluation of the processing of injector elements of Inconel 718 by Selective Laser Melting has delivered promising results in terms of material properties and performance. This has been used as initial boost to step into the development of ALM generation of more complex parts substituting the integration of several single components.

Design of fluid control equipment like valve components made of an aluminium alloy is restricted by the applicability of casting and machining processes to the often very complex tube systems. The additive manufacturing of different valve components has been tested, supported by material testing and the application of suitable NDI methods.

Supported by ESA the application of ALM methods to manufacture combustion chambers for satellite thrusters is developed. These thrusters remain uncooled during operation, thus materials with a high melting point have to be used, which are PtRh and PtIr. In the project the complete manufacturing sequence is analyzed and the synthesis of improved design features is studied.

The results found in all the projects give good prospects for an application of generative methods and the gain of cost and lead time benefits. But it will be also shown that for an industrialization of such processes there is strong need in the establishment of applicable routines for the whole process chain.