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ADDITIVE MANUFACTURING PROCESSES STATE OF THE ART AND VISON FOR RM

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ABSTRACT
The paper presents the basics and concepts of RM, state of the art with RM potential of RM, possible implementation of RM, and also with a practical example demonstrate current trends in product customization, where RM is enabling technology.
Keywords: additive manufacturing, Rapid Manufacturing, RM technological Platform

1. INTRODUCTION

To meet customer specific requirements at acceptable price levels, a large array of manufacturing technologies are being developed and combined to be able to produce products faster and more flexibly. Research done on conventional manufacturing technologies has resulted in both improved product data management and integration of design, engineering and production processes. The challenge is to find solutions to cost effectively reduce batch sizes and develop manufacturing processes on small scales [1].

One of the most unique technologies to achieve these goals is Rapid Manufacturing (RM): it integrates computer automated production with the intrinsic technology characteristic to make individual products in small volumes without the need of tooling - and all this with a high added value, environment friendly process and shorter time-to-market. [2].

Rapid manufacturing—the direct production of finished goods from additive fabrication—continues to grow and capture the attention of many. Increasingly, companies from the aerospace, motor sports, medical, dental, and consumer product industries are using additive processes to manufacture high-value parts in comparatively low volumes. Wohlers Associates believes that rapid manufacturing will eventually grow to become the largest application of additive fabrication [3].

Even over the last years, an extensive research efforts on RM have been performed but hardly any of the RM technologies is mature and widely available. Furthermore, RM is fragmented throughout Europe and there is no coherent strategy yet. Therefore we are presenting the latest activities within the RM platform, which has been established to helps to solve this enabling to achieve the most dynamic and competitive knowledge-based economy 2020. This by bringing together the best research and technology driven companies with top-level academia and technology centres who have expressed their intension to work together [4, 5].

2. RAPID MANUFACTURING – BASIC CONCEPTS

Rapid Manufacturing (RM) can be defined as: ***"The use of a computer automated additive manufacturing process to construct parts that are used directly as finished products or***

components”. RM is a Layer Manufacturing Technology (LMT) in which a CAD design is sliced and built by an additive technology, see ***fig. 1*** [4]. The additive-manufactured parts may be post processed in some way by techniques such as infiltration, bead blasting, painting, plating, etc. RM should not be confused with Rapid Prototyping (RP); RP is used in the product design and development phase to manufacture prototypes; RM fabricates fully functional products. A key advantage is that RM eliminates the need for tooling, such as moulds or dies, including related manufacturing processes such as machining, milling and grinding. This is especially relevant for production runs that range from a single part to thousands of parts, as there is no requirement to amortise the costs of traditional tooling.

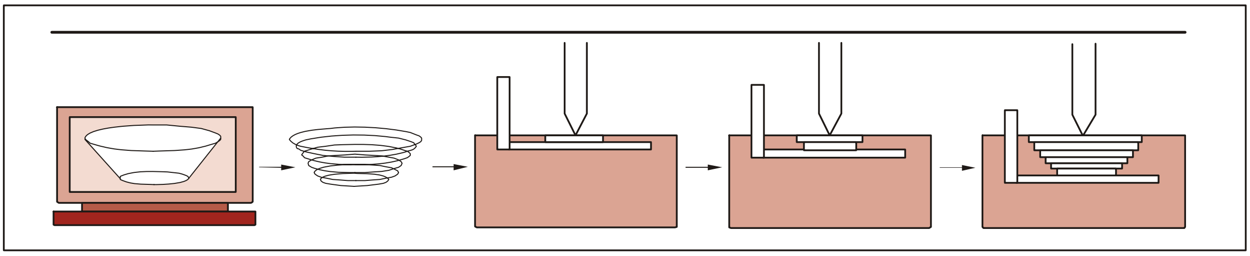

Figure 1. Schematic overview of LMT [4].

Manufacturing technologies have to address smaller production runs, highly profitable niche markets, and custom manufacturing. In addition, manufacturing systems of the future must support knowledge-based processes that focus on services rather than on products. RM supports these requirements because it is:

- ***Lean***. It shortens the supply chain because it eliminates the need for production tooling. It also allows integration of multiple materials, thus reducing part count and assembly costs.
- ***Efficient***. RM reduces energy costs and waste being not a subtractive technology. In RM systems, typically all the raw material is converted to usable product.
- ***Agile***. The RM environment makes it possible for minimal production planning, adaptability for customisation, product improvement, and multiple material production.
- ***Flexible***. It is possible to manufacture any shape, regardless of complexity.
- ***Value chain enhancement***. The direct process from design to part gives more freedom to the manufacturing company to improve its position in the value chain.

Several studies have identified that the following markets are most attractive for RM having the most potential relevant applications [4]:

- Medicine: customised scaffolds and intelligent ceramic, titanium or polymer implants, artificial organs, bioactive bone, skin tissue as also (customised) surgical tools.
- Consumer: individualised products (to the body); helmets, ski boots, jewellery, backpacks.
- Protection and safety: fire-fighter products fitting optimum, customised sports protections.
- Automotive: functional test products, driver adapted interiors, limited edition cars.
- Aerospace: spare parts in space, all low volume products, customised pilot equipment.
- High end equipment: complex machine parts, electronics, electrical engineering, packaging.

3. RM PROCESSES

Currently, hardly any purpose designed RM system exists. RP technology is being used successfully in some RM applications for the manufacture of end-use parts, but these machines where initially designed for one off prototypes and not for efficient end use manufacturing. Inherent limitations are poor strengths, costs, surface finish, accuracy and repeatability. Another issue is the processing of multiple materials. Therefore what we see today is only a pale outline of the future [2]. A few RP systems specifically aimed at rapid manufacturing applications are just beginning to appear commercially (***see figure 2***) [6].

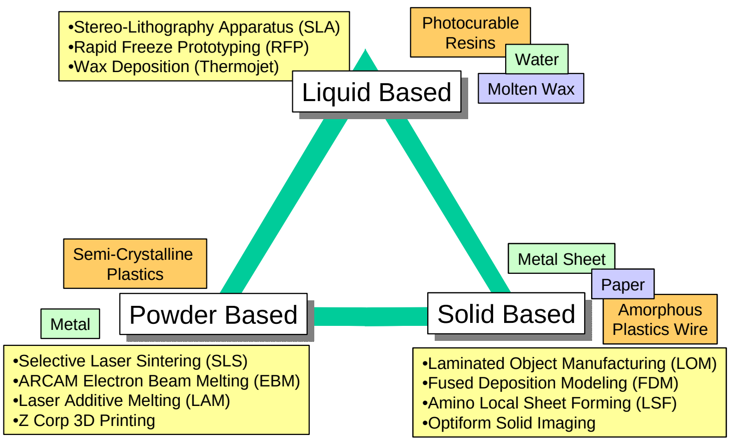

Figure 2. Three basic types of Rapid Manufacturing processes on the market [6].

Under "Custom-Fit" EU research project four process developers aimed to develop the high-speed layer manufacturing machine based on four different concepts [7]. TNO and Lboro aimed to develop RP machine which are based on printing of highly viscous material (preferable polymers and bio-polymers) by 'continuous –ink-jet' and 'screen printing' concepts respectively. SINTEF & DMU's processes were based on commercially proven technology of high-speed photocopiers that use Electrophotography (including Xerography and Ionography) to develop Metal and plastic objects respectively.

4. RM CASE STUDY

The current most used RP technology dedicated for several RM applications is EOSINT laser sintering of polymers. In relation to this fact we are presenting here manufacturing of housing for some laser device (as an RM case within the development activities of RTCZ – Regional Technological Center Zasavje). RM products are made using a P385 EOS machine for selective laser sintering of polymers. Material used is PA 2200, it is based on polyamide 12, granulation 40 - 90 microns (similar as the real polyamide), some characteristics of sintered material and are: density 0,90 - 0,95 g/cm^3, tensile strength 45 ±3 N/mm^2 , toughness (Charpy) 53 ±3,8 kJ/m^2 , Hardness (Shore-D) 75 ±2.

P385 RM machine and a sintered product are presented in ***figure 3***. Dimension of the machine chamber is 340x340x620 mm, and dimension of the housing is 106x186x110 mm. At one chamber it is possible to make simultaneously 15 completes of housing; with manufacturing time of 42 hours for 15 products, all the customers demand related to the quantity, price, quality and flexibility are fulfilled. Therefore we can state that we are presenting a case of Rapid Manufacturing of final products.

Figure 3. RM product and EOS PA 2200 machine

5. CONCLUSIONS

RM is making reliable functional end products "directly" from CAD using additive Layer Manufacturing Technologies (LMT). Generate products with addition of layers, and have a development history of more than 15 years and are now already in the stage of disillusionment. Over the last years, already some research is performed but hardly any of the technologies is mature and widely available. Activities within the RM technological platform are focused into the major pillars with the aim to contribute further development of RM [5]:

- ***Business implementation***: The total realisation chain will be affected via customer need, data capture, design, design verification, manufacture, logistics, but also education, liability, data ownership and standards.
- ***Design for RM***: Design will change dramatically in the coming years, the challenges and responsibilities of the individual designer will become bigger and bigger and therefore he has to be supported by for instance automatic design software.
- ***RM materials***: Materials development is the main driving component because materials properties and processing directly influences the later on usability and product features. Production technology will be supplemented by a very wide range of stable materials which properties could be predicted over time by simulation and adapted test procedures.
- ***RM Processes***: RM enjoys specific advantages over conventional manufacturing technologies, such as production of complex internal features, insertion of in situ sensors at locations impossible to reach once the part is produced, and minimal design constraints on part geometry.

6. REFERENCES

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