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AN REVIEW ABOUT RAPID MANUFACTURING

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Abstract: The paper present a new area of manufacturing, developed from a family of technologies known as Rapid Prototyping. This technique for manufacturing is named Rapid Manufacturing. It present the most technlogies used for rapid manufacturing, aplication of rapid manufacturing and material for production of parts and tools, in special mold. It also present the advantages and disavantages comparatively with conventional manufacturing.

1. INTRODUCTION

With increased competition from the global economy, manufacturers face the challenge of delivering new customized products more quickly than before to meet customer demands. A delayed development or delivery can mean business failure. Several technologies collectively known as Rapid Manufacturing (RM) have been developed to shorten the design and production cycle, and promise to revolutionize many traditional manufacturing procedures. Before production of a product begins, a sample or *prototype* is often required as part of the design cycle, to allow demonstration, evaluation, or testing of the proposed product. The fast creation of a prototype is known as Rapid Prototyping (RP). Prototyping traditionally required considerable skilled hand labor, time, and expense, typically applied to cutting, bending, shaping, and assembling a part from standard stock material. The procedure was often iterative, with a series of prototypes being built to test various options. For many applications, this process has been revolutionized by a relatively recent technology known as layer manufacturing or Solid Freeform Fabrication (SFF), in which a part of an arbitrary shape can be produced in a single process by adding successive layers of material. For some products, it can be economical to use layer manufacturing to produce the final products themselves, sometimes in a matter of days instead of weeks or months. Although the layer fabrication process itself is typically not as fast as traditional mass production techniques, it eliminates tooling, setup, and assembly processes, can produce parts of superior quality and complexity, and can be ideal for making custom parts based on a customer's special requirements. More manufacturers are taking advantages of these techniques. Layer manufacturing allows parts of completely arbitrary 3-dimensional (3D) geometry to be fabricated, offering designers a new freedom to shape parts optimally without the constraints imposed by forming, machining, or joining. Another important advantage is that the process utilizes the computer description of the part shape directly, and allows integration of the Computer Aided Design (CAD) with the Computer Aided Manufacture (CAM) of the part. In addition, the profiles used by the fabrication process are straightforward for the designers and customers to understand, thus facilitating technical communications **[6], [7], [9].**

2. TERMINOLOGY AND DEFINITION

Rapid Manufacturing is a new area of manufacturing developed from a family of technologies known as Rapid Prototyping. These processes have already had the effect of both improving products and reducing their development time. This in turn resulted in the development of the technology of Rapid Tooling, which implemented Rapid Prototyping techniques to improve its own processes. Rapid Manufacturing has developed as the next stage, in which the need for tooling is eliminated. This form of manufacturing can be incredibly cost-effective and the process is far more flexible than conventional manufacturing.

Rapid manufacturing is a technique for *manufacturing solid objects* by the sequential delivery of energy and/or material to specified points in space to produce that part. Current practice is to control the manufacturing process by computer using a mathematical model created with the aid of a computer. Rapid manufacturing done in parallel batch production provides a large advantage in speed and cost overhead compared to alternative manufacturing techniques such as laser ablation or *die casting.* Where the part is used in the development process only then the appropriate term is rapid prototyping. Rapid manufacturing for large products with layer based manufacturing from metals, ceramics, and polymers is well known for several industrial applications in the military and aerospace sectors. Small products and microsystem applications are known in medical as well as diagnostics and sensor technologies. Batch production of very small parts by rapid manufacturing techniques offers advantages in cost and time. Rapid manufacturing benefits from materials science, the goal of which is to realize functional parts and with improved product life times.

According with others authors **[4], [5]**, Rapid Manufacturing is “the use of a CAD-based automated additive manufacturing process to construct parts that are used directly as finished products or components.”
The requirement for universally recognised terminology is one that will aid the initial transition period as the technologies find their place in industry. However, the current confusion that exists needs to be addressed to aid this transition and the ambiguities that prevail need clarification and consensus before this can happen. The following is a comprehensive list of the many generic terms that are circulated and used by industry in this respect:
• Rapid Manufacturing (RM)
• Additive Fabrication
• Freeform Fabrication (FF)
• Additive Manufacturing
• Direct Manufacturing
• e-Manufacturing™
• Freeform Manufacturing (FFM)
• Digital Manufacturing
• Digital Fabrication
• Fabbers.

For clarity, there needs to be a distinction between the processes/technologies and the applications of the technology. Terry Wohlers is leading this quest and his qualification of this is simple when scrutinised:

“Additive Fabrication serves well as an umbrella term for the additive layer technologies (SLA, SLS, FDM, SLM, PolyJet, etc.), under which there are several applications of the technology. These applications can be grouped into three broad categories:

- design/concept modelling;

- fit/function prototyping;
- Rapid Manufacturing.”

Basically, all layer manufacturing systems consist of a combination of a computer CAD system with an operation machine to perform the fabrication of a layer under computer control. First, a 3D CAD representation of the part is created by a computer software package such as ProEngineer, SolidWorks, SolidEdge or AutoCAD. The computer representation of the part is then sliced into layers of a certain thickness, typically 0.1 to 0.25 mm, and their two-dimensional profiles stored in a triangulated format as a .STL file. Second, the software converts the .STL data to machine data, which are sent to the operation machine to generate each layer of the part by the specific fabrication process. The process is repeated many times, building the part layer by layer. The final step is finishing, removing the part from the machine, detaching support materials, and performing any necessary cleaning or surface finishing. Polishing or painting the parts can improve their appearance **[6], [9]**.

3. TECHNOLOGIES FOR RAPID MANUFACTURING

Virtually all rapid prototyping technologies are presently being used or considered in some form or another for RM. Those that have the advantage of already utilizing target materials in powdered or extruded form predominate at present. The list includes selective laser sintering, Three Dimensional Printing and related technologies. In table 1 are gives a representative selection of today's major technologies used to make parts in specific classes of materials.

Table 1. Technologies being used for Rapid Manufacturing

Plastic parts	Metal parts	Ceramic parts
▪ Selective Laser Sintering (SLS) ▪ Fused Deposition Modeling (FDM) ▪ Stereolithography (SLA)	▪ Selective Laser Sintering (SLS) ▪ Laser Powder Forming ▪ Sprayed Metal	▪ Three-dimensional Printing (3DP) ▪ Selective Laser Sintering (SLS) ▪ Fused Deposition Modeling (FDM) ▪ Robocasting (TM) ▪ Stereolithography (SLA)

In the table 1, the technologies are arranged roughly top to bottom from most to be used and well-developed to least.

There are numerous additional technologies which are being pursued for particular applications or market segments.

3.1. Applications of rapid manufacturing

Rapid Tooling. It was one of the first, if not the first, important application for rapid manufacturing. After all, tooling is a low -volume, highly-customized product and engineers were early to see the potential benefits. As with many other RM applications, rapid tooling illustrates the ambivalence of today's state of the art: On the one hand, rapid tooling can provide dramatically shortened fabrication time while lowering costs.

On the other hand, rapid tooling still usually requires hand or CNC finishing to compensate for inadequate finishes and details. No rapid tooling technology is yet capable of producing truly high volumes of parts because of material choices and characteristics. The threat of additive rapid tooling spurred improvements in high speed machining, which have made subtractive CNC techniques more competitive over time **[5], [9]**..

4. MATERIALS USED FOR PRODUCTION OF THE METAL PRODUCTS BY RAPID MANUFACTURING [2], [3].

DMLS (Direct Metal Laser Sintering) materials vary from bronze-based alloys to tool steel and stainless steel. Light metals on the basis of titanium and super alloys, for example cobalt-chrome, have already been developed at EOS for use in EOSINT M systems. Such alloys are especially interesting for applications in the medical device industry, as well as in aerospace.

DirectMetal 20 is a very fine-grained bronze-based, multi-component metal powder. The resulting parts offer good mechanical properties combined with excellent detail resolution and surface quality. The surfaces can be easily post-processed by shot-peening and can be polished with very little effort. The specially developed powder mixture contains different components which expand during the laser-sintering process, partially compensating for the natural solidification shrinkage and thereby enabling a very high part accuracy to be achieved. This material is ideal for most prototype injection moulding tooling applications (DirectTool) and for many functional metal prototype applications (DirectPart). Parts built from DirectMetal 20 also have good corrosion resistance.

Typical applications:

- injection moulds and inserts for moulding up to tens or even hundreds of thousands of parts in standard thermoplastics using standard injection parameters;
- direct manufacture of functional metal prototypes.

DirectSteel H20 is a very fine-grained steel-based, multi-component metal powder which offers high strength, hardness, wear resistance and surface density. The resulting parts have properties similar to conventional tool steels and can be polished to an excellent, pore-free surface finish. This material is particularly suitable for DirectTool applications such as injection moulds for series production, pressure die-casting tooling and other applications where high strength and wear resistance and/or best possible surface quality are important.

Typical applications:

- heavy duty injection moulds and inserts for moulding all standard thermoplastics using standard injection parameters, with achievable tool life of up to millions of parts

- die casting moulds for small series of up to several thousand parts in light alloys
- metal stamping and other heavy duty tooling applications
- direct manufacturing of heavily loaded functional metal prototypes.

EOS StainlessSteel 17- 4 is a pre-alloyed stainless steel in fine powder form. Its composition contain: Mn, Mo, Ni, Si, C, Cr and Cu. This kind of steel is characterized by having very good corrosion resistance and mechanical properties, especially excellent ductility in laser processed state, and is widely used in a variety of engineering applications.

Typical applications:

- engineering applications including functional prototypes, small series products, individualised products or spare parts;
- parts requiring high corrosion resistance, sterilisability;
- parts requiring particularly high toughness and ductility.

EOS CobaltChrome MP1 is a fine powder mixture for laser-sintering on EOSINT M 270 systems, which produces parts in a cobalt-chrome-molybdenum-based superalloy. This class of superalloy is characterized by having excellent mechanical properties (strength, hardness, etc.), corrosion resistance and temperature resistance. Such alloys are commonly used in biomedical applications such as dental and medical implants (note: widely used in Europe). The laser-sintered parts are characterized by a fine, uniform crystal grain structure. This material is ideal for many part-building applications (DirectPart) such as functional metal prototypes, small series products, individualised products. Typical applications:

- prototype or one-off biomedical implants for example: spinal, knee, hip bone and dental;
- parts requiring high mechanical properties in elevated temperatures (500 - 1000 °C) and with good corrosion resistance, for example turbines and other parts for engines, cutting parts, etc.

EOS CobaltChrome SP1 is a fine powder mixture which produces parts in a cobalt-chrome-molybdenum-based superalloy. In addition to excellent mechanical properties (strength, hardness etc.), corrosion resistance and temperature resistance, it has been especially devel-oped to fulfil the requirements of dental restorations which have to be veneered with dental ceramic material.Typical applications: dental restorations (crowns, bridges etc.).

EOS Titanium Ti64 is a fine powder form. This well-known light alloy is characterized by having excellent mechanical properties and corrosion resistance combined with low specific weight and biocompatibility. The ELI (extra-low interstitial) version has particularly low levels of impurities. Typical applications:

- parts requiring a combination of high mechanical properties and low specific weight, example structural and engine components for aerospace and motor racing applications;
- biomedical implants.

5. ADVANTAGES AND DISAVANTAGES

The benefits of Rapid Manufacturing must be balanced against its substantial limitations today. Essentially all additive fabrication technologies provide the ability to fabricate with illimited geometric freedom. It's their most important advantage over subtractive methods and main reason to exist. Geometric freedom comes with several limitations using today's technology, however. The finishes and accuracy are also not on a par with conventional technology. Secondary operations are also required, such as support removal and hand-finishing. In a production situation, where multiple parts are fabricated, secondary operations can add up and become time-consuming. There are also part size limitations at present which are more restrictive than those of standard methods.

Materials. Additive fabrication offers the potential to use multiple materials as well as to control the local geometric meso- and micro-structure of a part.

Elimination of tooling. CAD directly drives all additive fabrication processes, making it theoretically possible to avoid the use of tooling altogether. In practice, it may often still not be possible to do that because of process and materials limitations of one kind or another, but complementary rapid tooling technology might offer a beneficial compromise.

Produce short-run quantities of parts where the cost of a traditional mold would be high on a per-part basis.

Need parts that utilize complex geometries with negative angles, undercuts, thin walls or complex injection mold parts.

They can also validate market acceptance before committing to large manufacturing runs.

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