STUDY OF SHAPE DEPOSITION MANUFACTURING

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ABSTRACT

We are entering in twenty-one century but we have to face lot of problem in manufacturing & technology this problem's are solved by using advanced manufacturing. There are many advanced manufacturing process available e.g. Shape Deposition Manufacturing, Microwave Machining, Tube Hydro forming, Electro-Discharge Method, Electro-Chemical Method, Ultrasonic Machining Method, Abrasive Jet Machining, Water Jet Machining, Electron Beam Machining etc. In this paper we are discussing one of the advanced technique, which are as follows,

The process of Shape Deposition Manufacturing (SDM) is based on the concept of layered manufacturing, facilitates the automatic planning and execution of fabrication by eliminating the need for part specific tooling or fixturing. SDM uses deposition and shaping steps to create a layer. Three dimensionally shaped layers are create BY using THE 5-axis CNC machining, to achieve the required geometric accuracy for fully functional shapes. A novel, droplet based deposition process, micro casting, has been developed, to create well-bonded, high-strength material, while minimizing the heat input into previously shaped layers. The process of SDM is a modified process of Solid Freeform Fabrication (SFF), Functional metal shapes, such as production-quality custom tooling (e.g. injection molds) typically require superior surface and material properties. Therefore they cannot be directly created with current SFF approaches. Thus led to the development of Shape Deposition Process (SDM).

I. INTRODUCTION

The process of Shape Deposition Manufacturing (SDM) is based on the concept of layered manufacturing, which "rapidly" create three dimensional shapes of arbitrarily complex geometries by incremental material deposition of 3D, cross-sectional layers embedded in complementary shaped, sacrificial support material. This approach facilitates the automatic planning and execution of fabrication by eliminating the need of part by using specific tooling or fixturing. SDM uses deposition and shaping steps to create a layer. Three dimensionally shaped layers are created using 5-axis CNC machining, to achieve the required geometric accuracy for tottaly functional shapes. Thermal deposition technologies (thermal spraying, welding) are used to gain the required material properties. A novel, droplet based deposition process, micro casting, has been developed, to create well-bonded and high-strength material, while minimizing the heat input into previously shaped layers.

An automated test head facility is being installed at Carnegie Mellon's Shape Deposition Laboratory is discussed, and shows the feasibility of automating the process.

II. SDM METHOD

2.1 Need For Sdm

- Requirement of rapid and cost effective "development" of high quality products.
- Decreased delivery time for low production "one-of-a-kind" parts.
- Automation for high precision with minimum human intervention.

2.2 The Shape Deposition Manufacturing

The Shape Deposition Manufacturing (SDM) Process has been designed to directly produce functional prototypes from CAD models. This process utilizes the benefits of layered manufacturing methodologies used in Solid Freeform Fabrication, the superior material quality of welded or cast structures and 3D shaped layers are created using the accuracy of 5-axis CNC machining processes. To manufacture a part the CAD model is decomposed into 3D slices (layers). Every slice is manufactured in alternating deposition and shaping steps.

After deposition each layer is a shaped (material removal step) using conventional CNC technology, such as milling, grinding or EDM. Peripheral processes such a shot peening are used to eliminate stress buildup on a layer per layer basis. In additional steps objects such as pre-built mechanical parts, electronic components or circuits and sensors can be embedded the mterial layer. Multi-material layers (i.e. layer containing more than one material) can be manufactured by repeating the cycle for each of the materials.

The basic concept of the SDM process improves upon the accuracy of the part by avoiding the stair-step effect, which is typical for SFF processes. Instead of using 2D cross-sections, built up to a fixed layer thickness, SDM uses true, 3D slices of the part. In addition to shaping the layers according to their 3D geometry SDM also provides for adaptive layer thickness. For local features with big changes in curvature the accuracy is improved by using thinner layers, for features with small changes in curvature layers will be kept thicker to optimize material usage and shorten processing times. Due to the consideration of 3D layer geometries planning strategies are more complex than the ones used by SFF processes, but are still far less complicated than for conventional CNC operations. The additive nature of growing the object enables the part to be split into separate layers in critical spots. Therefore, planning remains straightforward and completely predictable. Overall, it was shown, that SDM is capable of producing metal parts with high strength and surface qualities comparable to conventional rapid prototyping processes (e.g., Stereolithography).

III. THE SHAPE DEPOSITION MANUFACTURING PROCESS

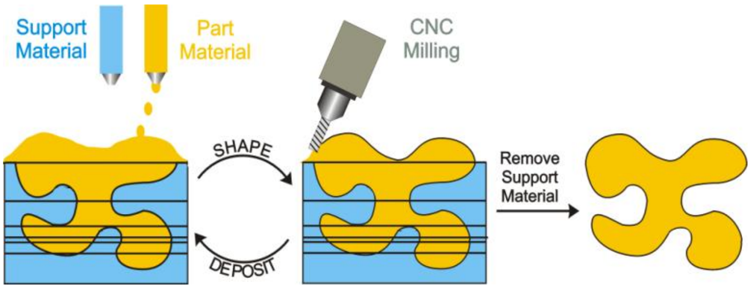

Figure 1 - Shape Deposition Manufacturing (Cross-sectional View)

Most solid freeform fabrication (SFF) systems are based upon a material additive, layered manufacturing paradigm. Computer-aided-design models are first decomposed into thin 2-1/2D cross-sectional layer representations, and then physical parts are built up in a custom fabrication machines, layer-by-layer and using material additive processes. Layers of sacrificial structures are simultaneously built up to fixture and support the growing shapes. While layered manufacturing facilitates rapid prototyping of a arbitrarily complex shapes, the resulting surface finish and accuracy, which are critical factors for being able to the fabricate functional parts, that can be compromised by the discretization process. High accuracy and quality surfac finishes, could required for such applications as custom tooling, precision assemblies, and structural ceramics, are best achieved with material removal processes such as 3 and 5-axis computer-numerically-controlled (CNC) milling. To help address this issue, Shape Deposition Manufacturing (SDM) is a SFF process, which systematically combines the advantages layered manufacturing with the advantages of material removal processes (Figure 2.2). The basic SDM fabrication methodology is to deposit individual segments of a part, and of support material structure, as near-net shapes, then machined each to net-shape before depositing and shaping additional material. This method takes advantage of the basic SDM decomposition strategy, which is to decompose shapes into segments, such that undercut features need not be machined, but formed by depositing onto previously deposited and shaped segments. Each compact in each layer is deposited as a near-net shape using one of several available deposition processes. The thickness of each compact depends not only on the local part geometry, but also on deposition process constraints. After the entire part is built up, the sacrificial support material is removed to reveal the final part.

3.1 Shape Decomposition:

Unlike most other Solid Freeform Fabrication (SFF) techniques which decompose models into thin 2-1/2 dimensional layers, SDM retains a three dimensional representation of the part and creates variable layer thickness' which are dictated by the geometry of the part. Layer boundaries are strategically inserted at heights where there are transitions between undercut and non-undercut surfaces or where there are changes in material composition. The sequence for depositing and shaping part and support materials therefore depends upon the local geometry as is illustrated in Figure 2.

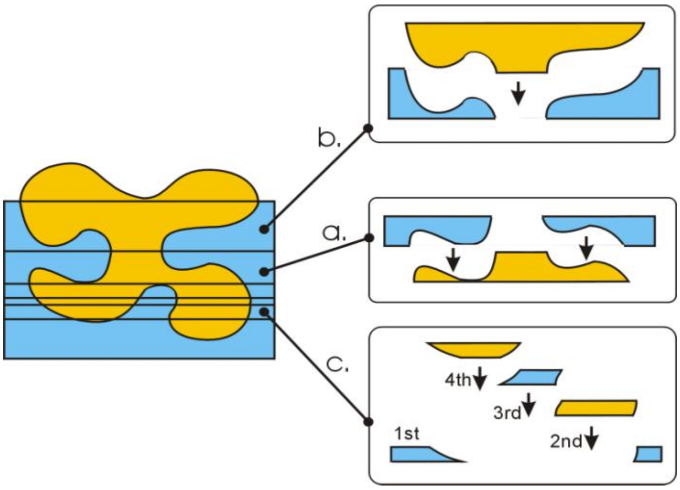

Figure 2 Shape Decomposition

In general, any shape composed of a single part material can be decomposed into layers that are characterized by one of three categories:

Category1: The layer has no under-cut features (relative to the building direction).

Category 2: The layer has only under-cut features.

Category3: The layer has both under-cut and non-undercut features.

The thickness of each layer and the sequence for depositing and shaping the primary and support materials in each layer will vary based upon part geometry. For layers in the first category (e.g., layer in Figure 2b), the primary material is deposited first and then machined. The support material is then deposited then the entire layer surface is planed; this sequence is illustrated in Figure 3. For layers in the second category (e.g., layer in Figure 2c), the support material is deposited and machined first; then the cavity created by the support structure forms the undercut features of the part. Layers in the third category containing both types of surfaces must be further decomposed into layer segments, or 'compacts', which are deposited and shaped in a sequence such that all under-cut features (of either the primary or support materials) are formed by the previously shaped non-undercut feature (e.g., layer in Figure 2b).

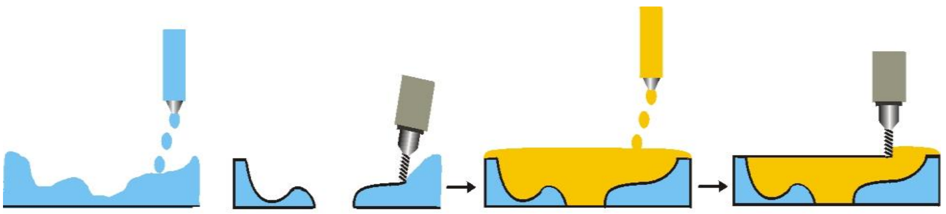

Figure 3. Example of a deposition and shaping sequence

IV. HETEROGENEOUS STRUCTURES

In addition to the rapid prototyping of complex shapes, selective additive material processing not able to the fabrication of multi-material structures and it also permits prefabricated components to be embedded within the growing shapes as shown in depicted in Figure 4a. Another goal of SDM research is to investigate how the capability to fabricate such heterogeneous structures not able the manufacture of novel product designs. The compact splitting strategy and sequence for depositing and shaping materials for a typical layer of a heterogeneous structure is depicted in Figure 4b. Note how the undercut surface of a compact is formed by depositing onto the machined surface of another compact beneath it.

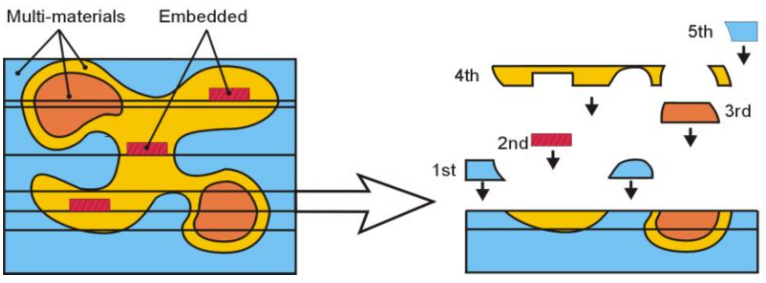

Figure 4a & 4b Multi-material structures with embedded components.

V. STEREOLITHOGRAPHY

Stereolithography (SLA), the first Rapid Prototyping process, was developed by 3D Systems of Valencia, California, USA, founded in 1986.

The most commercially used and still fastest growing solid free-form fabrication (SFF) method is Stereolithography, in which no tooling or machining is required. It allows an operator to build parts out of plastic before lots of money is spent on expensive machines and tools. It is a very useful process. For example if you are designing a new cell phone you can actually build a prototype overnight. By doing this you will be able to see if the phone will be comfortable to the ear before thousands of dollars are spent to make tooling that won't be used.

VI. PRINCIPLE OF STEREOLITHOGRAPHY

This is one of the earliest and most widely used variant of Rapid Prototyping. This works on the principle of photosensitive laser, which solidifies when exposed to a UV laser. This technique utilizes the computer generated drawing for producing a 3D image of the product to be made. The computer then slices the 3D image into thin slices and feeds the data to a laser beam system that shines a highly controlled laser beam into a tank full of photo-curable polymer. This polymer hardens by optical curing, and a hard slice is produced from the liquid filled tank. This is repeated, and next slice is formed. Slice upon slice, the whole object can be built up. The object thus made. The working principle of Stereolithography is shown in **fig. 5**

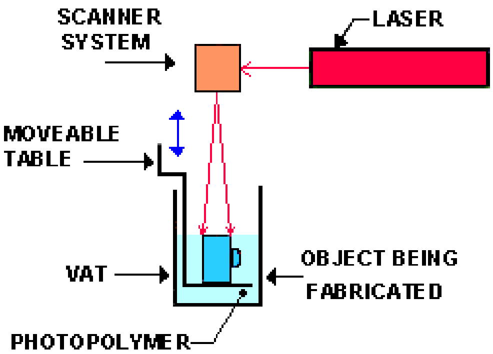

Figure 5 Principle of Stereolithography

VII. THE STEREOLITHOGRAPHY PROCESS

7.1 Working:

1. Stereolithography takes a 3D drawing from a computer and breaks it down into layers.
2. The machine uses an ultraviolet laser to harden a plastic resin.
3. The 3-D printer's laser "paints" one of the layers, exposing the liquid plastic in the tank and hardening it.
4. When one layer of the part is done being built, the platform table on the machine lowers. This allows the next layer to be built.

5. When parts are being grown it can take anywhere from a few minutes to a few days depending on how big and how detailed the part is.

The laser beam that solidifies the liquid is the HeCd-laser shown in the upper-left corner of fig. 6

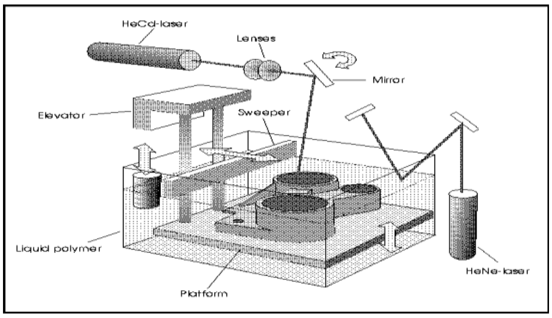

Figure 6 Working of Stereolithography

VIII. APPLICATIONS

An automated test bed facility is being installed at Carnegie Mellon's Shape Deposition Laboratory Stanford University. The experimental configuration of the SDM cell consists of several sub-processing stations for material deposition, shaping and intermediate processing steps. Currently, the manufacturing cell consists of the following sub-processes, which are positioned along a circle around the transfer robot: a deposition chamber, incorporating thermal spraying, micro casting, welding and deposition of waxes, a 5-axes CNC milling machine to shape each layer, shot-peening for residual stress release, and a washing station to remove residual cutting fluids or residue from the deposition process.

- **Heterogeneous Structures**: In addition to the rapid prototyping of complex shapes, another goal of SDM research is to investigate how the capability to fabricate such heterogeneous structures enables the manufacture of novel product designs.
- **Mold SDM:** A variant process of SDM called "Mold SDM" uses SDM to build molds for casting resins. In Mold SDM, a layered mold is fabricated. Both polymer and green ceramic parts have been cast using polymer molds and the Mold SDM approach.

IX. CONCLUSION

Overall, it was shown, that SDM is capable of producing metal parts with high strength and surface qualities comparable to conventional rapid prototyping processes (e.g., Stereolithography). It is believed, that the problems related to the residual stress buildup can be resolved, and the rapid production of parts with superior material properties is possible. Future commercialization of the process is expected to have a major impact upon manufacturing, especially in tool fabrication, where short turn-around times are required, and one-of-a-kind manufacturing. To this date, SDM is the only solid freeform fabrication process, capable of directly producing fully strong metal parts and assemblies.

Stereolithography has established itself as a leader in the area of high-end rapid prototyping technologies. It is the most widely used prototyping method. It saves a lot of time required to make a prototype. Thus it increases the manufacturing speed of a company. So any company can grab the market early by launching their model early according to the market trends with the help of stereo lithography, in this competitive world.

REFERENCES

❖ **BOOK**

♦ Ashley, S., "Rapid Prototyping Systems", Mechanical Engineering (113) 4, Edition April 1991, Page no.34-43.

♦ **WEBSITES**

1. www.cs.cmu.edu/ ~sdm/-1k
2. www.scientific.net
3. www.natec.org
4. www.howstuffworks.com/ stereolith.htm
5. www.google.com.