Study of LOM Additive Manufacturing Process in Pattern Making Application

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ABSTRACT

Additive Manufacturing Process is a recent development in industry to help and solve the problems and limitations of traditional prototyping methods. of course, "rapid" is a relative term. The term rapid prototyping refers to a class of technologies that can automatically construct physical models from computer aided Design (CAD) data. RP allows the designers to quickly create tangible prototypes that ere subtractive in nature. In addition to prototypes, RP techniques can also be used to make tooling and even production-quality parts. For small production runs and complicated objects, rapid prototyping is often the best manufacturing process available. The adoption of rapid prototyping (RP) techniques within the pattern making and foundry industry has necessitated a complete overhaul of skills requirements within the industry. The ever increasing, and soon to be universal, use of CAD by designers, even at prototype stage, has given the production of RP models a distinct advantage over conventional techniques. CAD data can be utilized directly by RP machines to generate a part, thus ensuring an exact replica, without the errors introduced by manual interpretation of drawings, is produced. This revolution has certainly cost jobs and is permanently eroding the skill base of pattern and model making, but only those who can adapt to the new methods of working will survive. Flexibility to give short lead times from CAD model to finished part are the main criteria for success and the prototype pattern maker, with adaptation, can play a vital role in this process.

INTRODUCTION

Prototyping is in essence of model making. This process has been developed around centuries and is used to help visualize a design. There are limitations to traditional prototyping methods such as (a) the required to fabricate the prototype, (b) the overall complexity of the object is limited, and (c) the traditional prototyping method is extremely labor intensive. Perhaps the greatest benefit of traditional prototyping is that the initial prototype can be made from the actual material of final product. This is good for any engineering testing of the part that may be done[1].

There are several methods of the RP process currently being used. Each method has its strengths and weakness. The greatest benefits associated with the process are the quick fabrication times. Most prototypes require from three to seventy-two hours to build, depending on the size and complexity of the object. This may seem slow, but it is much faster than the weeks or months required to make a prototype by traditional means such as machining[2].

Changes to design become more costly as they approach the final production stage. Thus, it is important to catch any inconsistencies or problems early on in the initial design phases. With the advances in computer technology, in particular CAD software that works based on parametric design, changes can easily be made to initial designs.Prototyping aids in this process by helping to ensure that the object is going to be produced as per the designer requirements. Thus, no time and money is wasted during the production phase of the manufacturing process .The majority of the product development cost occurs in the concept and design validation phases. During those times, much time is spent designing and re-designing the product. Prototypes are made and evaluated. Then changes are made and the whole process starts over. Eventually, the product design is completed and it goes to the manufacturing phase[3].

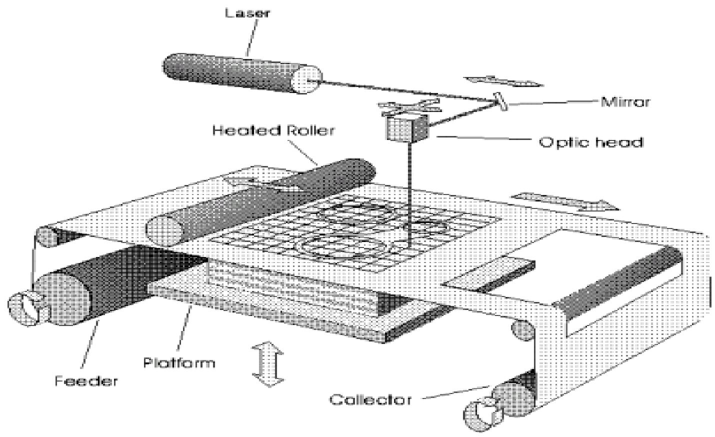
RP BASIC PROCESS CHAIN

Although several rapid prototyping techniques exist, all of them employ the same basic five step process for small production runs and complicated objects. The steps are[4]:

1. Create a CAD model of the design
2. Convert the CAD model to STL format
3. Slice the STL file into thin cross-sectional layers
4. Construct the model one layer atop another
5. Clean and finish the model

LAMINATED OBJECT MANUFACTURING

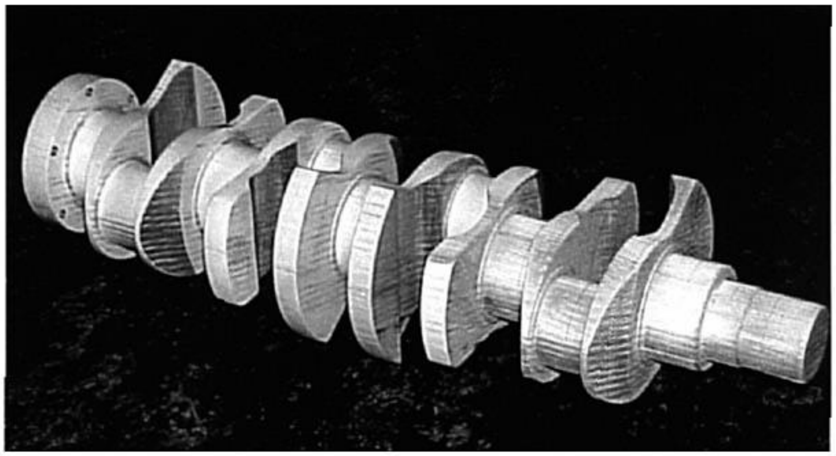
Laminated object manufacturing is a RP technique for manufacturing of 3D objects based on 3D geometrical data. This technique was developed by Helisys of Torrance. The paper in the form of a roll is used as a raw material for part building. Laser as per the lamina cuts the paper and the cut papers are stacked automatically and thus the part is built. The layers of adhesive-coated sheet material are bonded together to form a prototype. The original material consists of paper laminated with heat-activated glue and rolled up on spools. As shown in the figure below, a feeder/collector mechanism advances the sheet over the build platform, where a base has been constructed from paper and double-sided foam tape. Next, a heated roller applies pressure to bond the paper to the base. A focused laser cuts the outline of the first layer into the paper and then crosshatches the excess area (the negative space in the prototype). Cross-hatching breaks up the extra material, making it easier to remove during post-processing. During the build, the excess material provides excellent support for overhangs and thin-walled sections. After the first layer is cut, the platform lowers out of the way and fresh material is advanced. The platform rises to slightly below the previous height, the roller bonds the second layer to the first, and the laser cuts the second layer.



Schematic diagram of laminated object manufacturing

This process is repeated as needed to build the part, which will have a wood-like texture. Because the models are made of paper, they must be sealed and finished with paint or varnish to prevent moisture damage. Helisys developed several new sheet materials, including plastic, water-repellent paper and ceramic and metal powder tapes. The powder tapes produce a "green" part that must be sintered for maximum strength. As of 2001, Helisys is no longer in business[5].

Rapid prototyping in pattern making and foundry applications



A LOM model of an engine crank shaft

CAD GENERATION

Laminated object manufacturing (LOM)

LOM is used mainly for larger, bulky parts because the paper that it uses is relatively inexpensive compared with resins and powders used in other RP machines. Parts can be built quickly (500 mm diameter x 55 mm deep wheel within a day).

The large build envelope of this process means that there are no associated problems with manually joining parts for most automotive applications. Smaller parts can also be generated in LOM and the process produces parts that are fairly easy to finish. The models can be adjusted and modified using standard pattern making machinery and tools. The main disadvantage is the stability of the parts in humid conditions.

When parts are manufactured they are contracted by 2-3 per cent in the Z (build) direction. Over a period of time, after manufacture, parts grow into tolerance. Parts may also suffer from de-lamination if subjected to prolonged periods at elevated temperatures and can become unsuitable for casting. However, with the right controls a LOM pattern can be used to produce up to 20 castings, depending on the geometry.

A limitation of the LOM process, particularly in areas with thin wall sections, is the material's susceptibility to 'Air Set' sand formulations, resulting in de-lamination of the pattern. However, heavier section patterns can be used for pre-production runs. Where higher numbers of castings are required it is relatively straightforward to 'clone' polyurethane patterns from the LOM models, which are used for low-volume production. Indeed, often cast resin production equipment is cast from LOM patterns.

CONCLUSIONS

The incorporation of RP techniques is a natural development within the foundry industry and enables the production of rapid metal parts from rapid models. If metal parts are to be manufactured then the processes to be used need to be fully understood by all parties involved. A close liaison between designer, pattern maker, and foundry from the outset of project is vital to ensure that a project runs smoothly and time-scales are meter. RP is a growing and ever-changing industry and future developments will inevitably reduce the cost and time for manufacturing models. The question for the prototype pattern maker is where will it eventually lead? The ideal way of creating metal parts is directly from CAD data without the need for models or patterns. The direct production of metal parts by laser sintering, for example, is now possible, albeit it limited in terms of part size and materials.

When these processes become quicker, cheaper, and totally reliable for all metals, perhaps the prototype pattern maker might have to broaden his skills again

APPLICATIONS OF RAPID PROTOTYPING

Rapid prototyping is widely used in the automotive, aerospace, medical, and consumer products industries. Although the possible applications are virtually limitless, nearly all fall into one of the following categories: prototyping, rapid tooling, or rapid manufacturing.

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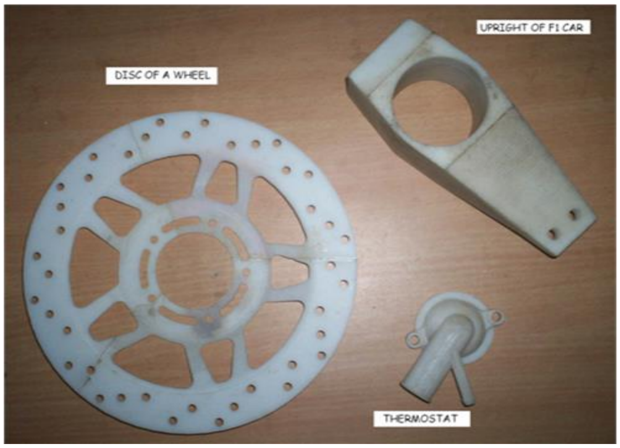
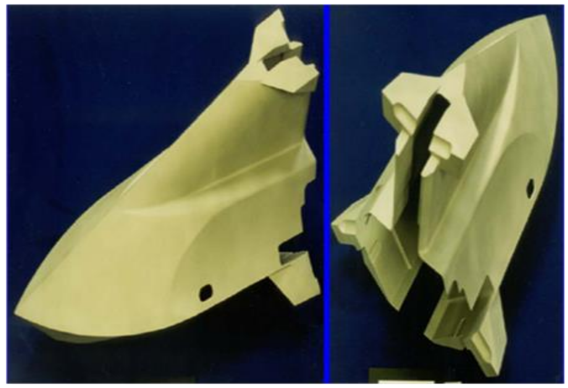
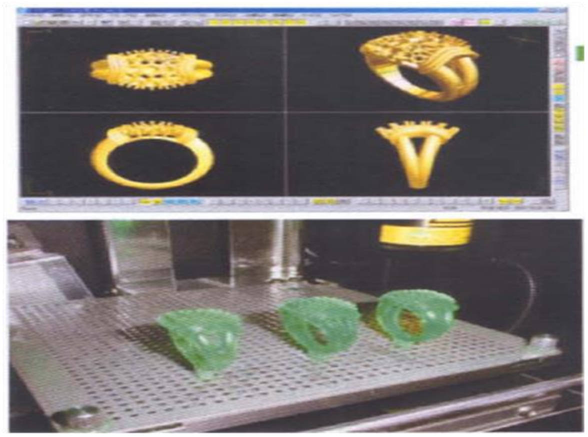




NASA SPACESHUTTLE MODEL

OPTICAL BENCH 3D TRUSS



Modeling jewelry

CONCLUSION

It is unlikely that Rapid Prototyping will replace conventional manufacturing, but it will reduce lab time as it compliments existing processes. As the technology and diversity of the product increases more and more types of objects can be devoted. Better and better systems can be produced because more, and early testing and experimenting can be carried out a prototype can be rapidly produced and verified. Rapid Prototyping is a simple tool that has tremendous, positive impact on the quotation process, scheduling, rework and customer service. RP is merely a communication tool. The physical, 3-dimensional model quickly and clearly illustrates the design to anyone. This clarity not only reduces errors and problems, but also maximizes the potential to discover new and better ways to attack the project. The tangible model is available in just days, independent of design complexity. As new and attractive technologies become available, system prices may drop. For now, prices remain high, although the price/performance ratio continues to improve as existing technologies advances in speed, accuracy, material quality, surface finish, ease of use and safety.

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