

The Role of Rapid Manufacturing Technology in Industrial Design

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Abstract: The "rapid manufacturing technology" solves the bottleneck problem of restricting R & D and trial production of industrial design as well as breaking the traditional mode of product design and development. When not open the mold, R & D personnel can achieve the production demands of small quantities and varieties of products. Using rapid manufacturing technology can obtain prototype almost exactly as the same as the quality of the actual product, which will help to put into mass production after the successful negotiation of transaction. At the same time, rapid manufacturing techniques facilitate the correction of possible design errors before opening the mold.

1. Introduction

"Rapid Manufacturing Technology" is an advanced digital manufacturing technology developed with the popularization of computers in the late 1980s. Under the control of computer, the three-dimensional digital model of the part is firstly layered and discrete, and then the materials are stacked or cut layer by layer according to the principle of digital integration, so that the three-dimensional CAD digital model can be rapidly transformed into a physical model. At present, the rapid manufacturing technology has been widely used in many fields, especially in the process of product design, and it provides the R & D personnel of design in industrial production with a new product development model that can quickly, directly and accurately transform the design concept into a physical model with usage features, by which it not only shortens the development cycle of new products, but also reduces the R & D expenses and enables enterprises to seize the opportunities in the fierce market competition.

2. Increasingly Sophisticated Rapid Manufacturing Technology

With the rapid development of computer technology and the widespread application of CAD / CAM technology, the global manufacturing industry has become more competitive, leading to the high-speed development of rapid manufacturing technology. At present, the rapid manufacturing technology has been out of the laboratory, is widely used in aerospace, medical, construction, animation, product design and other fields, and provides the physical prototype and new product verification with an efficient and low-cost solution.

The difference between rapid manufacturing technology and traditional manufacturing technology is that: firstly, instead of relying on traditional tools and molds, materials are accumulated and transferred by using light, heat and electricity; secondly, the quality of a part depends not only on the material itself, but also on a close relationship with the energy applied during forming, which requires



precise dynamic control of many key points. No matter what kind of rapid manufacturing technology, has to do four steps, including CAD modeling, preliminary treatment (such as the generation of STL file layout, the model slice layered), prototyping and post-processing (such as removing the stent, cleaning the surface and curing treatment)[1].

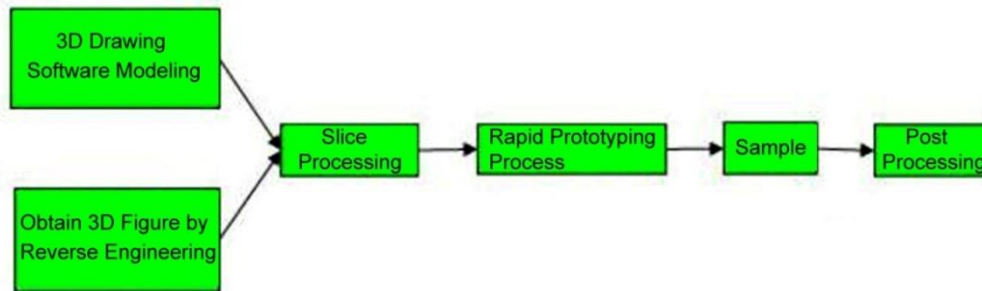


Figure1 Rapid manufacturing technology process

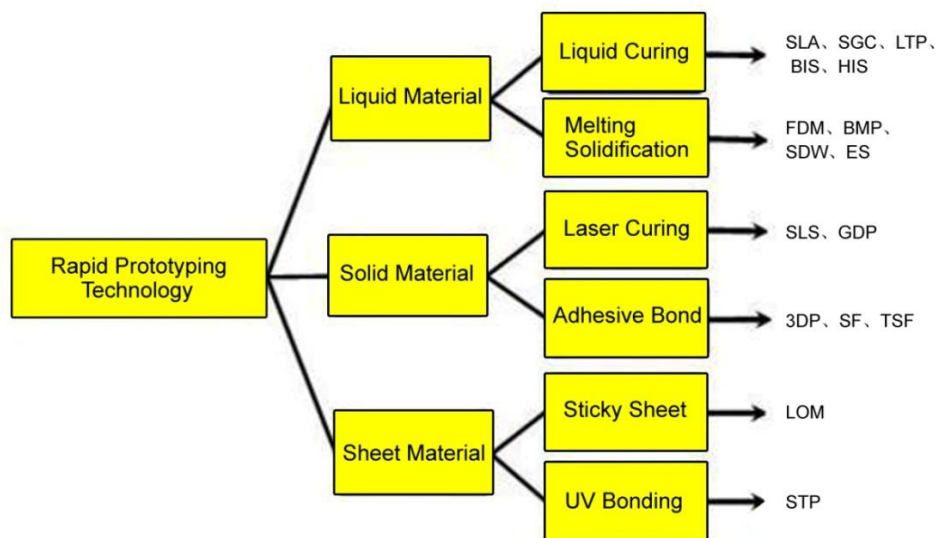


Figure2 Rapid prototyping process methods

There are many rapid manufacturing methods, and the properties of supplies not only distinguish different equipment of rapid manufacturing, but also determines the process of rapid prototyping manufacturing. So far, there are dozens of rapid prototyping methods, but there are four main methods: (1) Stereo Lithography Apparatus (SLA); (2) Laminated Object Manufacturing (LOM); (3) Selected Laser Sintering (SLS); (4) Fused Deposition Molding (FDM)[2]. These rapid prototyping methods manufacture physical parts by the way of materials gradually accumulated, which is commonly known in the industry as "Additive Manufacturing" (AM). In addition, although Computer Numerical Control (CNC) is regarded as "subtractive manufacturing", it is an automatic machine tool and should belong to the rapid manufacturing equipment. It is not adequate for a complete rapid manufacturing system to own molding equipment. It should also include a "three-dimensional scanner" for cloud data collection and a "3D scanner" capable of realizing small-lot production.

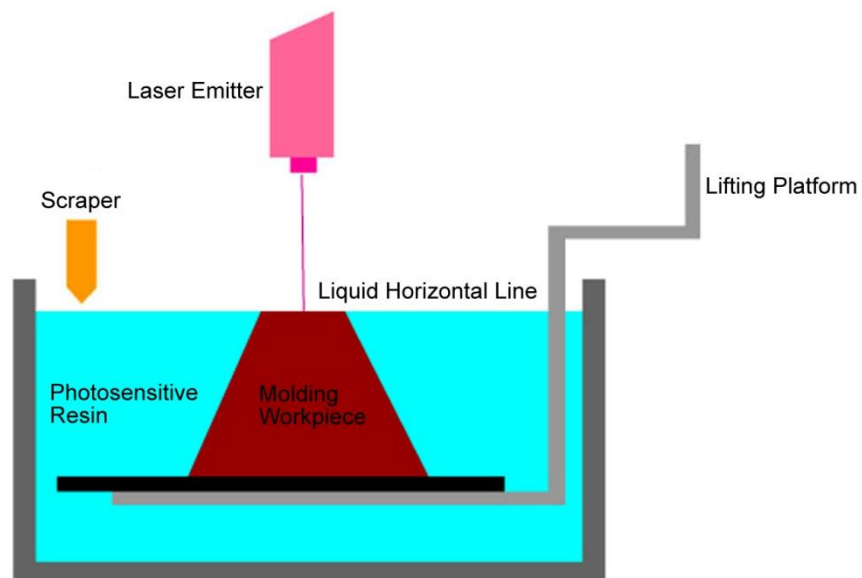


Figure3 Stereo Lithography Apparatus (SLA)

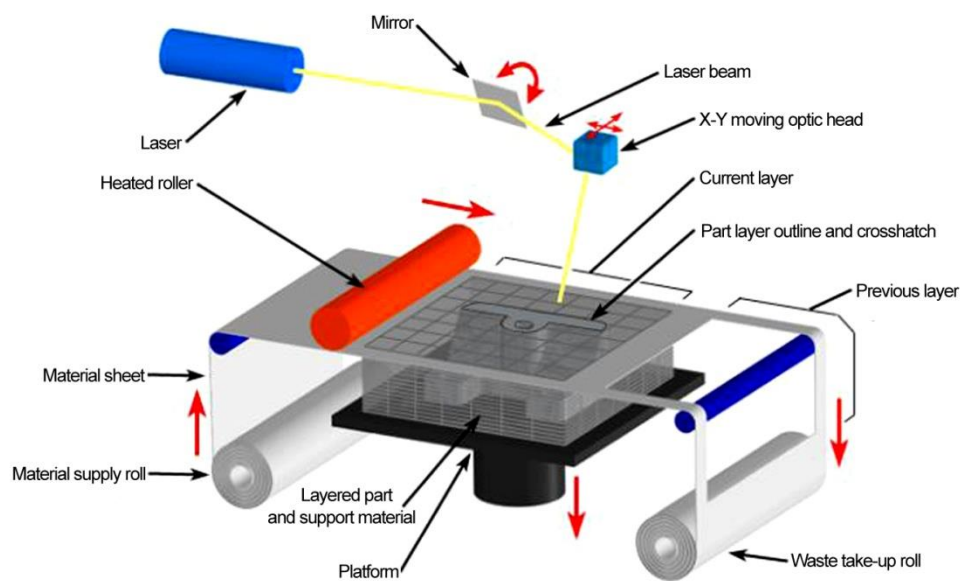


Figure4 Laminated Object Manufacturing (LOM)

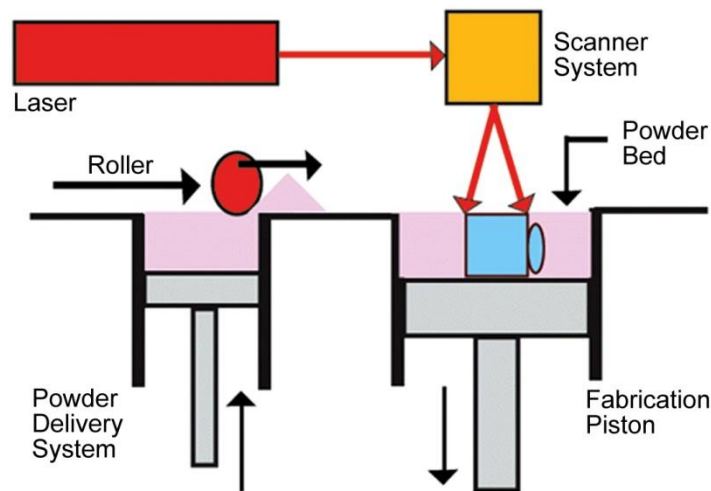


Figure5 Selected Laser Sintering (SLS)

3. Rapid Manufacturing Technology and Industrial Design

Based on modern scientific and technological achievements, industrial design aims to bring innovation, promote business success and provide a better quality of life. It is a design activity that applies the process of solving problem strategically to products, systems, services and experiences. At the same time, it is a creative activity that brings together innovation, technology, business, research, and consumers which is conceived as an opportunity to build better products, systems, services, experiences or business networks, and offers new values and competitive advantage[3]. The specific purpose of industrial design is to design products that suit the needs of consumers. Designers can summarize the design requirements of the target consumer through a large number of design surveys, market surveys, interviews, find the breakthrough point for product design, and then ascertain the shape of the product by the ways of hand-drawn, plane renderings, computer 3D modeling. However, it is difficult to get the design of the real product to verify whether the relevant consumer needs, it can not verify the assembly of the product and the deviation of actual size. These factors often determine whether the design of the product can eventually put into mass production, which is the problem that all the designers have to face.

The manufacturing of traditional model is limited by material properties and processing methods. Designers can not verify the product function, assembly process, and steps, and can not quickly get the "real model" of a product. Therefore, today, as the speed of product development becomes one of the main competitive elements, developing new products rapidly must rely on prototypes that are almost as the same quality as real products. The problems and defects exposed when using, quickly reflected to the designer to modify.

Taking the car design as an example, we should first determine the concept of modeling, and then draw a large number of predictions, make clay model after working out the program, and then use the 3D scanner to obtain cloud data, and then use the engineering software for digital reconstruction. At this moment, shrink-ratio models of 1: 8, 1: 5 and 1: 4 can be made by using a suitable rapid manufacturing technology and spray-painted with color for surface treatment for evaluation of design proposals, as well as giant CNC machines for machining 1: 2, 1: 1 logging models which is used into wind tunnel test or surface treatment with spray painted first and making a concept car. Thus, rapid manufacturing technology achieves positive-going and converse design procedure of industrial design.

For the design of precise instruments, it is almost impossible to use plastic to make housings due to the small output because of the high cost of molds that could outweigh the benefits of the project. The final design of the digital model with the SLA in rapid prototyping equipment is made into a physical

prototype, and then silicone mold be made according to the prototype, and finally finished product can be made in the vacuum injection molding machine. When making the finished product, the performance of finished product can also be transformed by changing the materials[4]. For example, ABS plastic can be made into shell and general structural parts, nylon can be made into gears and other engineering parts, and rubber can be turned into soft parts. The advantage of silicone molds is that small-lot products can be produced, and help to solve the "interference" problem, as long as the volume is not large, the structure is not too complicated to be smoothly "demoulded." Practice has proved that the involvement of rapid manufacturing technology makes this area more dynamic, changing the past dull, cold sheet metal shell. Organic surface modeling make the machine and people closer, and industrial designers can give full play to their design talents.

4. Rapid Prototyping and CNC Machining

The numerical control machine tool is a Computer Numerical Control (CNC) machine. Its control system can logically process programs with control codes or other symbolic instructions and decode them by the computer so that the machine tool performs the prescribed actions. The rough stock is processed into semi-finished or finished parts by cutting. In the process of R & D of industrial products, rapid prototyping and NC machining are the most efficient and accurate means to obtain prototypes, and the two can not completely replace each other. Designers and managers need to choose the method according to the actual situation of product design. CNC machine tools and rapid prototyping two technologies are different in five aspects.

4.1. Different molding methods

The CNC machining parts adopt the traditional cutting material method, which has a low utilization rate of materials and a serious waste of materials. The rapid prototyping technology adopts the processing method of "layering and overlaying", with high utilization rate of the materials, and almost no waste of materials. The weight of the parts is basically equal to the weight of raw materials, but the cost of raw materials is higher than the processing of CNC.

4.2. Different requirements of the shape of parts

Because the CNC machining is still using the traditional "material removal method", and using the cutting tool to machine, it is difficult to machine CNC when faced with complex parts with a cavity structure; if the parts with camber changes in the shell, are large, CNC can split the parts, machine them separately, and then bond them. Rapid prototyping technology uses the "additive manufacturing method", an physical and complex three-dimensional parts will be processed, which machines the discrete ply, greatly reducing the processing difficulty, and not limiting the complexity of the shape.

4.3. Different processing accuracy

Due to the different processing methods of CNC machine tools and rapid prototyping, the CNC machine tools need to manually orient the coordinates of the parts during the machining process. When the parts are processed completely and glued together, the deviation between actual size and design size will be large. The rapid prototyping only needs to locate coordinate once in the computer and does not need human intervention in the whole process of forming parts. With high precision, the final formed part exists only ± 0.05 mm between actual size and design size.

4.4. Different conditions of processing environment

The requirement of processing environment of CNC machine tools is relatively low, it can be processed at room temperature and general indoor environment. The rapid prototyping equipment usually requires constant indoor environment, and laser-forming materials are mostly photosensitive material which can not be affected by sunlight and ultraviolet light.

4.5. Different processing costs

The cost of CNC machine tools is lower than the rapid processing. CNC machine tools can process the materials like acrylic (Perspex plate), ABS (Acrylonitrile Butadiene Styrene), PC (polycarbonate), Nylon, POM, Brass, which are inexpensive and easy to obtain. The rapid prototyping is limited by the forming methods, and each forming method requires specific materials, such as laser curing method requires photosensitive resin, laser selective sintering method requiring a special solid powder, melt forming method requiring to use low melting point filamentous material[5]. These materials are generally expensive.

Both CNC machine tools and rapid prototyping are parts of the rapid manufacturing technology. Designers and managers can choose the proper rapid manufacturing technology based on the actual situation of the design when developing new products. The rapid manufacturing technology realizes the possibility of industrial product design being verified before mass production, and provides strong technical support for the advancement of sensual design to rational design.

5. Conclusion

In the increasingly fierce market competition, the manufacturing industry from the quality competition in the past to all-round competition throughout the life cycle, including four elements: T (timely), Q (high quality), C (low cost), S (superior after-sales service). Product development and manufacturing speed has gradually become one of the main contradiction of competition. At the same time, manufacturing needs to meet the changing needs of users as well as flexibility of manufacturing technology. Therefore, it becomes critical for manufacturing technologies to produce small-lot or even in one single piece without increasing the cost of the product. The diversity of people's culture, life style and emotions have directly raised new demands on industrial design. Some consumers are beginning to get tired of the products that are mass-produced in a thousand works, preferring to custom-built goods demonstrating self-aesthetic and self-cultivation and taste.

There is abundant case data showing that rapid manufacturing system technology of products reduce the product development cycle by one-fifth to one-tenth of the traditional method and development costs by one-third to one-fifth. With the continuous maturity and improvement of rapid manufacturing technology, its application will continue to expand, and it has also become a weapon to compete for orders and grab the market and become an effective measure to reduce market risk in product development. Rapid manufacturing technology can not only improve the level of research and development of industrial design, but also enhance the core competitiveness of the manufacturing industry.

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