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Research for Computer Integrated Manufacture in Complex Shape Piston of Diesel Engine

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Abstract. In order to improve complex shape piston productivity computer integrated manufacturing system (CIMS) technology is presented. Design elements need to be taken into account in CIMS technology, which are geometry, material choice, and rationalization of components (reducing assemblies) and cost. In design freedom phrase, this new design freedom will place much more responsibility on the designer to think about the exact requirements of a part – with the unlimited geometry capability designers will therefore need to be much more imaginative to make full use of the new manufacturing processes. New design paradigm is presented and mechanical designers will be able to manufacture any complexity of product they require. Effect of graded materials on product design is considered and 2D and 3D of piston are carried out. CAD issues and assembly constraints of complex shape piston of diesel engine are discussed. It gives new method to design and produce complex shape piston of diesel engine.

Introduction

In order to respond to increasing customer demands and global competition, diesel engine manufacturing enterprises in many parts of the world, especially in the developed countries, are compelled to seek advanced technologies as a means to shorten product life cycle, improve product quality, and increase productivity to satisfy a variety of customer profiles . One of the most significant outcomes of this search resulted from the concept of computer integrated manufacturing system (CIMS) at the end of 1980s. Piston is one of the most important parts and it affects the combustion and emission. One of the larger issues concerning the uptake of piston is that designers have very little material data available to them. For piston applications, designers typically need material properties ranging from -40º to +2500ºC. Therefore, the project is undertaking extensive material testing for a range of materials over this temperature range with different humidity and also over extended time-periods to consider the ageing of the materials.

In the paper, three dimensional manufacturing part of piston is carried out. With CIMS techniques, objects are created from a 3D CAD model without the use of either molding or tooling. This is achieved by taking discrete 2D slices of the 3D CAD file and, either through the deposition of material, the sintering or binding of powder or by selectively changing the state of a resin into a solid using a light source, objects are built-up layer-by-layer until the part is complete.

Design

For years, designers have been restricted in what they can produce as they generally have to design for manufacturing (DFM)– that is, adjusted their design intent to enable the component (or assembly) to be manufactured using a particular process or processes. Taking injection mould as an example, in order to process a component successfully, at a minimum, the following design elements need to be taken into account: (1) geometry; (2) material choice; (3) rationalization of components (reducing assemblies); (4) cost.

Design freedom. Additionally, the advent of CIMS will have profound implications for the way in which designer works. Generally, designers have been taught to design objects that can be made easily using current technologies – this being mainly due to the geometry limitations that exist with available manufacturing processes. For parts that are molded, this means that draft angles, constant wall thickness, location of split line, etc., have to be considered in the design. However, with the additive manufacturing technologies, these limitations are removed as it is not necessary to withdraw the part from the mould and therefore it would be possible to have re-entrant shapes without complicating manufacturing, no draft angles, variable wall thickness and no split lines. This new design freedom will place much more responsibility on the designer to think about the exact requirements of a part – with the unlimited geometry capability designers will therefore need to be much more imaginative to make full use of the new manufacturing processes. In the past, the processes have severely restricted designers and so they have become accustomed to designing relatively simple geometries.

New Design Paradigm. CIMS will change the divide between mechanical and aesthetic design. As demonstrated in the case study featured, the ability for industrial designers to create the parts that they design without the need to consider issues such as draft angle and constant wall thickness (needed for injection molding) means that, in effect, they are able to produce end-use items rather than just creative design briefs that are made by mechanical designers. Because of this, there will be a requirement for industrial designers to consider much more issues such as the integration of other components (such as batteries, key-pads, etc.). Conversely, mechanical designers will be able to manufacture any complexity of product they require. It is therefore suggested that there will be a need to create a new breed of hybrid designer where mechanical and aesthetic designers are educated in each other's fields in order to produce better products.

Effect of Graded Materials on Product Design . The over-molding technique is a classic example of how design can be influenced by the availability of a manufacturing technique. Over-molding allows designers, within limits, the ability to produce parts that have added functionality and enhanced design. Indeed, the design of over-molded components very often incorporates the different material combinations to accentuate the design to the extent that designers are able to exploit the delineation of the different materials used to produce design features as well as extra functionality. This is perfectly illustrated by the simple case of a piston – an item that will often include over-molding to give a handle that is stiff, with an over-molded grip and a different material at the neck to give a special head. This is shown in Fig 1.

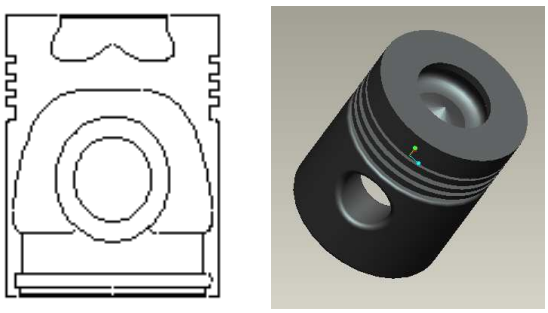

Fig. 1. 2D and 3D of piston

Discussion

One of the obvious examples from the project is the piston of the new design, which has a re-entrant surface for covering the inner component. Such a feature would require more expensive tooling costs even if manufactured conventionally in injection molding. CIMS may significantly enhance the degree of concurrency that can be employed by industrial designers. The introduction of CIMS has wider implications since the digital CAD model created can be used as the basis for the

interaction of other downstream engineering functions. In the future, it is likely that a new breed of "super-designer" who is able to function with both aesthetic and mechanical design will be required – these two functions are generally separated in the conventional product design phase.

CAD issues . One of the most important issues to be overcome for CIMS in the future will be the limitations and difficulties of using current CAD systems. The CAD design produced was, in essence, what was originally sketched, but lacked some of the spontaneity of the creative design sketch. This difficulty of interpreting the design intent is compounded by the fact that CAD systems are "expert systems" that require extensive training. One of the advantages of CIMS will be the possibility of producing more custom designs – however, there is a dichotomy between an increase in custom design that will necessitate more CAD input and the difficulty in producing those designs using current CAD. Considering the current design, some design ideas were "killed" by the constraints of the current CAD design system. Some of the initial designs were adventurous and organic; these would have been ideal for the CIMS research, but would have been complicated to produce in CAD systems and also would have been time-consuming. The result is that the initial creative idea could not be produced faithfully as some complicated details had to be changed or ignored through the current CAD package. It should also be noted that the time to produce the CAD model far outweighed the time to actually manufacture the product. In conventional manufacturing, the manufacture of the tooling to produce the piston components (for example) is usually the longest part of the product development process. When utilizing CIMS, the CAD takes the longer time and therefore becomes the bottleneck. The complexity of the CAD systems also has the effect of limiting those who can and want to use the CIMS technologies. The "ease of use" requirement has traditionally been the stumbling block for the most existing CAD systems.

Assembly constraints. Unfortunately, a freeform design that completely capitalizes on the freedoms given by CIMS is not necessarily suitable to receive the components and mechanisms required to make it work. In this case, the organic freeform shapes are not suited to house the square internal components. The outcome of this is that a design that is produced for CIMS is basically not limited by the constraints of conventional manufacturing, but by the fact that products require components to be assembled inside them.

Conclusion

CIMS will have a profound affect on the way the designers work. Key points emerge from the on-going design for CIMS project includes the following:

(1) With the advent of the CIMS technologies, designers will be able to manufacture any freeform shape that they design and will no longer be constrained by the limitations imposed by either the conventional molding process or the tool making process.

(2) The conversion of the industrial design sketches to a useable CAD model is non-trivial as there is difficult in re-producing the exact design intent.

(3) As all tooling is eliminated, the CAD modeling phase becomes the most time-consuming aspect of the project and therefore CAD becomes the bottleneck that requires a skilled operator to produce.

(4) In conventional product design, the industrial designer would pass the initial design ideas to a mechanical designer who would incorporate the "internals" and consider the manufacturing route. As the industrial designer is able to "print" a part directly, much more consideration of mechanical design is needed by the industrial designer or a general designer in the future. Thus, it is likely that the advent of CIMS will lead to a new breed of unique multi-skilled designer.

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