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Author(s): Sun, W.; Chu, S.; Xiao, D.
Title: CAD/CAM/CNC of dies for car alloy wheels and golf clubs
Year of publication: 2007
Citation: Sun, W.; Chu, S.; Xiao, D. (2007) 'CAD/CAM/CNC of dies for car alloy wheels and golf clubs' Proceedings of Advances in Computing and Technology, (AC&T) The School of Computing and Technology 2nd Annual Conference, University of East London, pp.228-232
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CAD/CAM/CNC OF DIES FOR CAR ALLOY WHEELS AND GOLF CLUBS

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Abstract: This paper presents 3D solid feature based modelling of a new design of a car alloy wheel derived from the ball pattern of the World Cup 2006 and golf clubs using a CAD system. Finite Element Analysis was applied to improve the new designs. Their dies were extracted from the parts/assemblies. The dies were scaled down to 20% of their original size using the CAD system, and these models were transferred into a CAM system. The machining processes were simulated for a three axis CNC mill controller using the CAM system. The tool paths were produced and the CNC programmes were generated by the modified postprocessor for controlling the CNC machine. The models of the dies of the new car alloy wheel and the golf clubs were produced using the modified CNC programmes with accurate shapes and reasonable surface finish. There is good potential for die making markets and industrial developments.

1. Introduction

Computer aided design, computer aided manufacture, and computerized numerical control, CAD/CAM/CNC, has been widely used in modern manufacture (Xiao, 2000; Brecher, 2006). CNC machining plays an important role in machining 3D surfaces of complex shapes of moulds and dies. Shapes, patterns and styles of car alloy wheels are changed and improved frequently by car designers and manufacturers. A new design of car alloy wheel with a new pattern and style derived from the ball of the World Cup 2006 was created and designs of golf clubs were modified and improved using SolidWorks 3D solid modelling CAD system. Finite element analysis for improving the mechanical properties and performance of the car wheel and golf clubs was applied using the FEA functions in the CAD system. The designs were modified and improved, and the final versions of the designs were concluded. Their dies were extracted from the final versions of the parts/assemblies considering the shrinkages in casting and forging, and their dies were scaled down to 20% of their original dimensions using the CAD system for experimental and machining test purposes. The models of their testing dies were cut into a reasonable number of pieces using the CAD system for the moulds/dies opening in casting and forging processes. Every piece of the models of dies was transferred into AlphaCAM CAM system for simulation of machining on Hitachi VM40 3-axis machining centre. The tool paths and CNC codes were generated by a modified postprocessor in the CAM system. The models of the dies were CNC machined using foam material.

2. CAD of a new car alloy wheel, golf clubs and their dies

2.1 CAD modelling of a new car wheel

The linking dimensions with tyre and cylinder of the alloy car wheel followed the standards (Alloy wheel, 2000). The shape, appearance, pattern and style of the wheel panel were derived from the newly-

designed official match ball, named "+Teamgeist", for the World Cup 2006 FIFA, with irregular 14-panel configuration shown in Figure 2.1, and the gap which lay alongside the spoke came from the appearance of the shark gill. The circular revolving and linear pattern functions, and sweep feature of SolidWorks CAD system were employed to produce the disk and rim (Wysack, 1997). The 3D solid modelling of the wheel is shown in Figure 2.2.

Figure 2.1 New-designed ball of World Cup 06

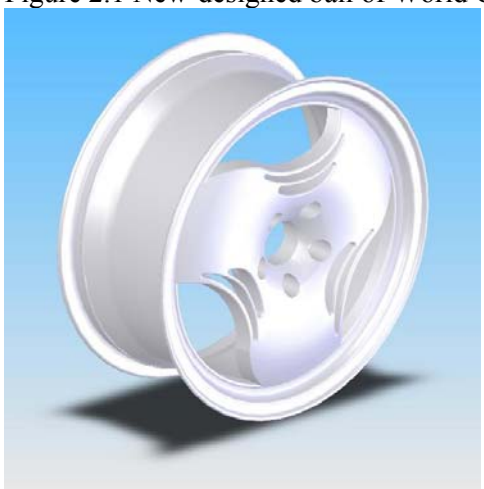


Figure 2.2 CAD modelling of car wheel

2.2 CAD modelling of golf clubs

The design data of golf clubs are based on the current patents' standards (Mahaffey, 2006). Some details were modified. The body of putter club and iron club were modelled by various tools, surfacing tools, curving tools and assembly tools of SolidWorks CAD system. Some of the models are shown in Figure 2.3.

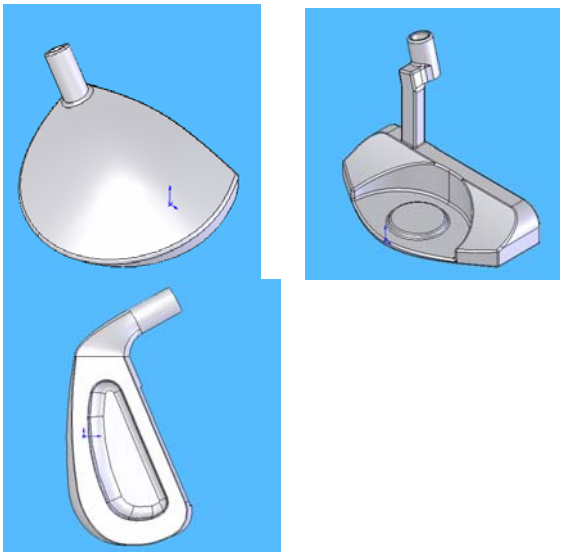


Figure 2.3 CAD modelling of golf clubs

2.3. Improving designs by Finite Element Analysis applications

Finite Element Analysis was applied to the models for evaluating the designs under certain load conditions using COSMOSXpress FEA functions of SolidWorks CAD system through defining material properties, restraints and loads. Figure 2.4 shows one of the examples of the car wheel under six restraints (from one axle and five bolts) and the load force (1,500kg) on the face.

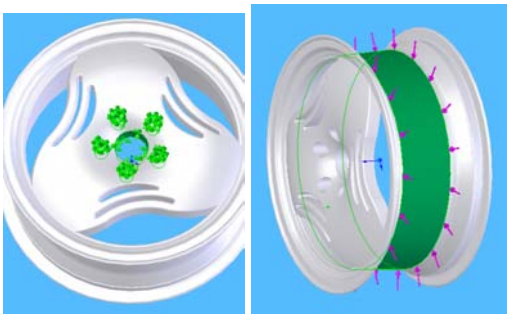


Figure 2.4 The restraints and Loads on the wheel

Figure 2.5 showed one of the FEA results of the car wheel and Figure 2.6 showed one of the FEA results of the putter club.

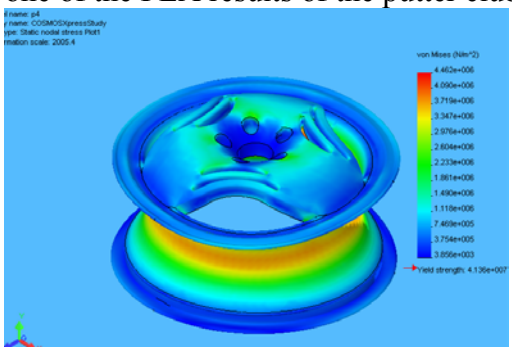


Figure 2.5 FEA results of the car Wheel

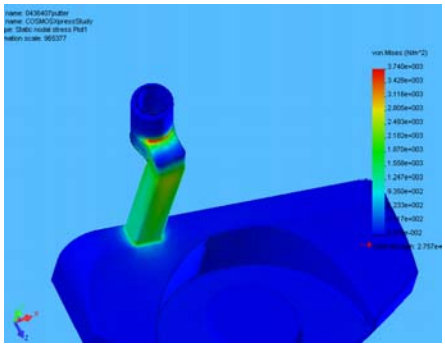
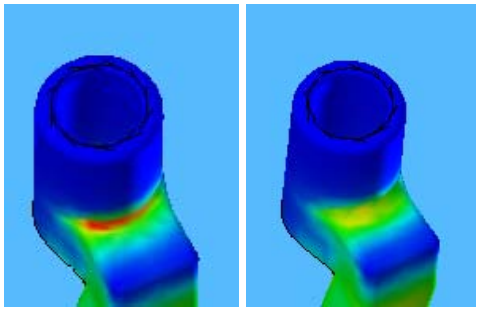


Figure 2.6 FEA results of the putter club

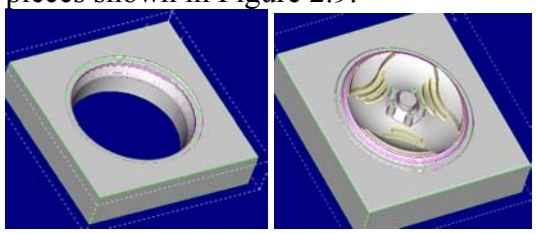
The FEA helps designers in various ways to evaluate the performances and improve the designs for achieve maximum service life under the relevant conditions (Xiao, 1996). The original designs were modified and improved by the FEA. Figure 2.7 showed one of the examples, the fillet in the red colour area was modified.



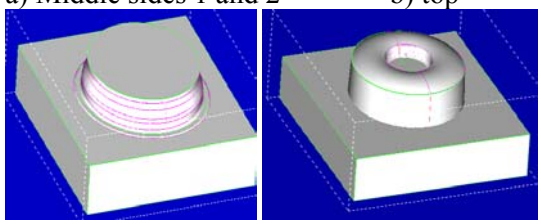
(a) Before (b) After
Figure 2.7 Modification of the putter-type club

2.4. Extracting the dies from the improved part designs

Core, cavity, assembly and partition functions of the CAD system were used for the die extraction from the improved designs of the car wheel and golf clubs with consideration of shrinkages in casting or forging processes (Wysack, 1997). The die for the wheel was cut into five pieces (side 1, side 2, top, middle, and bottom), which is shown in Figure 2.8, and the die for one of the golf clubs was cut into three pieces shown in Figure 2.9.



a) Middle sides 1 and 2 b) top



c) Middle d) Bottom
Figure 2.8 The die for the car wheel

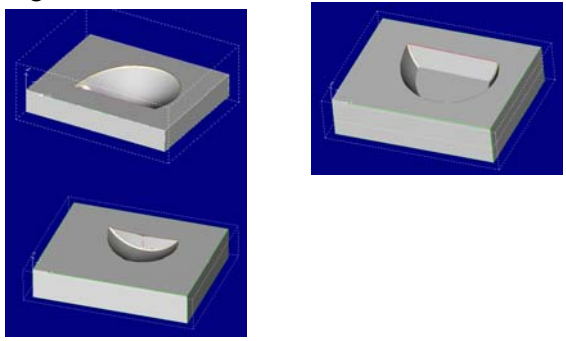
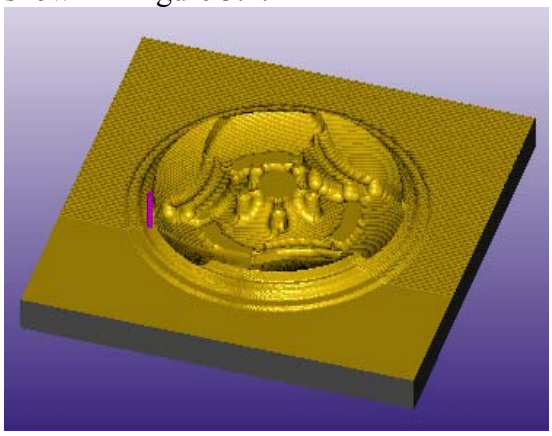


Figure 2.9 The die for one of the golf clubs

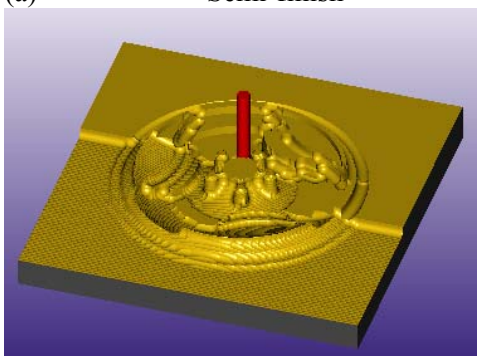
3. CAM of the dies

The CAD models of the dies were transferred from the CAD system,

SolidWorks, to CAM system, AlphaCAM. The machining processes for every piece of the dies in foam testing material were simulated in AlphaCAM. Facing, Z contour, parallel and angle in roughing, semi-finishing and finishing using various diameter flat end and ball end milling tools with high speed steel and carbide materials were employed. The machining simulation of the top of the die for the car wheel was shown in Figure 3.1. A similar simulation of the die for one of the golf clubs is shown in Figure 3.2.



(a) Semi-finish mill



(b) Finish mill

Figure 3.1 Machining simulation of the top of the die for the car wheel

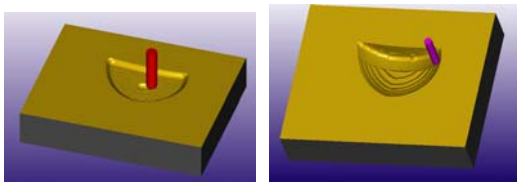


Figure 3.2 Machining simulation of die for one of the golf clubs

The tool paths of the dies were generated through the machining simulation. The NC codes (CNC programmes) were generated by the modified postprocessor for the Hitachi VM40 CNC machine. The NC codes are in the range of between 40,000 and 60,000 lines.

4. CNC machining of the dies on Hitachi VM40

The NC codes generated by the CAM postprocessor and slightly modified were transferred to the controller of the VM40 CNC machine line by line using "drip feed" through the network. The machining on VM40 for the top of the die for the car wheel was shown in Figure 4.1. The machining took about 25 minutes for the testing foam material. The machining of the die for one of the golf clubs is shown in Figure 4.2.

Figure 4.1 Machining of the top of the die for the car wheel

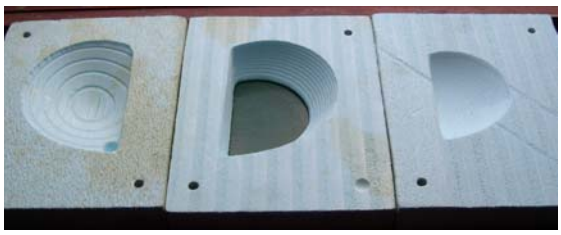


Figure 4.2 Machining of the die for one of the golf clubs

5. Discussions and conclusions

This paper presents a new idea of designing a car alloy wheel based on the shape and pattern of the ball of World Cup 2006. FEA as a powerful design tool was used for evaluating and improving the performances, optimizing designs and achieving maximum service life under the relevant conditions. The modified postprocessor for Hitachi VM40 worked well. The CNC codes generated from the postprocessor could be used for the CNC machine with minor modification. The large CNC programme (tens of thousands of lines of code) could be continuously fed through the network and executed on the CNC machine using "drip feed". The machined dies in the foam material with accurate shapes and reasonable surface finish showed good practice for machining casting dies and forging dies in real die materials. It takes about double the time to machine the real die materials using carbide milling tools. There is good potential for die making markets and industrial developments.

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