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Şeref Aykut
Bitlis Eren University
saykut@bitliseren.edu.tr
Bitlis-Turkey

DESIGN AND MANUFACTURING OF A NEW TYPE CAR DOOR HANDLE

ABSTRACT

Fast development of technology and environment of rivalry necessitate improvement of quality and productivity. For this reason, new approaches have been introduced. In this study, ergonomic design of new type car door handle's production has been analyzed. The model designed with CAD software is transferred to CAM and by composing tool path with SolidCAM software. Verification is put into practice through simulation. Using Abaqus method under the load up to 600 N, stress analyses has been carried out. At the last stage using Shigley's method, a design which is suitable is manufacturing in CNC.

Keywords: Car Door Handle, CAD, CAM, Abaqus, SolidCAM

YENİ BİR OTOMOBİL KAPI KOLU TASARIM VE İMALATI

ÖZET

Hızla gelişen teknoloji, artan rekabet ortamı üretimde verimliliği ve kaliteyi arttırmayı zorunlu hale getirmekte, bu amaçla yeni yaklaşımlar ortaya konulmaktadır. Bu çalışmada; farklı bir otomobil kapı kolunun ergonomik tasarımı, üretimi gerçekleştirilmektedir. CAD yazılımı ile tasarlanan model CAM'e aktarılmakta ve SolidCAM yazılımıyla takım yolları oluşturularak simülasyonla doğrulama yapılmaktadır. Abaqus ile 600 N değerine kadar uygulanan yükler altında gerilme analizi gerçekleştirilmektedir. Shigley yöntemiyle son adımda yeterli bulunan tasarım CNC de imal edilmektedir.

Anahtar Kelimeler: Otomobil kapı kolu, CAD, CAM, Abaqus, SolidCAM

1. INTRODUCTION (GİRİŞ)

Computer Aided Design (CAD) includes benefiting from computers with the purposes of facilitating, speeding, and increasing the quality of mechanic and electro-mechanic parts and systems design process. In order to see the product from every perspective and grasp a better idea about the real structure and shape of that product, an image of the product is generated in the computer environment based on the real measures of the product in question [1 and 2]. CAD systems are generally composed of software and hardware elements. Software part contains modules which are used for generation of the solid model and determination of static, dynamic, and thermal performance of the designed model. Hardware part is composed of peripheral units such as monitor, mouse, keyboard, etc [3].

Computer Aided Manufacturing (CAM) is the next stage of the process after CAD. CAD model knowledge is used in CAM software when shaping the raw material as requested using the methods of manufacturing such as lathing or milling. For example; in the CAD model, the selected material is used for determination of rounds and feed speed where dimensions of CAM model are used for tool selection and determination of tool paths. Hence, a real machine part becomes three dimensionally producible. CAM, at the same time, includes planning and managing computer systems and operations that are performed directly or indirectly in the control of a manufacturing process. CAD/CAM technology is advancing towards a higher integration of design and manufacturing [2]. CAD and CAM software used today are continuously developed. Some of this software is used in an integrated way and some is used independently.

One of most important issue in CAD/CAM integration is the automatic extraction of manufacturing and assembly information from 3D CAD models. Many of current CAD systems contain all geometric information of the part. However, they define mechanical components by low-level information such as points, curves, surfaces, and solids. But, in CAD/CAM form features such as slot, hole and pocket, etc., and material technological information, tolerance, surface roughness, hardness, material, etc., are required [4]. CAD databases are not appropriate for use directly in CAM systems, thus, a common database, which can be used by CAD and CAM, is necessary [5]. In order to interface CAD and CAM, one approach may be part recognition system which analyses a CAD model and identifies it. The parts analyzed in the part recognition algorithm can be then used as input to CAD/CAM applications such as process planning, group technology and computer aided assembly [6].

The basic idea in Computerized Numerical Control (CNC) is operating the machine tools by the help of commands that are composed of symbols such as number, letter, etc. and coded according to certain logic and tool control unit’s being able to realize production with the help of part program. Following the verification realized in CAM, the necessary NC codes are written to transfer this information to CNC machine tools. One of the parameters to be handled with caution is the type of post processor of the CNC tool to be used. NC codes are transmitted to the CNC tool by a wired connection or using a memory card. Stock model in the dimensions as it was determined in CAM is tied to the tool. After adjusting the reference point determined in CAM and setting the tools, the program is run. The operation performed is realization of the simulation conducted in CAM. After the operation is finished, target model is obtained from the stock model. Flow diagram of this process explained is demonstrated in Figure 1.

2. THE IMPORTANCE OF STUDY (ÇALIŞMANIN ÖNEMİ)

The aim of this study is to perform the design-production process and realize CAD/CAM/CNC integration; and to generate an ergonomic interior door handle prototype, which is in accordance with the finger ergonomics, for a different automobile. SolidWorks is used in the CAD stage of design-production process. In the CAM stage, design-production process is continued by using SolidCAM. In the models developed using SolidWorks, shifting and sweeping operations are used; in model arrangements, correction operation and ancillary reference planes are used for edge radiuses. Stress analysis is conducted in Abaqus by applying certain loads on the door handle and the door handle is manufactured on a CNC milling machine tool.

3. MATERIAL AND METHOD (MATERYAL VE METOT)

In this research, polyamide, which is easy to shape, and wooden materials are used as the material of the prototype. The materials are prepared so to have the dimensions of 150x119x20 mm. In the experiment, end-mill, end-mill with spherical cutter, and drill with cutting edges that have the respective diameters of 6, 6, and 5 mm are used. In Table 1, cutting tools that are used in the experiment and cutting conditions are demonstrated.

In order to design the handle Shigley's method used. Although the method of Regh and Kraebber have five basic steps Shigley's has of six steps recognition of the needs, definition of the problem, synthesis, analyses and optimization, evaluation, and presentation. In the study, initially, simulations built on SolidCAM software are realized. The information on NC codes, which are generated by the realized simulations, is translated to CNC machine tools using memory cards. Afterwards, a stock model having the dimensions as determined in CAM is tied to the tool and after the reference point determined in CAM is adjusted and the tools are set, the program is run. The operation that is performed is a realization of the simulation which is conducted on CAM. After the operation is finished, the target model is obtained from the stock model.

Table 1. Used experimental study cutting tools and cutting conditions
(Tablo 1. Deneyde kullanılan kesici takım ve kesme şartları)

Diameter cutting tools, [mm]	Cutting tool length, [mm]	Type of cutting tools	Revolutions per minute, [rpm]	Cutting speed, [mm/min]
6	25	End milling	2000	250
6	20	Ball milling	2500	150
5	30	Drilling	2000	200

4. INTEGRATION OF CAD/CAM/CNC (CAD/CAM/CNC'NIN ENTEGRASYONU)

The integration of Computer Aided Design and Computer Aided Manufacturing has received significant attention in the recent years according to the development of faster computing power tools. However, the actual integration between CAD and CAM, for the downstream applications such as process planning, can be achieved only when the manufacturing information can be obtained directly from 3D solid model and hence automate the process planning functions [7, 8, and 9].

CAD and CAM have received significant attention in the recent years according to the development of faster computing power tools. However, the actual integration between CAD and CAM, for the downstream applications such as process planning, can be achieved only when the manufacturing information can be obtained directly from 3D solid model and hence automate the process planning functions [10]. Integration of CAD/CAM systems with CNCs is a requirement of design and manufacturing processes. In fact, these concepts, which are different from each other, are used today even in small enterprises in an integrated way.

The basic role of CAD is to precisely define the geometry of a design, as it is critical to all the subsequent activities in the product cycle. Similarly, CAM is the technology concerned with the use of computer systems to plan, manage and control manufacturing operations through either direct or indirect computer interface with the plant's production resources so that a design can be materialized. Because a 3D model contains enough information for NC cutter-path programming, the linking between CAD and CAM is made easier. So-called turnkey CAD/CAM systems were developed based on this concept and became popular in late 1980s. One of the earliest developed technologies in the areas of CAM is Numeric Control (NC), which is the technique of using programmed instructions to control machine that mills, cuts, punches, grinds, bends or turns raw stock into a finished part.

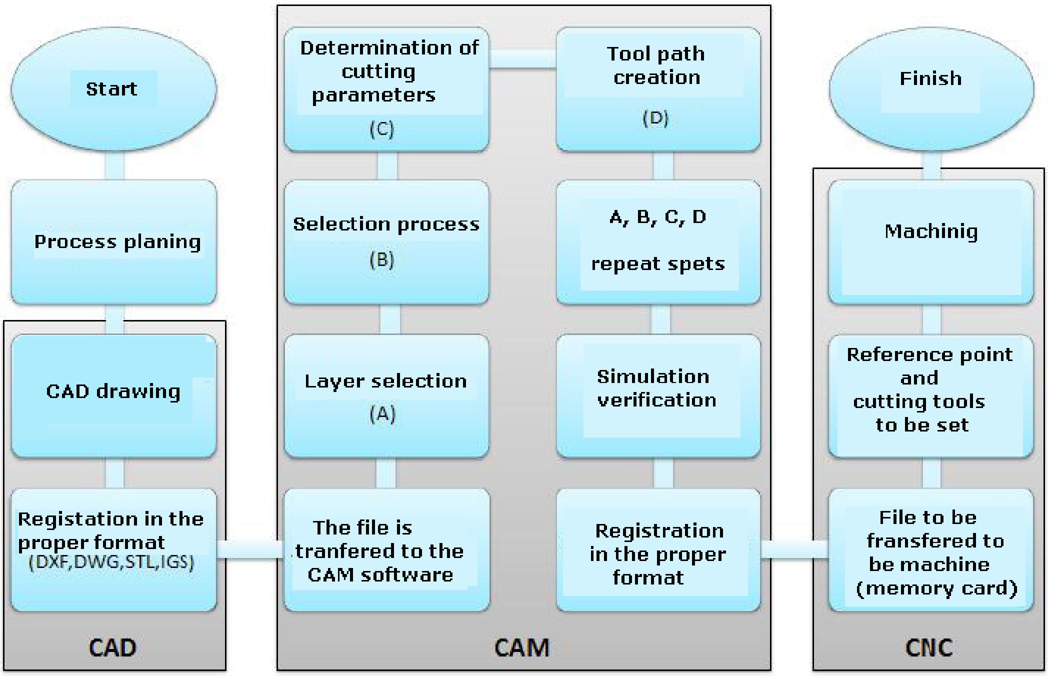

Figure 1. Integration of CAD/CAM/CNC
(Şekil 1. CAD/CAM/CNC'nın Entegrasyonu)

In an integrated CAD/CAM environment, there are two types of interfaces, the interface for neutral data exchange between CAD and CAM or two different CAD or CAM systems, and the interface for communications between a CAM system and a CNC machine tool [11]. The former is now available and generally considered sufficient. The later, which is effectively the machine control data (NC part program), presents a weak link in a much-needed integrated CAD/CAM environment [12].

The model generated with the required drawings of the part to be produced is transferred to the CAM software. This stage may exhibit differences according to the system used. While some CAD and CAM software work in an integrated way, some other software work independently. While in the software working in an integrated way, it is possible to directly migrate from modeling screen to operating screen in CAM, in software that is not integrated the model is prepared in CAD and saved in a format compatible with the CAM software to be used and the operation is continued only after this new file is opened in the CAM software. In CAM, initially, dimensions are given for the design model taken from CAD or a stock model is generated automatically. The stock model is a semi product before the part is processed. In other words, it is the work piece to be tied to the CNC tool that is used in the simulation to reach the target model. Target model, on the other hand, is the processed form of the part that comes out of the CNC tool. In order to reach this model, the necessary operations, appropriate tools and appropriate tool paths are determined. In CAM, simulations of the operations to be performed are monitored and if there are plunges then they are corrected and tool paths are verified. In Figure 1 flow chart of CAD/CAM/CNC integration is depicted.

5. ANALYZING BY ABAQUS (ABAQUS’DE ANALİZ)

Abaqus used as finite element software. Designed model shown in Fig 2 and obtained mesh of model shown in Fig 3.

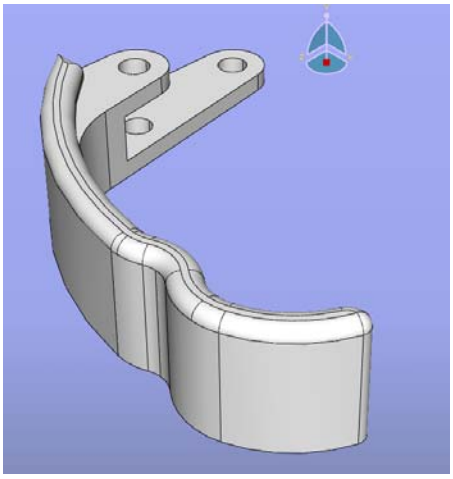

Figure 2. The Model of The Door Handle
(Şekil 2. Kapı Kolu Modeli)

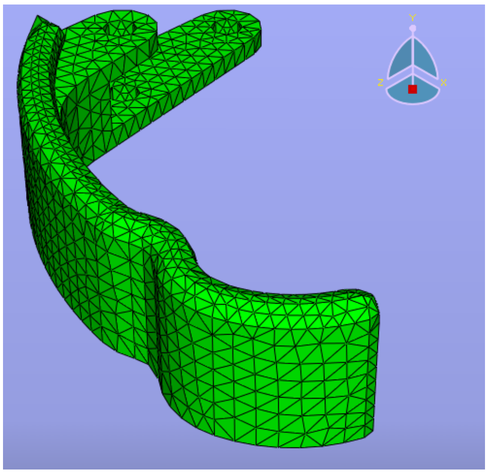

Figure 3. FEM of Mesh Door Handle
(Şekil 3. Kapı Kolunun FEM’de Gösterimi)

Door handle stress analysis under the loads up to 600 N carried out (Table 2). Modulus of elasticity and Poisson's' ratio of the material were 207 GPa and 0,30 respectively.

Table 2. Analysis is applied to loads obtained the minimum and maximum stress
(Tablo 2. Analizde yük uygulanmasıyla elde edilen mak. ve min. gerilmeler)

Load [N]	10	50	100	200	400	600
Min. stresses [MPa]	0,0075	0,0337	0,0754	0,1510	0,3010	0,4529
Max. stresses [MPa]	7,639	38,200	76,390	152,80	305,60	458,40

Stress regions occurring on the loaded door handle are given in Figure 4. Stress value is at its minimum level on the regions that are blue and maximum on the regions that are close to red. As it can also be seen from the figure, the locations of stress accumulation regions do not change due to the fact that the applied load is in the same direction at all times. According to this, the most dangerous section in the analyzed model is on the junction region that is between the ball pin and the part to which load is applied. On this region which is obtained as dangerous (on the red region), it has been detected that strain values increase depending on the amount of load applied. Hence, it could be said that the probability of getting damaged on this point would increase depending on the amount of load applied.

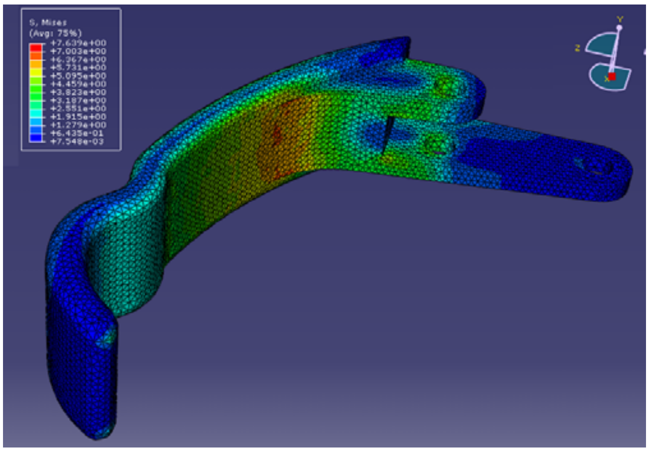

Figure 4. Stress Regions Occurred on the Loaded Door Handle
(Şekil 4. Kapı Kolunda Meydana Gelen Gerime Bölgeleri)

6. PRODUCTION PROCESS OF PROTOTYPE DOOR HANDLE (KAPI KOLU PORTATİFİNİN İŞLEME SÜRECİ)

Realizing an integration of CAD/CAM/CNC, an ergonomic interior door handle prototype for automobiles is manufactured. This research is designed motivated by the existence of an idea that interior door handles of automobiles are/are not appropriate for the finger ergonomics. In the CAD stage of design-production process, SolidWorks software is used. In the CAM stage, using SolidCAM as the software, design-production process is continued. In the models built with SolidWorks, shifting and sweeping operations are used; in model arrangements, correction operation and ancillary reference planes are used for edge radiuses. The application is realized in three stages on a CNC tool and for each stage, work-piece is tied to the tool in a different position and tool reset is performed. Production process of prototype door handle was manufacturing three stages.

The door handle model is processed in three stages on CNC milling machine tool because of its structure. In order to obtain the target model, the part is three times tied to the tool in different positions and references are determined. After the tool paths are also determined, the simulation is realized. After the simulation is verified in CAM program, NC codes are derived. NC codes obtained as a result of the simulation code are transferred to the CNC milling machine by the help of a flash memory. NC code output generated in CAM; an image from the moment of model building on CNC; in Figure 5, door handle model prepared in SolidWorks; and in Figure 6, ergonomic interior door handle produced from wood are given.

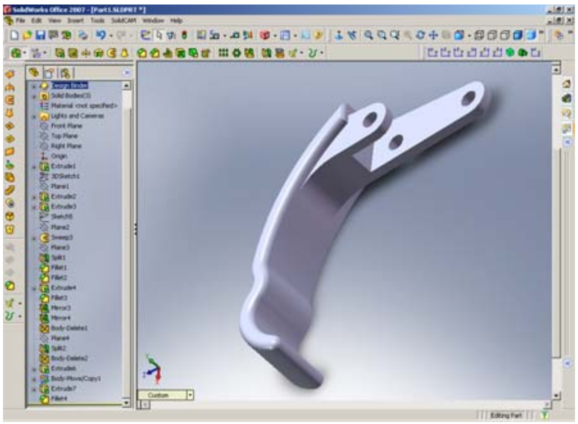

Figure 5. The Door Handle Model Has Been Prepared in Solidworks
(Şekil 5. Kapı Kolu Modelinin Solidworks'de Hazırlanması)

Figure 6. Manufactured from Wood Ergonomic Interior Doors Handle
(Şekil 6. Ergenomik Kapı Kolunun Ahşaptan Üretilmiş Şekli)

7. CONCLUSIONS (SONUÇLAR)

In this study a new handle has been designed and manufactured. With Abaqus software program, the door handle is analyzed by applying loads of 10, 50, 100, 200, 400, and 600 N to it. Stress values are at their minimum level on the blue regions and at their maximum level in the regions with colors close to red. The locations of stress accumulation regions do not change since the applied load is in the same direction at all times. According to this, the most dangerous section in the analyzed model is on the junction region that is located between the ball pin and the part which is applied the load. It is detected that stress values increase depending on the amount of load applied on the red region which is obtained to be dangerous. Hence, it could be said that the probability of getting damaged here increases with the magnitude of load to be applied.

REFERENCES (KAYNAKLAR)

1. Shigley, J.E., (1986). Mechanical Engineering Design. McGraw-Hill Book Co. Inc.
2. Groover, M.P.E. and Zimmers, W., (2002). CAD/CAM Computer-Aided Design and Manufacturing, Antony Rowe Ltd, Eastbourne.
3. Yağmur, L., (2004). Tasarım ve imalatta CNC ve CAD/CAM sistemlerinin fonksiyonları, Metal Makine Dergisi: 149, 436-554.
4. Çiçek, A. and Gülesin, M., (2004). Reconstruction of 3D models from 2D orthographic views using solid extrusion and revolution, Journal of Materials Processing Technology: 152, 291–298.
5. Gülesin M. and Jones, R.M., (1994). Face oriented neighboring graph (FONG): a part representing scheme for process planning", Computer Integrated Manufacturing Systems: 7 (3), 213–218.
6. Cicek, A. and Gülesin, M., (2007). A part recognition based computer aided assembly system. Computers in Industry: 58, 733–746.
7. Chang, H-C., Lu, W.F., and Liu, F.X., (2002). Machining process planning of prismatic parts using case-based reasoning and past process knowledge. Applied Artificial Intelligence: 16(4), 303–331.
8. Mansour, S., (2002). Automatic generation of part programs for milling sculptured surfaces. Journal of Materials Processing Technology: 127(1), 31–39.
9. Miao, H.K., Sridharan, N., and Shah, J., (2002). CAD/CAM integration using machining features. International Journal of Computer Integrated Manufacturing: 15(4), 296–318.
10. Nasr, E.S.A. and Kamrani, A.K., (2006). A new methodology for extracting manufacturing features from CAD system. Computers and Industrial Engineering: 51, 389–415.
11. Regh, J.A. and Kraebber, H.W., (2005). Computer Integrated Manufacturing. 3rd. Edition. Pearson Education Co. Inc.
12. Xu, X.W. and He, Q., (2004). Striving for a total integration of CAD, CAPP, CAM and CNC. Robotics and Computer-Integrated Manufacturing: 20, 101–109.