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CURRENT TRENDS IN PROCESS OF DESIGN AND PRODUCTION OF AUTOMOBILES

SAVREMENI TREDOVI U DIZAJNIRANJU I PROIZVODNJI AUTOMOBILA

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Abstract: *Time of innovation cycle in automotive industry is being reduced thanks to increasing market competition. It is possible to follow this trend only by means of CA-applications in the design and production phase of product life cycle.*

Key words: *automotive industry, design*

Apstrakt: *U automobilskoj industriji zbog rastuće konkurencije na tržištu sve je veća potreba za stalnim uvođenjem inovacija. Ovaj trend moguće je pratiti samo primenom CA tehnologije u procesu dizajniranja, konstruisanja i proizvodnje.*

Ključne reči: *automobilska industrija, dizajn,*

1 INTRODUCTION

Intensive improvement of the consumer and automotive industry puts more and more demands on technologies of plastic material processing and forming.

Design, analysis and production of parts and components is in these industry branches inconceivable without using CA technologies and CA approaches connected with them for design and production.

Current requirements on design and production of shapes in the automotive and consumer industry result from the way of shape design and its next production. An automobile is composed of many components: supporting skeleton consists of shape profiled sheets (fig. 1). External shapes are from sheets or plastic materials

1 UVOD

Intenzivan razvoj tržišta i automobilske industrije postavlja stalno nove zahteve u oblasti tehnologije prerade i oblikovanja plastičnih materijala.

Dizajn, ispitivanje i proizvodnja delova i komponenti u ovim granama industrije je nezamisliva bez primene CA tehnologije i CA pristup

Aktuelni tržišni trendovi diktiraju dizajn novih modela i oblika koje je automobilska industrija prinuđena da prati. Automobi se sastoji iz puno različitih komponenti: noseća konstrukcija koja je sastavljena od profilisanih limova (sl. 1). Spoljni deo ili karoserija izrađena je od metalnog lima ili plastičnih materijala (sl.1). Unutrašnjost je uglavnom

(fig. 1). Interior is mainly from plastic materials or textile fabrics by using which hard foams are covered with. Every part has its own tool by using which is produced. Tools production for serial production of shape parts is related with the fact.

izrađena od plastike i tekstila sa kojim se prekrivaju delovi izrađeni od čvrstog sunđera. Za izradu svakog dela koristi se posebna vrsta alata, pa s tim u vezi, imamo i proizvodnju alata za serijsku proizvodnju različitih delova.

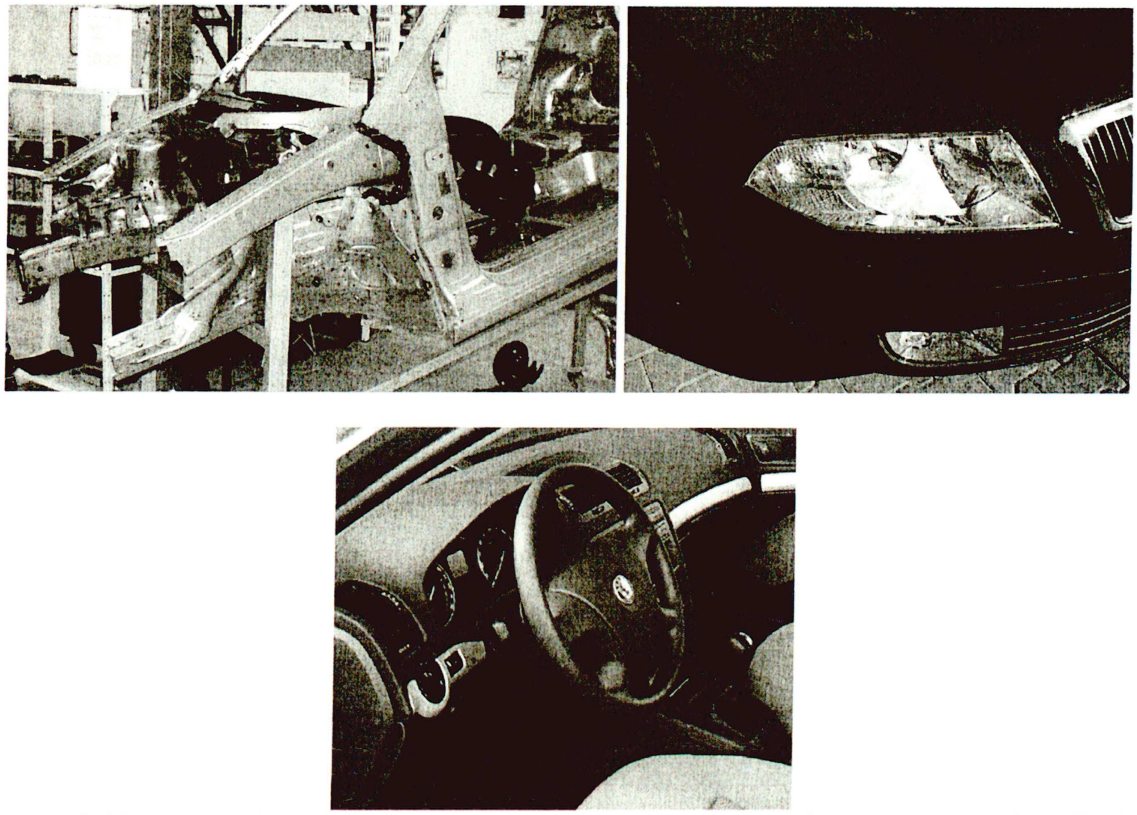


Figure 1 The supporting skeleton, plastic and metallic external components of car body, plastic mouldings of interior.
slika 1 Noseća konstrukcija, plastične i metalne komponente karoserije, delovi unutrašnjosti modelirani u plastici

Final shape production in technologies of injection moulding and sheet-metal pressing is made by using a tool that is called a form. Form active parts contain information of product shape that is produced with their help. [1]

Finalna proizvodnja karoserije vrši se primenom tehnologije injekcionog izlivanja i presovanja metalnog lima uz pomoć specijalnog alata, odnosno kalupa. Aktivni delovi kalupa sadrže sve podatke neophodne za oblikovanje proizvoda [1].

2 DESIGN AND PRODUCTION: IN THE PAST AND TODAY

2.1 Comparison of shape solution for front-end car section

Shape design for mentioned car part was quite restricted by possibility of production of individual components not long ago. Headlights were mainly with circular diameter 160 or 130 mm . Škoda 105/120 had the same headlights as e.g. Lada 1200/1500. Similarly it was also in the

2 DIZAJN I PROIZVODNJA NEKAD I SAD

2.1 Poređenje rešenja za prednji i zadnji deo karoserije

Ne tako davno dizajn pomenutih delova automobila bio je veoma ograničen zbog limitiranih mogućnosti proizvodnje pojedinačnih komponenti. Farovi su u većini slučajeva bila kružnog oblika u prečniku 160 ili 130mm. Na primer, Škoda 105/120 je imala ista farove kao

West of our continent. Alfa Romeo, VW, Fiat, Ford and Simca had also circular headlights. Bumpers were mostly chromium-plated molded panels. One of components the most different among various automobile marks was shape of direction indicators that were the molded plastic parts. [2]

i Lada 1200/1500. Sličnu situaciju imali smo i na Zapadu; Alfa Romeo, VW, Fijat, Ford i Simka su takođe imali kružne farove. Branici su se uglavnom izrađivali od hromiranih profila. Jedna od komponenata čiji oblik je pretrpeo najviše izmena su poziciona svetla koja se sastoji iz plastičnih komponenti. [2]

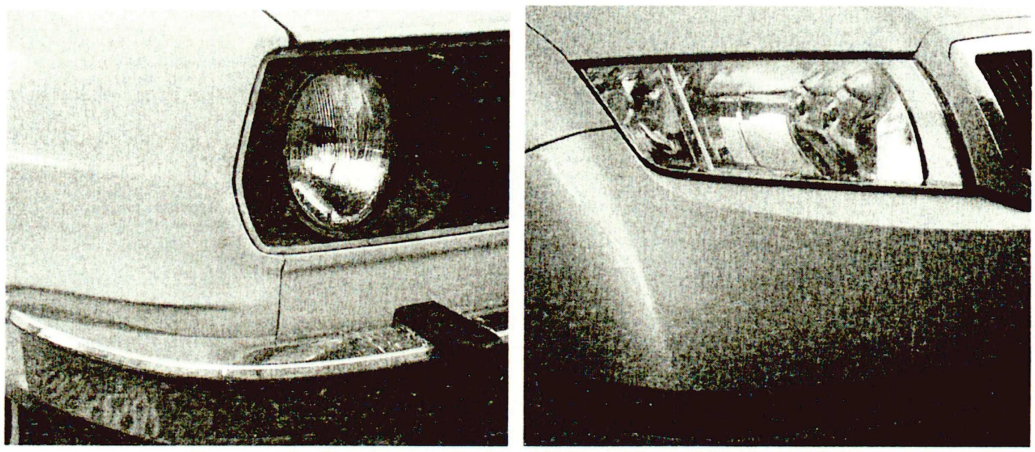


Figure 2 Comparison for shape of car bodies [2]
slika 2 Uporedni prikaz različitih modela karoserija

Designers at past times were able to model other various shapes for bumpers, headlights or direction indicators but technologies of the past times did not allow their mass production.

Konstruktori i dizajneri su u prošlosti mogli da menjaju oblik branika, farova ili pozicionih svetala, ali tehnološke mogućnosti nisu dozvoljavale njihovu masovnu proizvodnju.

2.2 In the past

Complicated shapes were produced on the basis of the manually produced models from wood or modelling material. Off-print of the model again into the modelling material the model negative was created. According to it was created by using profiler the form cavity.

2.2.1 Model shape acquirement – a clay model

Shape designers in the automotive industry materialized their primary ideas by using paper and a pencil into the sketch which represented individual views on shape of designed car body. Materialization of the idea into the 3D model was made by modelling clay according to the sketches. There were created the shape designs and models in scaling factor 1:10 in initial phase and after shape adjustment in scaling factor 1:5 or 1:1 [6] (fig. 3). In the end the accurate model from clay and laminates was produced in its real size, so called „master model", which served as the unique car body reference (fig. 3).

2.2 Nekad

Komplikovaniji oblici proizvodili su se pomoću ručno izrađenih kalupa od drveta ili nekog materijala za modeliranje. Kalup se utiskivao u materijal za modeliranje čime se oblikuje model na principu negativa.

2.2.1 Oblikovanje modela – glineni model

Ljudi zaduženi za dizajn karoserije materijalizovali su svoje prvobitne ideje na papiru pomoću nacrta u različitim perspektivama. Da bi se omogućila trodimenzionalna materijalizacija ideje bilo je neophodno prema nacrtima izraditi glineni model i to u razmeri 1:10 u početnoj fazi. Eventualne izmene su se unosile u sledeći model koji se izrađivao u razmeri 1:5 ili 1:1 [6] (slika 3). Konačno, finalna verzija modela od gline i laminata izrađivana je u prirodnoj veličini kao „osnovni model", koji služi kao uzorak za izradu karoserije automobila (sl. 3).

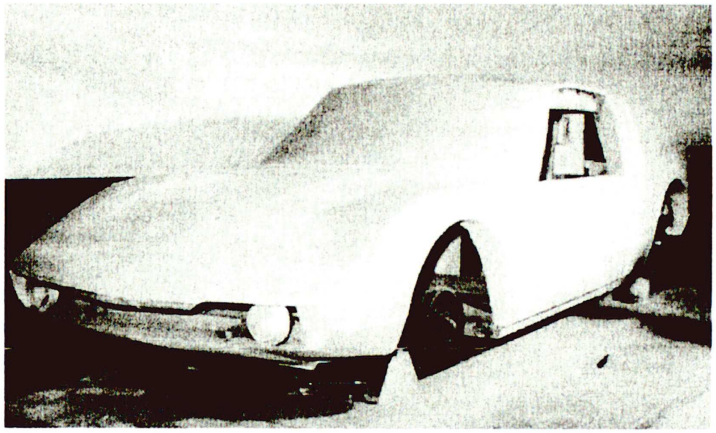


Figure 3 „Master model" intended for shape scan for tools production [5]
slika 3 „Osnovni model" karoserije koji služi za izradu posebnih alata

The approach for shape design was described by very simplified scheme. In fact many activities were several times repeated [6].

Opis ovog procesa je ovde prikazan u krajnje pojednostavljenoj formi pri čemu su izostavljene mnoge faze, koje se mogu i po nekoliko puta ponavljati. [6]

2.2.2 Copying – by profiler

2.2.2 Izrada replika pomoću kalupa

Demonstration of copying of shape for part of dies by using a laminate model is shown in fig. 4.

Na slici 4 prikazana je izrada replika uz pomoć kalupa prema modelu izrađenom od laminata.

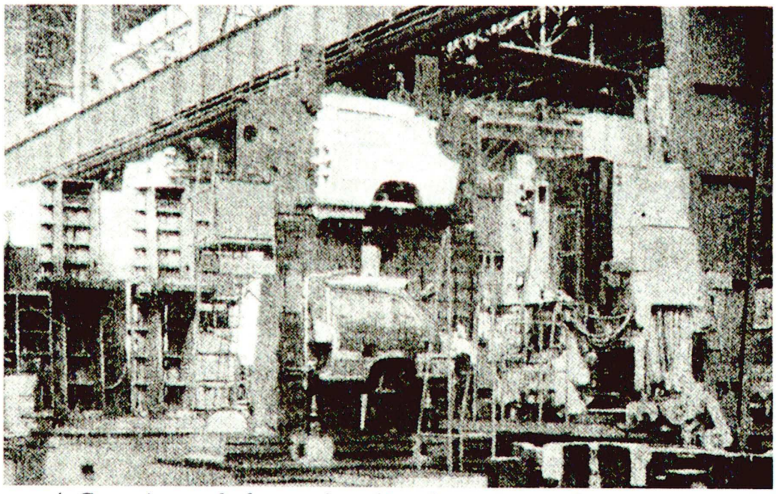


Figure 4 Copying of shape for dies by using a laminate model [6]
slika 4 Izrada replike pomoću kalupa prema modelu od laminata [6]

The whole process could be shortly described as follow: Model shape was created by using modelling approaches on clay or laminates basis. There were scanned shapes from completed model in scaling factor 1:1.The shapes served for negative shape production by using profiler or the clay model was laminated or moulded into the cavity off-print. The model was then used for production of the form insertion by profiler. By the classical approach a profiler was used as a tool for shape transformation from laminate model as a pattern into the active tool part – the form produced from tool steel. Profilers were used for the purpose.

Ceo proces može se ukratko opisati u sledećim crtama: oblik osnovnog modela izrađen je modeliranjem gline ili laminata. Na osnovu osnovnog modela prave se modeli pojedinih segmenata u razmeri 1:1. Ovi segmenti koriste se kao negativ za izradu pojedinačnih kalupa ili se ceo model izliva u obliku školjke kao kalup za štampanje. Ovako izrađen kalup se zatim koristi za izradu školjke automobila. U ovom klasičnom pristupu kalup je korišćen kao sredstvo za oblikovanje alata prema modelu.

2.3 Today

By using CA approaches for design and production the boom was made in design of mentioned car parts. (fig. 2). CA technologies lining as well as progressive technologies for material processing connected with them allow to mass production of shapes that have not been able to snag nor produce by classical manner.

The clay model production for negative shape acquisition losses its meaning at present. The model negative is obtained directly in CAD system by using simply Boolean operation of subtraction. If the problem is snagging of cavity shape but it is possible to snag the positive shape then the approach for model production is as "electrode". Shape cavity of the form is then reached by electro erosion machining.

Simply said from shapes designed in CAD system with support of NC modules CAM system data for NC machines can be generated. The machines are able according the data to produce desired shape of parts into tools for their production (tools for sheet-metal pressing, forms for plastic materials injection moulding, and so on).

Also thanks to this fact progress in car shape image for various automobile marks was reached. Headlights and direction indicators are today contour and create one complete whole in connection with splash-board and bumper. [2]

2.3.1 Shape acquisition for virtual model

Product shape can be obtained:

- **By creation of computer virtual model in graphical environment of CAD system** by using approaches of surface or volume modelling. A model is created either directly by CA skilled designer or by CAD expert (a modeller) on the ground of sketches and idea designs of a designer. A model is created in an environment of surface modeller from basic elements in 2D.On ground the elements are then created 3D shape surfaces. The result is the surface model of the shape.

2.3 Danas

Primena CA tehnologije u procesu dizajniranja, konstruisanja i proizvodnje automobila predstavlja bum u ovoj grani industrije (sl. 2). CA tehnologije omogućavaju masovnu proizvodnju različitih oblika koje nije bilo moguće postići, ni proizvesti, primenom konvencionanih metoda.

Izrada modela od gline radi izrade kalupa da bi se obezbedio negativ za proizvodnju školjki u današnje vreme u potpunosti je izgubila smisao. Negativ se direktno dobija u CAD sistemu jednostavnom primenom Booleanove operacije oduzimanja. Ukoliko se popjave problemi prilikom modeliranja oblika školjke u negativu isti se modelira u pozitivu. U tom slučaju prilikom proizvodnje primenjuje se princip „elektrode". Željeni oblik školjke se zatim postiže mašinskom obradom pomoću elektro-eroizije.

Jednostavno rečeno, od oblika koji se projektuju u CAD sistemu uz podršku NC modula mogu se generisati podaci CAM sistema za NC mašine. Ove mašine su u stanju da u skladu sa raspoloživim podacima izrade alatke za proizvodnju pojedinih delova u željenom obliku (alatke za presovanje lima, kalupi za injekciono izlivanje plastičnih materijala itd.).

Zahvaljujući ovim mogućnostima postignut je veliki napredak u dizajnu mnogih vrsta automobila. Farovi i poziciona svetla sada čine jednu celinu zajedno sa blatobranom i branikom. [2]

2.3.1 Preuzimanje oblika iz virtuelnog modela

Oblik proizvoda može se dobiti:

- **generisanjem virtuelnog modela na kompjuteru u grafičkom okruženju CAD sistema** primenom modeliranja površina i zapremine. Generisanje modela može da obavlja obučeni projektant ili CAD stručnjak (modelar) na osnovu nacrta i idejnog projekta projektanta. Model se prvo stvara u 2D okruženju prema osnovnim elementima, a zatim se generiše 3D oblik modela sa svim površinama. Rezultat je virtuelni model automobila.

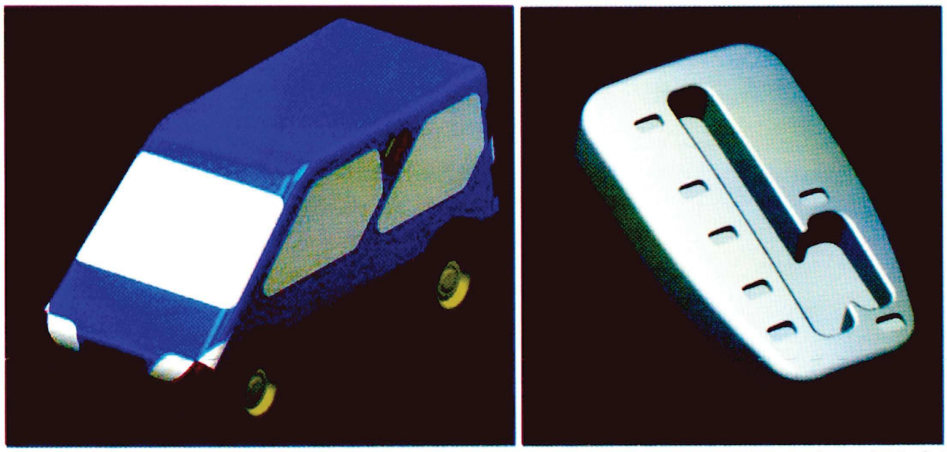


Figure 5 Virtual automobile model and sceneries of gear control created in SW CATIA [9]
slika 5 Virtuelni model automobila i prikaz rada menjačke kutije u SW CATIA [9]

- **By scanning of points position data for the clay model by using three-dimensional digitizing machine - scanner.** The first step in model transfer from real into the digital environment is its detail measure. For needs of „reverse engineering" it is used at present the principle of contact-less scanning by optical or laser 3D scanners. The result of measurement is high number of points with X, Y, Z measures – it means „a cloud of points" usually exported with triangular net in data format STL for the next processing. The measured STL model is in the follow phase transformed into the CAD surface data. The digital model is always a compromise among surface smoothness, deviation from measured data and speed of their creating [4].

- **skeniranjem pozicionih tačaka glinenog modela korišćenjem mašine za trodimenzionalnu digitalizaciju – skener.** Prvi korak u prenošenju modela iz realno u digitalno okruženje je njegovo detaljno merenje. Za potrebe „obrnutog projektovanja" trenutno se koristie optički ili laserski trodimenzionalni skeneri. Kao rezultat merenja dobija se veliki broj tačaka sa X, Y, Z merama, odnosno obično se dobija „oblak" tačaka koje se eksportuju i obliku trougaone mreže u format STL radi dalje obrade podataka. Izmereni STL model se u sledećoj fazi transformiše u CAD površine. Digitalni model uvek predstavlja kompromis između glatke površine, odstupanja od izmerenih podataka i brzine generisanja [4].

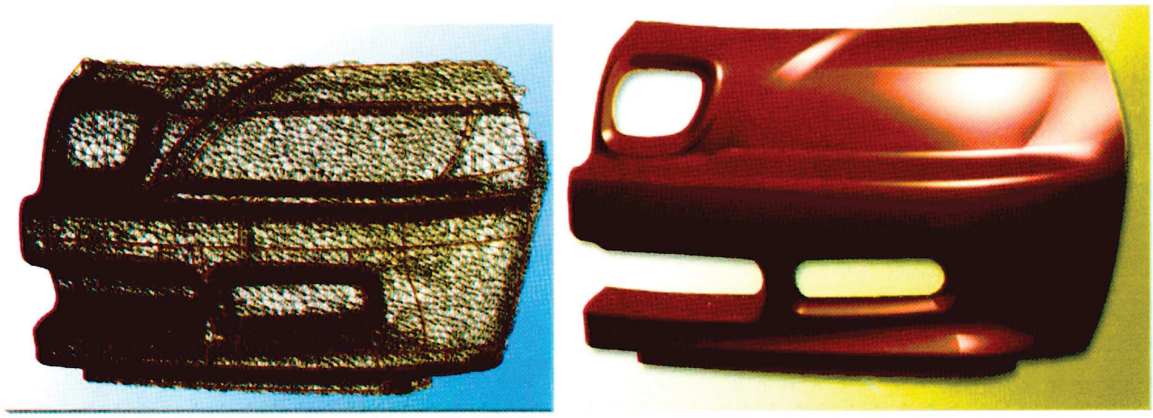


Figure 6 „Cloud of points" with s triangular net and smoothed surface model in ICEM Surf [7]
slika 6 „Oblak" tačaka sa trougaonom mrežom i model glatkih površina u ICEM Surf [7]

2.3.2 Copying a virtual model by the CNC machine

On the ground of virtual (CAD) model there are generated CNC data by using system CAM modules. The data are description of model surface position data on which a tool has to go through for snagging desired shape. It is not a case of mechanical, electro mechanical or hydraulic systems of profilers which transfer shape from template into the form shape. There are the modern CNC milling centres which on the ground of digital data created on CAD model basis with support of CAM module will snag desired shape. The template or pattern is mentioned CAD model on which „surface" the tool of CNC machine is led.

Demonstration of snagging on the ground of virtual model is shown in fig.7 and 8.

2.3.2 Kopiranje virtuelnog modela pomoću CNC mašine

Na osnovu virtualnog (CAD) modela generišu se CNC podaci upotrebom modula CAM sistema. Podaci predstavljaju opis pozicije na površini modela na koju treba usmeriti alat radi postizanja željenog oblika. Ovde se ne radi o mehničkim, elektro-mehaničkim ili hidrauličkim sistemima koji vrše modeliranje prenošenjem mustre sa kalupa. Ovde imamo savremenu CNC glodalicu koja na osnovu digitalnih podataka generisanih u CAD modelu uz podršku CAM modula izrađuju željeni oblik. Mustra, odnosno kalup, u ovom slučaju predstavlja pomenuti CAD model na čiju „površinu" se usmerava alatka CNC mašine.

Demonstracija izrade na osnovu virtuelnog modela prikazana je na sl.7 i 8.

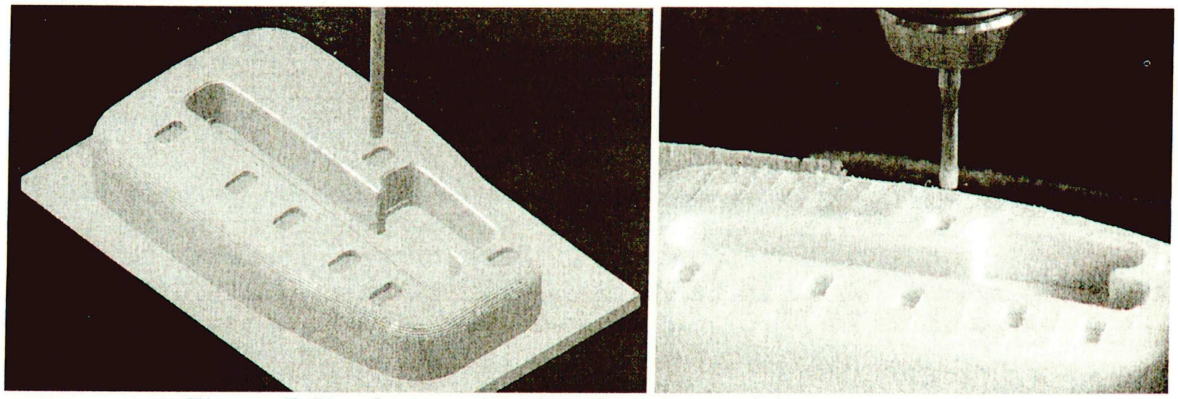
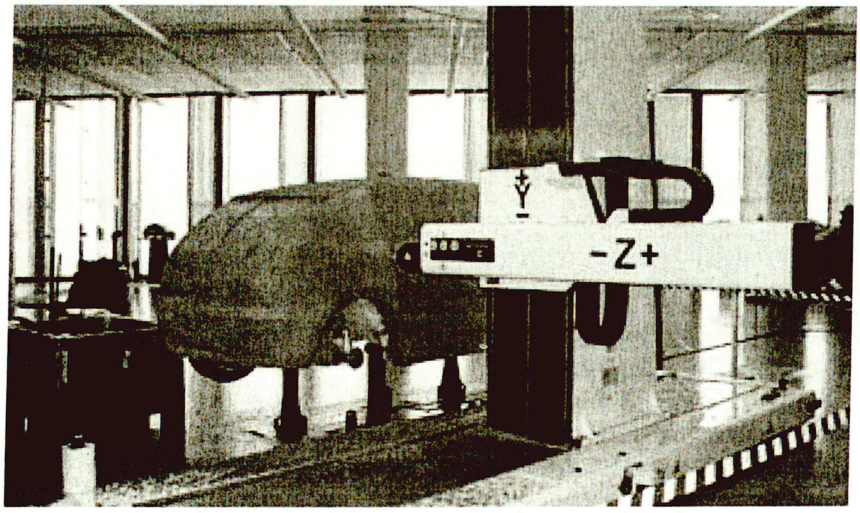


Figure 7 Simulation of tool path and a model production [3]
slika 7 Simulacija rada alatke i proizvodnja modela [3]



Figire 8 A maquette production 1:1 on CNC machine in development centre PSA [8]
slika 8 Maketa proizvodnje u razmeri 1:1 na CNC mašini u PSA centru [8]

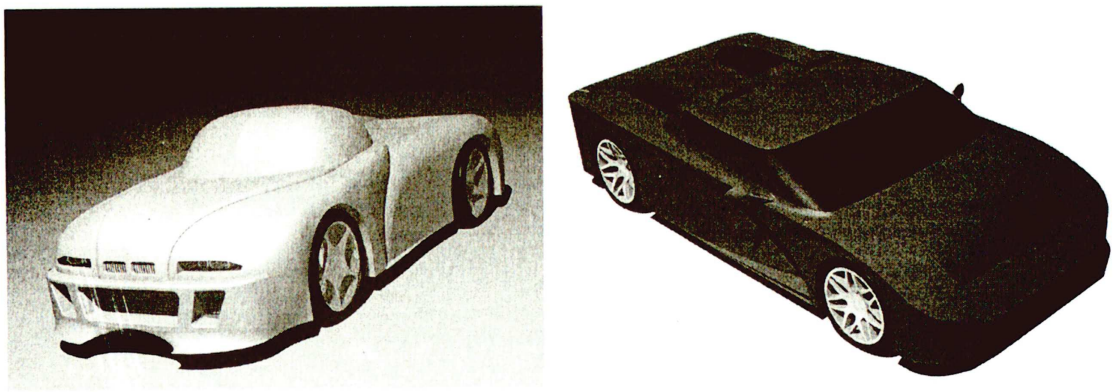


Figure 9 Design of automobile shape (designed by: Ladislav GURBAĽ – student of 4th year) [9]
slika 9 Dizajn modela automobila (autor Ladislav GURBAĽ – student četvrte godine) [9]

CONCLUSION

In connection with start in business of concerns like Volkswagen, PSA and KIA in Slovakia requests for competent technical staff experienced with CA technologies will always increase. Our university has the tradition in teaching the systems on basis of software CATIA and Pro/ENGINEER (fig. 9). Many of our graduates were successfully practiced in the automotive industry in Czech Republic and Germany thanks to CA approaches handling of design and production.

ZAKLJUČAK

Imajući u vidu da je veliki broj koncerna kao što su Folksvagen, PSA i KIA počeo da posluje u Slovačkoj postoji velika potražnja za kompetentnim tehničkim osobljem koje ima iskustva u radu sa CA tehnologijama. Na našem univerzitetu se tradicionalno vrši nastava u oblasti sistema koji rade na bazi CATIA i Pro/ENGINEER softvera (slika 9). Mnogi od naših diplomaca su sa velikim uspehom bili na praksi u automobilskoj industriji u Češkoj Republici i Nemačkoj zahvaljujući CA pristupu u dizajniranju, konstruisanju i proizvodnji.

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