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IZRADA PREKRETAČA PALETA TEHNOLOGIJOM OBRADE DEFORMIRANJEM
CREATING A PALETTE BOW TIPPER WITH TECHNOLOGY OF DEFORMATION

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Sažetak: *Rad prikazuje cjelokupni proces izrade prekretača paleta. Opisan je proces modeliranja, pripreme i proces proizvodnje. Dijelovi su pripremani za obradu na strojevima upotrebom softvera CAD/CAM prateći pravila tehnologije obrade deformiranjem. Prikazanim postupkom proizvodnja se optimizirala, ubrzala, te je proces proizvodnje kontroliran u svim koracima. Modeliranje i simulacija izvršeni su pomoću softvera SolidWorks, a zatim je model rastavljen na dijelove koji su prebačeni u softver ToPs 300, gdje se izvršilo optimalno planiranje i iskorištenje ploče lima. U ovome radu definirana su osnovna pravila modeliranja i prikazana neka tehnološka rješenja prilikom sklapanja prekretača palete.*

Ključne riječi:
– oblikovanje lima
– modeliranje
– savijanje
– probijanje

Abstract: *Work shows the entire process of palette bow tipper construction. The process of modeling, preparation and the process of production are described. Parts were prepared for processing on machines by the use of CAD/CAM software following the rules of deformation technology. With the demonstrated procedure, the production process was optimized, and the production process was accelerated and controlled in all production steps. Modeling and simulation were performed by the use of the software SolidWorks. Then the model was separated into sections that were transported in the software ToPs 300, where the optimum use of sheet metal panels was planned and carried out. In this work, the basic rules of modeling and some technological solutions during the execution of the bow tipper palette are demonstrated.*

Keywords:
– sheet metal forming
– modelling
– bending
– punching

1. UVOD

Razvoj računalne tehnologije pridonio je povećanju kvalitete, točnosti i proizvodnosti. Korištenjem softverskih paketa koji sadrže sve potrebne informacije o alatima i strojevima simulira se izrada proizvoda koji su tehnološki mogući [1-4]. Softver automatski stvara popis alata i sam određuje putanju. Programer prilagođava putanju alata tako da se skrati vrijeme obrade. Na početku dizajna određuju se potrebne dimenzije lima i njegova debljina, nakon toga ploča se stavlja na stroj na kojem se izvodi probijanje i grickanje [5]. Nakon obrade na stroju za probijanje i grickanje dobivaju se dijelovi koji se kasnije savijaju na prešama za savijanje. Gotovi dijelovi daju se u montažu i tako nastaju sklopovi i podsklopovi prekretača paleta koje u konačnici i trebamo dobiti.

1. INTRODUCTION

The development of computer technology has contributed to an increase of quality, accuracy and productivity. With the use of software packages that contain all the necessary information on tools and machines, different products that are technologically possible are simulated [1-4]. Software automatically creates a list of tools and determines orbit independently. The programmer adjusts the tool path so as to shorten processing time. At the very beginning, dimensions of the sheet and its thickness are selected, after which records are put on a punching machine that performs punching and nibbling [5]. After that, the obtained parts are folded on the bending machine. Finished parts are sent to the assembly line and the bow tipper palettes are created, which is in the end the finished product.

Povezanost modeliranja i CNC-programiranja uvelike nam smanjuje mogućnost pogreške i povećavaju proizvodnost [4]. Pri izradi prekretača paleta bit će prikazan način naprednog modeliranja pomoću softverskog paketa *SolidWorks*, da bi se u konačnici mogao dobiti razvijeni oblik lima dijelova prekretača paleta [1]. Razvijeni oblici limova dalje se obrađuju u programu *ToPs* [6] te se za svaki pojedini dio stvara CNC-program. Da bi se dobio konačni proizvod, inženjer izrađuje realan trodimenzionalni model prekretača paleta. Iz dobivenog modela za svaki dio se dobiva razvijena površina lima, za tako pripremljen lim određuje se kako treba biti izrezan ili probijen, te na koju stranu i pod kojim kutom treba biti savijen. Za takav se model radi popratna dokumentacija i programiraju se strojevi koji se koriste za proizvodnju svakog dijela. U programu *ToPs* određuju se putanje alata – time štedimo vrijeme, a smanjuje se i postotak škarta materijala.

2. MODELIRANJE PREKRETAČA PALETA U *SOLIDWORKSU* KORIŠTENJEM NAPREDNIH FUNKCIJA *SHEET METAL*

Najbolji i najbrži način za modeliranje prekretača paleta u *SolidWorksu* je korištenje naprednih funkcija *Sheet Metal*. Napredne *Sheet Metal* funkcije koriste se da se iz modeliranih dijelova dobiju razvijene površine. *SolidWorks* omogućuje izradu dijelova (*part*), njihovo sklapanje u podsklopove (*assembly*), sklapanje podsklopova u jedinstveni sklop (*assembly*), te izradu nacrta koji predstavljaju pojedine dijelove podsklopova i sklopova.
Sklop prekretač paleta bit će izrađen od 3 podsklopa:

1. Postolje kontejnera
2. Kontejner
3. Vrata kontejnera.

U sklopu prekretača paleta korišteni su i ostali standardni dijelovi koji su nabavljenih od drugih proizvođača. Za svaki dio, podsklop i jedinstveni sklop bit će izrađeni odgovarajući nacrti.

Glavni koraci u modeliranju dijelova prekretača paleta:

1. Modeliranje alatima *Sheet Metal*
2. Crteži dijelova
3. Korištenje simetrije.

U nastavku je prikazano nastajanje poklopca pumpe (slika 1 i 2) koji je ugrađen u nosač kontejnera. Za efikasnije modeliranje bitno je uočiti ako u nacrtu ima profil koji je zajednički prema svim savijanjima u modelu. Kod modeliranja poklopca pumpe uočen je profil prednje ravnine koji sadrži najveći broj savijanja, taj profil se koristi kao baza za daljnje modeliranje. U *Sketchu* se nacrta profil koji predstavlja bazu (slika 1), pozicionira se da centar ravnina bude u središtu te se dimenzionira prema zadanim dimenzijama. Odabirom funkcije *Base Flange* stvori se nacrtani profil u trećoj dimenziji.

Interconnection modelling and CNC programming greatly reduces the possibility of errors while increases productivity. During the construction of the bow tipper, the advanced modelling software package *SolidWorks* is used to ultimately gain a developed form of sheet metal parts. Developed forms of plates are processed further in the program *ToPs* [6], and for each part is created a CNC program. In order to obtain the final product, the engineer creates a realistic three-dimensional model of the bow tipper.
From the obtained model, each part of the area gets a developed sheet. Then every specific sheet is defined how to be cut or pierced, on what side and under what angle to be bent. For such a model, supporting documentation and machine programming is needed for production. In the program *ToPs* the tool path is calculated; this saves time and also reduces the percentage of reject material.

2. MODELING BOW TIPPER BY USING ADVANCED SOLIDWORKS SHEET METAL FUNCTIONS

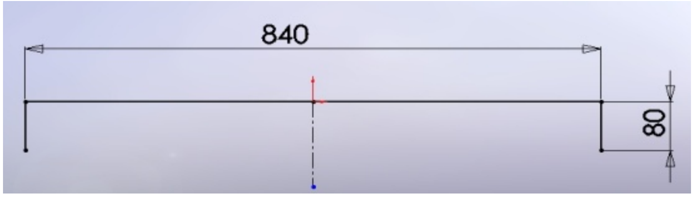
The best and fastest method for modelling the bow tipper in *SolidWorks* is using the advanced functions of *Sheet Metal*. We use advanced *Sheet Metal* features that are used to get the developed surfaces from model parts. *SolidWorks* enables the parts construction (part), their assembly into the sub-assemblies, then connecting them into a unique sub-assembly (assembly), and also the preparation of the draft, which represents individual districts and sub-assemblies. The bow tipper assembly will be made of 3 sub-assemblies:

1. Podium containers.
2. Containers.
3. Door containers.

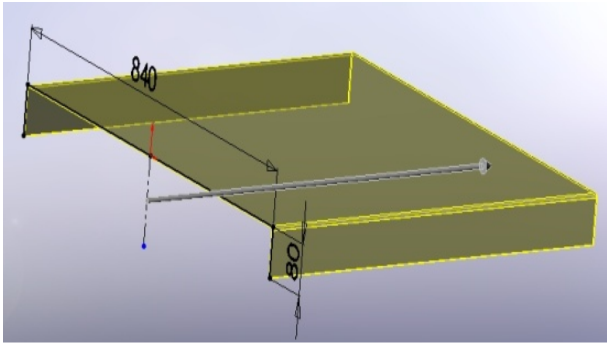
Within the bow tipper, assembly standard parts were used that are supplied by other manufacturers. For each section, sub- and unique assembly plans will be custom made.
The main steps in the modelling of the parts of the bow tipper:

1. Modelling Tools with *Sheet Metal*.
2. Drawings of parts.
3. Using symmetry.

In following text, the development of the pump cover (Figure 1 and 2) is shown, which is embedded in the carrier containers. For more efficient modelling, it is important to notice if the draft has a profile that is common to all the bending in the model. With the modelling pumps cover, there is a profile of the plane containing the maximum number of bending. The profile is used as the basis for further modelling. The *Sketch* is used to draft a profile that represents the base (Figure 1), with the position to be the centre plane in the centre and accurate by default dimensions. Selecting the *Base Flange* creates a profile that is drawn in the third dimension.



Slika 1. Profil poklopca pumpe
Figure 1. Profile of the pump cover



Slika 2. Razvoj modela
Figure 2. Development of the model

U funkciji *Base Flange* definirani su 3D komponenta, debljina lima, radijus savijanja te je potrebno učitati tablicu savijanja (*Bend Table*) [2] iz koje će *SolidWorks* izvlačiti korekturne faktore. Sva su savijanja izvedena sa zadanim radijusom savijanja. Pristupom određivanja profila baze uštedjelo se na vremenu modeliranja i izbjegnuta je moguća pogreška pri savijanju.

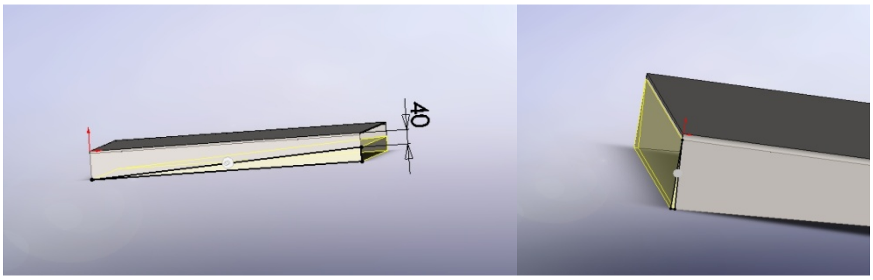
In the function of Flange Base, it is necessary to define the 3D component, sheet thickness and bending radius. It is also necessary to load the table of bending (*Bend Table*) [2]. from which *SolidWorks* determines the proofreading factors. All the flexing will be exported by the given bending radius. This approach to profile base determination is useful for saving modelling time.

Slika 3. Korekturni faktori
Figure 3. Proofreading (correcting) factors

Na slici 3 prikazane su opcije funkcija *Sheet–Metal* i *Base Flange*. U polju *Bend Parametars* odabiru se radijus savijanja i debljina lima. Pod poljem *Bend Allowance* odabire se tablica savijanja, odabire se tablica savijanja *Schiavi* koja je definirana strojem na kojem se savijaju dijelovi limova. Profil se prilagođava na zadane dimenzije tako da mu se reže bočni dio po cijeloj dužini profila i stražnji dio se prilagođava za preklapanje rubova odrezivanjem pod 93°.

Figure 3 below shows the functions *Sheet-Metal Base* and *Flange*. In the *Bend Parameters*, the bending radius and sheet thickness are selected. Under field *Bend Allowance*, the bending table is selected. The selected bending table is *Schiavi*, which is defined by the machine where the sheet metal parts are bended. The profile is adapted to the default size by cuts on the side part along the entire length of the profile. The rear part is adjusted for cutting under overlapping edges under 93°.

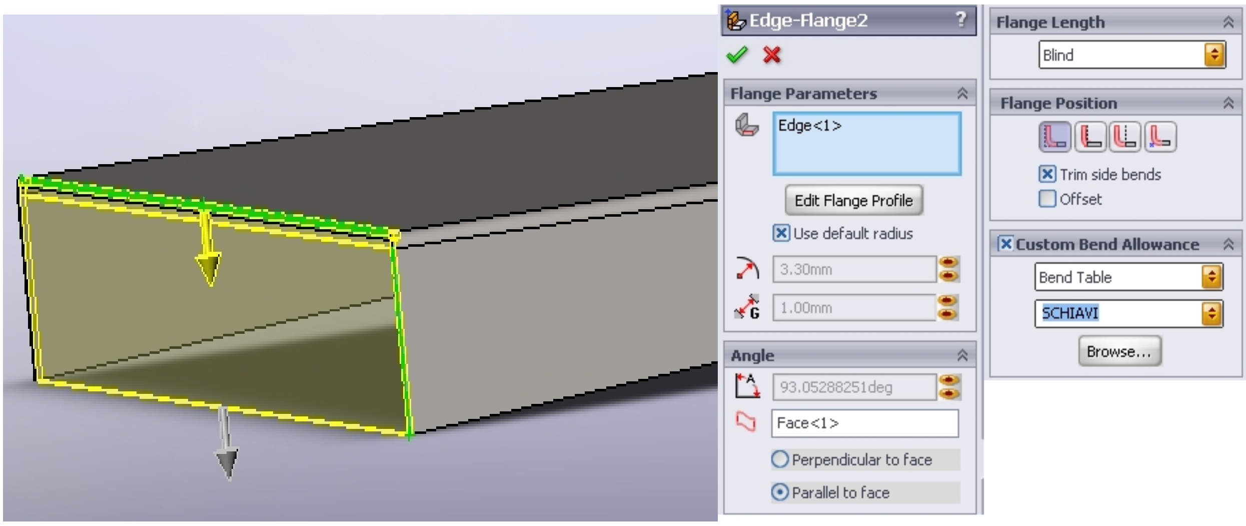
Slika 4. Opcije Extruded Cut
Figure 4. Options Extruded Cut



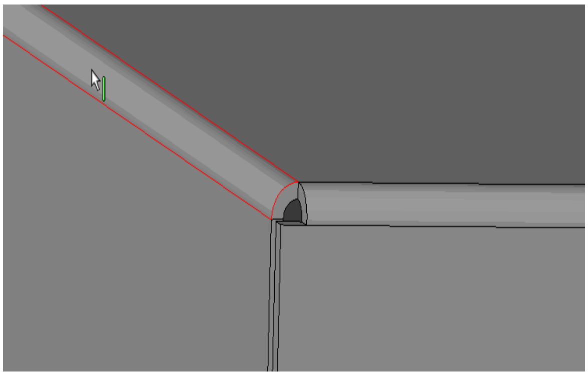
Slika 5. Prilagođavanje profila
Figure 5. Adjustment of the profile

Na slici 4 prikazana je opcija *Exstruded Cut*. U prozoru *From* definirana je površina na kojoj je nacrtan dio koji se reže, dok je u prozoru *Direction 1* odabrano da će se rezanje napraviti kroz cijeli profil (*Through All*). Kada se prilagodio profil (slika 5) na stražnju se stranu dodaje savijeni dio (*Edge Flange*). Na slici 6 prikazana je funkcija *Edge Flange*. U prozoru *Flange Parametars* prikazano je da su debljina lima i kut svijanja identični s profilom. Pod prozorom *Angle* određuje se kut u odnosu na površinu na koju se dodaje savijanje. U prozoru *Flange Position* određeno je da se materijal nalazi unutar kuta savijanja tako da se dimenzije profila ne promjene. Moguće je još odabrati da je samo debljina lima izvan kuta, ili da je cijeli radijus savijanja izvan kuta, odabir ovisi o načinu modeliranja. Takvim se načinom izbjegava dodatni rad za poravnavanje rubova, rubovi poklopca su se preklopili s vanjske strane.

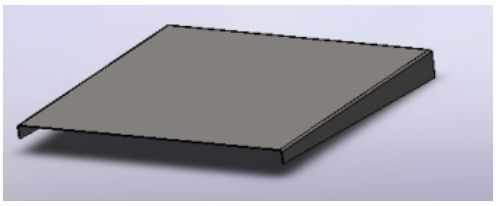
Figure 4 shows the options for *Extruded Cut*. In the window *From*, the surface area in which a part that needs to be cut is drawn. In the window *Direction 1*, cutting will be made through the entire profile (through all). When the profile (Figure 5) on the back is customized, a bent part is added (*Edge Flange*). Figure 6 shows the *Edge Flange* features. In *Flange Parameters* it is shown that the sheet thickness and angle bending are identical to the profile. Under the window *Angle*, the angle relative to the surface is determined for added bending. The window *Flange Position* determines that the material is located within the angle of bending so that the dimensions of the profile do not change. It is possible to choose to have only a sheet thickness outside the angle or the entire area outside the bending angle. The choice depends on the modelling. In this way alignment of the edges is avoided. Cover edges are turned on the outer side.



Slika 6. Dodavanje savijenog dijela
Figure 6. Adding a folded part



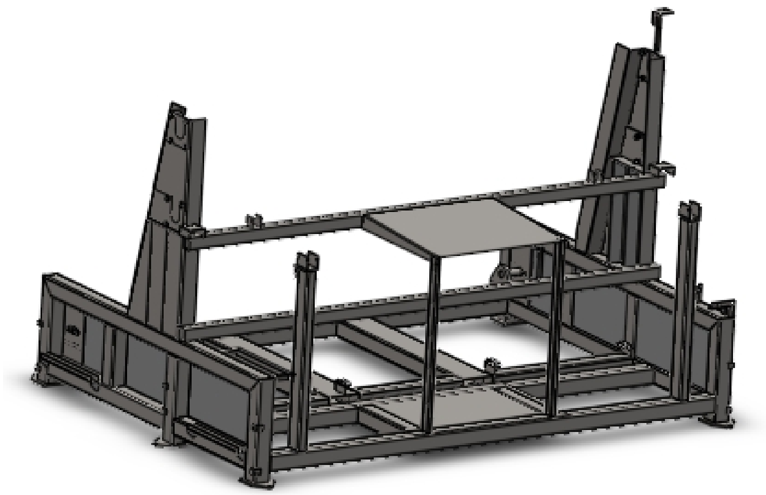
Slika 7. Preklapanje rubova
Figure 7. Overlay edges



Slika 8. Gotov model poklopca pumpe
Figure 8. Finished pump cover model

Nakon modeliranja poklopca pumpe (slika 7 i 8) modeliraju se i ostali dijelove koji čine podsklop postolje prekretača paleta. Svaki dobiveni dio provjerava se što se tiče točnosti dimenzija i u odnosu na svaki susjedni dio u samom podsklopu. Sastavljanjem svih dijelova dobiva se postolje prekretača. Sastavljanje se vrši funkcijom *Mate* kojom se definiraju odnosi između dijelova podsklopa (slika 9). Sastavljanjem su provjereni odnosi između površina i rubova dijelova.

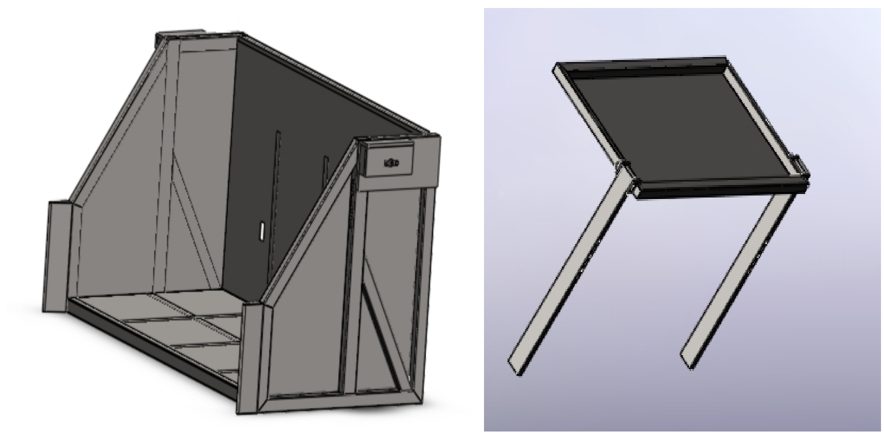
After the modelling of the pump cover (Figures 7 and 8), other parts are also constructed that make up the sub-assembly of the tipper bow. Each part is checked for accuracy of dimensions and in relation to each adjacent part of the sub. By joining parts of the assembly, the eating bow tipper is created. Assembly is done by the function *Mate*, which defines relations between sub-parts (Figure 9). The assembly has established the relationships between part surfaces and edges.



Slika 9. Postolje prekretača
Figure 9. Bow tipper seating

Nakon završetka postolja modeliraju se ostali dijelovi podsklopova (slika 10) te se potom dobivaju preostali podsklopovi. Kao i kod postolja provjerava se jesu li svi dijelovi u zadanim granicama tolerancije, te preklapaju li se kada su sastavljeni u zadani podsklop. Ako slučajno dolazi do preklapanja, dijelovi se moraju korigirati da kasnije u proizvodnji ne bi došlo do pogrešaka.

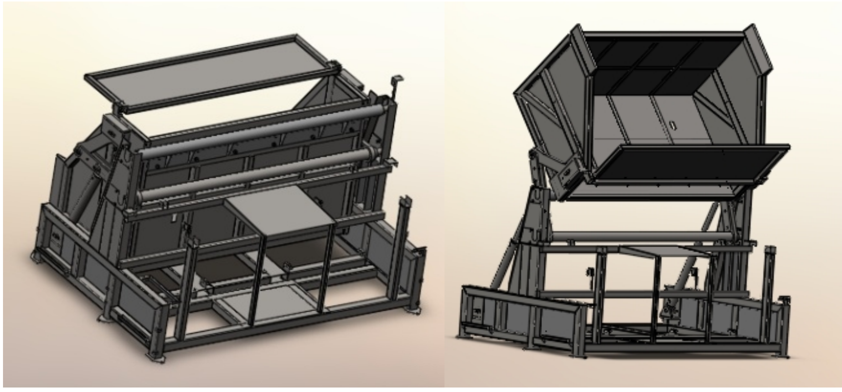
Upon completion of the base, other parts of the sub-assembly (Figure 10) are modelled together to get the remaining sub-assemblies. As with the base, a check is made to determine whether all the parts are in the set limits of tolerances and whether they overlap when they are compiled in the default sub. If by chance an overlapping of parts occurs, it must be corrected in order to avoid errors later during production.



Slika 10. Kontejner i vrata kontejnera
Figure 10. Containers and door containers

Nakon modeliranja podsklopova pristupa se sklapanju glavnog sklopa (slika 11). Kada se odrede relacije podsklopova, dobiva se cijeli model prekretača paleta. Važno je pravilno odrediti relacije da se odmah iz modela može ustanoviti koje su kritične točke pri samoj montaži te dolazi li kod podizanja kontejnera do kolizije između dijelova podsklopova.

The construction of the main assembly (Figure 11) can be approached after sub-modelling. When the relations between sub-assemblies are designated, the entire model of bow tipper has been obtained. It is important to correctly determine the relationships in order to identify what are the critical points in the installation and whether the erection of containers at a collision between the sub-parts comes directly from the model.



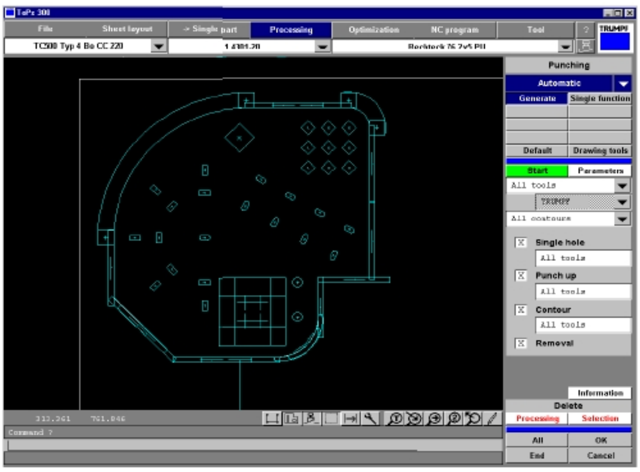
Slika 11. Prekretač paleta
Figure 11. Palette bow tipper

3. PRIPREMA ZA PROIZVODNJU U *ToPs*-u 300

Nakon završetka modeliranja u *SolidWorksu* i sklapanju glavnog sklopa prekretača paleta potvrđene su dimenzije i ispravnost svih dijelova korištenih pri sklapanju te se pristupa procesiranju CNC-programa. Izrada CNC-programa vrši se u *ToPs* 300 (slika 12) koji koristi sustav za probijanje i kombiniranu obradu. Na svim dijelovima podsklopa označava se koordinatni sustav te se sprema u .IGES formatu čuvanja podataka. *ToPs* 300 može prepoznati taj format te se u programu radi proces gniježđenja i odabiru se alati. Svaka promjena i putanja alata definira se kako bi se uštedjelo na vremenu i da bi se stroj zadržao u granicama točnosti. Nakon obrade na stroju za probijanje svaki je dio potrebno saviti na stroju za savijanje *Schiavi* kako bi on poprimio zadani oblik. Koraci savijanja su unaprijed definirani nacrtom. Po završetku savijanja dijelovi prekretača spremni su za montažu.

3. PREPARATION FOR THE PRODUCTION IN *ToPs* 300

Upon completion of modelling in *SolidWorks*, conclusion of the main assembly of the palette bow tipper and the validity of the dimensions are confirmed for all parts used in the assembly and then the processing of CNC programs is addressed. The production of CNC programs can be made on the *ToPs* 300 (Figure 12), which uses a system for punching and the combined treatment. All parts of the sub-assembly coordinate system are indicated and are saved in the .IGES format of storage data. *ToPs* 300 may recognize the format and the program for the process of nesting and selection of the tools. All changes and the tool path are defined in order to save time and to keep the machine within the limits of accuracy. After processing on a punching machine, each part must be bent on the bending machine *Schiavi* in order to acquire the default form. Bending steps are pre-defined on the design. Upon completion of bending, the parts of the palette bow tipper are ready for assembly.



Slika 12. Procesiranje CNC -programa
Figure 12. The processing of CNC program

4. ZAKLJUČAK

Prikazano je konstruiranje prekretača paleta od lima korištenjem softverskog paketa *SolidWorks*. Simulirana je funkcionalnost gotovog sklopa. Prikazana je izrada crteža te je napravljen odabir načina obrade i izrade CNC-programa korištenjem softvera *ToPs* 300. Korištenjem softvera CAD/CAM ubrzana je konstrukcija samog dijela i skraćeno je vrijeme potrebno za pripremu proizvodnje. Fleksibilna je proizvodnja postignuta te se ubrzao proces konstruiranja, pripreme proizvodnje i proizvodnje. Time se ostaje konkurentnima na tržištu i fleksibilnima pri promjenama narudžba postojećih kupaca. Budući rad uključivat će istraživanje različitih tehnoloških rješenja koja utječu na bitne parametre u procesu.

4. CONCLUSION

Design of the bow tipper for plate palettes constructed from sheet metal has been shown with the use of software package *SolidWorks*. Functionality of the final assembly has been simulated. The creation of drawings and the selection of methods of processing and production of CNC programs by using software *ToPs* 300 is shown. Using CAD/CAM software, construction of the parts has been accelerated and the time it takes to prepare the production has been shortened. Flexible production has been achieved, and the design process, preparation for production and the production have been accelerated. Market competitiveness has been retained, with a flexible change order for existing customers. Future work will involve the study of different technological solutions that affect important parameters in the process.

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