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THE TECHNIQUE OF QUICK DESIGNING OF CASTING PANEL FOR PLASTIC GEAR WHEEL INJECTION

Milutin Ogrizovic, Goran Dudukovic

Professional paper

The current technological level of mechanical engineering sequentially requires an active software application in all construction stages of certain mechanical projects – products. When we say product today in engineering we refer to the design of a product, as well as to the actual construction. ProEngineer, as basic software of this thesis, with its interactively connected modules, is a completely functional tool for solving even the most complex tasks of mechanical engineering in acceptable time frame. The notion of acceptable construction time frame and mechanical design production includes problem solving aiming at constructing the final product, in any shape, tending to optimize all stages of planning, analysis, development and production. The speed of construction task solving conditions the existence of profitable production in mechanical engineering, which should be proved through the work under this title. It is said previously that the foundation of this thesis is the application of interactively joined software modules for constructing a casting panel for injected plastic gear wheel.

Keywords: *casting panel, interactive connected modules, plastic gear wheels, Pro/Engineer*

Metoda brzog projektiranja ljevačkog panela za ubrizgavanje plastičnog zupčanika

Strukovni članak

Sadašnji tehnološki nivo strojarstva zahtijeva aktivnu primjenu softvera u svim stadijima izrade nekog strojarskog projekta – proizvoda. Izraz proizvod u strojarstvu se danas odnosi i na projektiranje i na stvarnu izradu tog proizvoda. ProEngineer, kao osnovni softver ovoga rada je, sa svojim interaktivno povezanim modulima, potpuno funkcionalan alat za rješavanje i najsloženijih strojarskih zadataka u prihvatljivom vremenskom razmaku. Pojam prihvatljivog vremena proizvodnje i izrade proizvoda uključuje rješavanje problema s ciljem dobivanja finalnog proizvoda, bilo kojeg oblika, uz optimiziranje svih stadija planiranja, analize, razvoja i proizvodnje. Brzina rješavanja konstrukcijskog zadatka je uvjet postojanja profitabilne proizvodnje u strojarstvu, a ovaj bi rad to trebao dokazati. Ranije je rečeno da je ovaj rad zasnovan na primjeni interaktivno povezanih modula softvera za konstruiranje ljevačkog panela za ubrizgani plastični zupčanik.

Ključne riječi: *interaktivno spojeni moduli, ljevački panel, plastični zupčanik, Pro/Engineer*

1 Introduction
Uvod

The basic task, within the theme framework of this thesis, is to produce a tool within a short space of time, and then place the cast gear wheels in gauge set and conduct the tests. The strategy for solving this particular construction task was clear: establish a new calculation model for the gear wheel tooth evolute in the program calculation module – MathCad, and as a result choose 15 interpolation points in Cartesian coordinate system. These points represent the basis for creating 3D gear wheel models, through application of special module program tools "Part", properties similar to the presupposed ones. The simulation analysis in this module provides the necessary parameters "Blend", or "Swept Blend". This combines the direct interactive software connection of two program modules, with the automatic correction possibility of any computation parameter. The choice of the gear wheel material in "Plastic Advisor" module, as well as the choice of potential casting system position can help in detecting places where cracks, air pockets or thickness variation might appear. The work in the said module is extremely functional, because of the existence of a vast material data base of various manufacturers and material properties, so the change of any parameter yields immediate results, but also suggests the best and most precise material with the

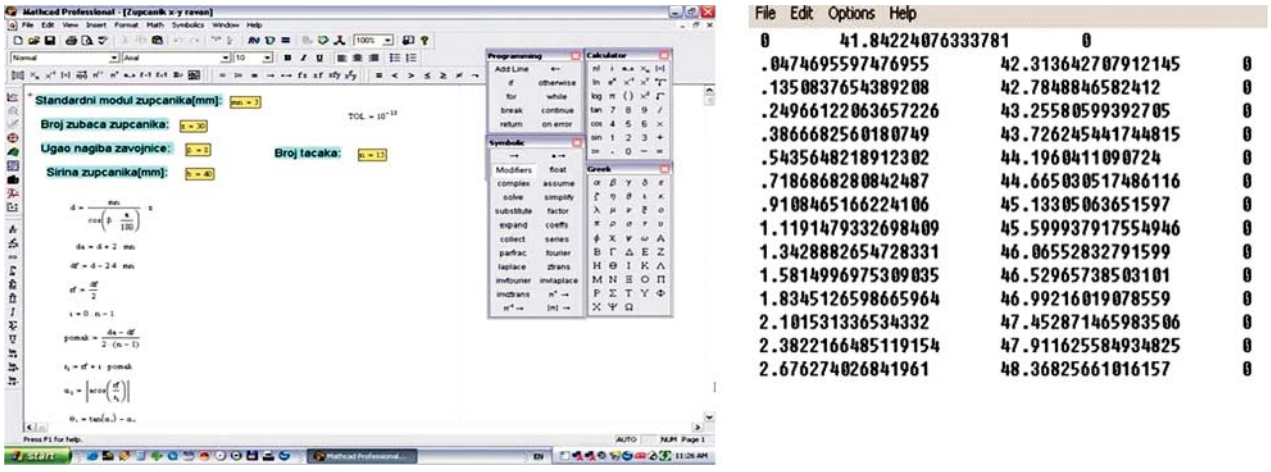


Figure 1 *The calculation in MathCad and the results obtained for the evolute calculation in 15 points*
Slika 1. *Proračun u MathCadu i rezultati za proračun evolvente u 15 točaka*

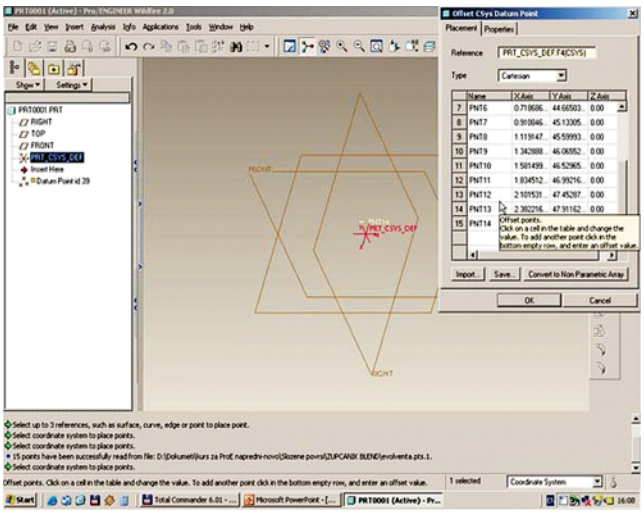


Figure 2 *Important points in "Part" module*
Slika 2. *Važne točke u modulu "Part"*

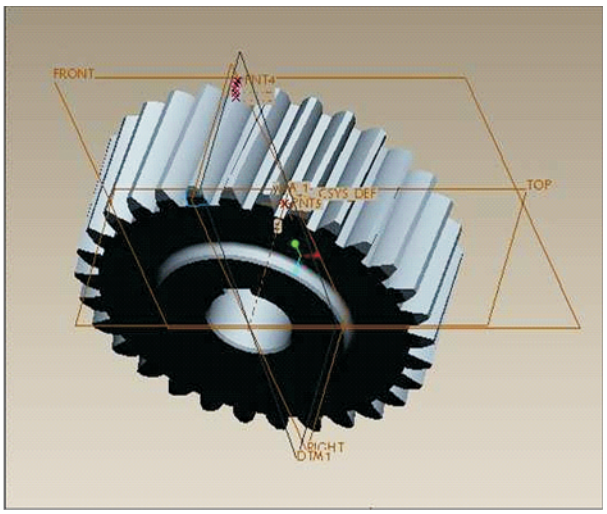


Figure 3 *3D gear wheel model*
Slika 3. *3D model zupčanika*

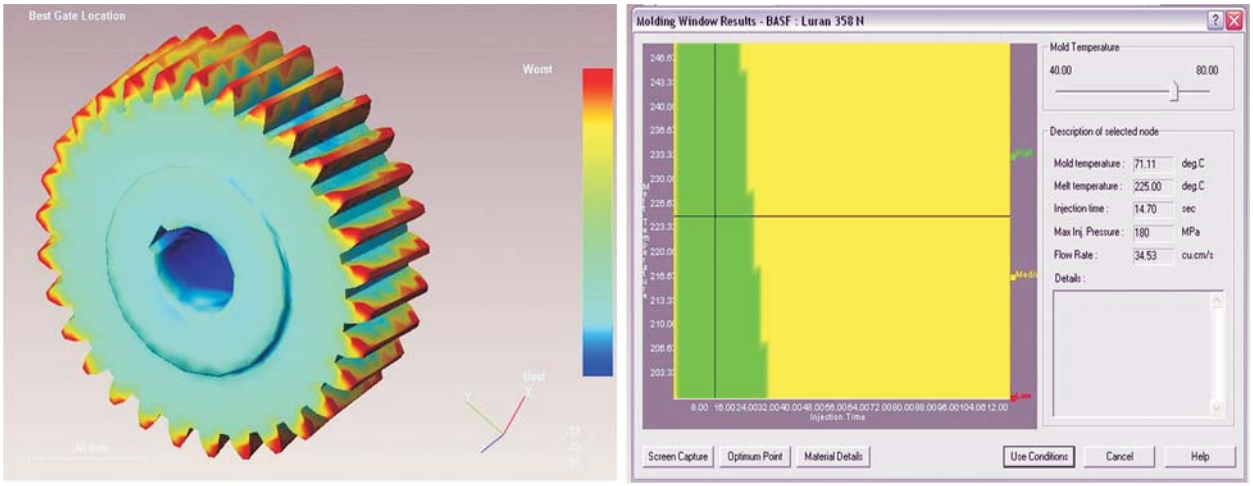


Figure 4 *Mold temperature, Melting temperature, Injection time, Max. injection pressure, Flow rate. The stated results have been obtained based on the dimensions of the gear wheel, i.e. the chosen place for the injecting nozzle*
Slika 4. *Temperatura kalupljenja, Temperatura taljenja, Vrijeme ubrizgavanja, Maksimalni tlak ubrizgavanja, protok. Rezultati su dobiveni na osnovu dimenzija zupčanika tj. izabranog mjesta mlaznice za ubrizgavanje*

for the injection machine, which is of extreme importance for obtaining predesigned product quality – gear wheel. In the end, by choosing optimum technological sequence parameters in program module "Manufacturing", a direct steering file is created for the specific CNC milling machine on which injection tool casting panels are manufactured.

2
Modelling, gear wheel casting process simulation and creation of steering file for casting panel manufacturing

Modeliranje, simulacija postupka lijevanja zupčanika i kreiranje datoteke za pokretanje proizvodnje ljevačkih panela

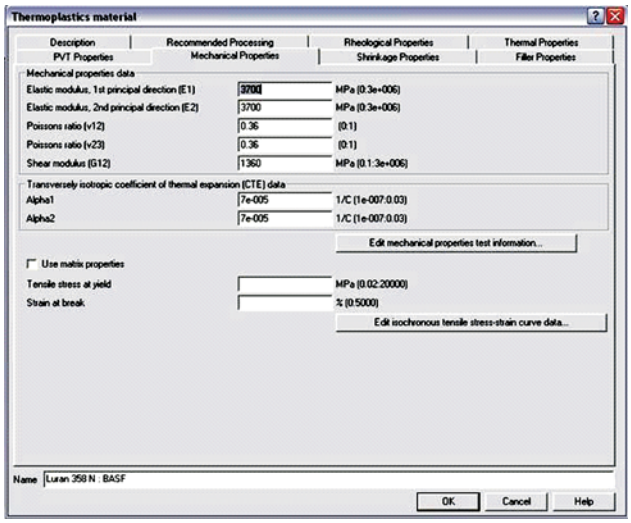
The interactive engineering element modelling with combined software tools has a 3D model as a base. The 3D gear wheel model designed according to the chosen calculation parameters of cam wheel profile evolute enables swift tool designing and gear wheel casting. The results of cam wheel profile evolute calculation in MathCad (Fig. 1) are inserted in module "Part" (Fig. 2), which represents the base for the application of "Blend" program tool creating the gear wheel model, as well as the gear wheel final model (Fig. 3).

2.1
The choice of the material, casting point, casting quality analysis and casting panel designing

Izbor materijala, točka lijevanja, analiza kvalitete lijevanja i projektiranje ljevačkog panela

The designed gear wheel model, by simple activation of "Plastic Advisor" module, becomes available for analysis defining the shape and position of tool casting panel, determines the casting place (nozzle), tool temperature, the optimum flow of plastics through the nozzle, i.e. recommends injection machine property in view of the required injection pressure (Fig. 4). All parameters obtained are set according to the properties of the chosen plastic material (BASF Luran 358 N).

The material choice from the program data base is highly functional, because every material has the defined general mechanical properties, as well as the specific ones like the shearing module (Shear module), which provides absolutely reliable goal parameters (transmission ratio) to those required. Besides the general mechanical properties, within material data base framework specific data like mechanical properties of material behaviour at certain temperatures (Thermal properties) are available, i.e. the surface area condition - the key condition for functional



work of plastic gear wheels under the specific work regimes (Fig. 5).

In "Plastic Advisor" module it is possible to check, besides the mentioned parameters, the places of potential cracks, air pockets, as well as the condition of the surface layer. This completes the analysis of the potential casting. The shrinkage percentage can be adopted (Shrinkage by scale) due to which the model must be enlarged before designing the casting panel (Fig. 6).

Figure 5 *Chosen material mechanical properties palette*
Slika 5. *Paleta mehaničkih svojstava izabranog materijala*

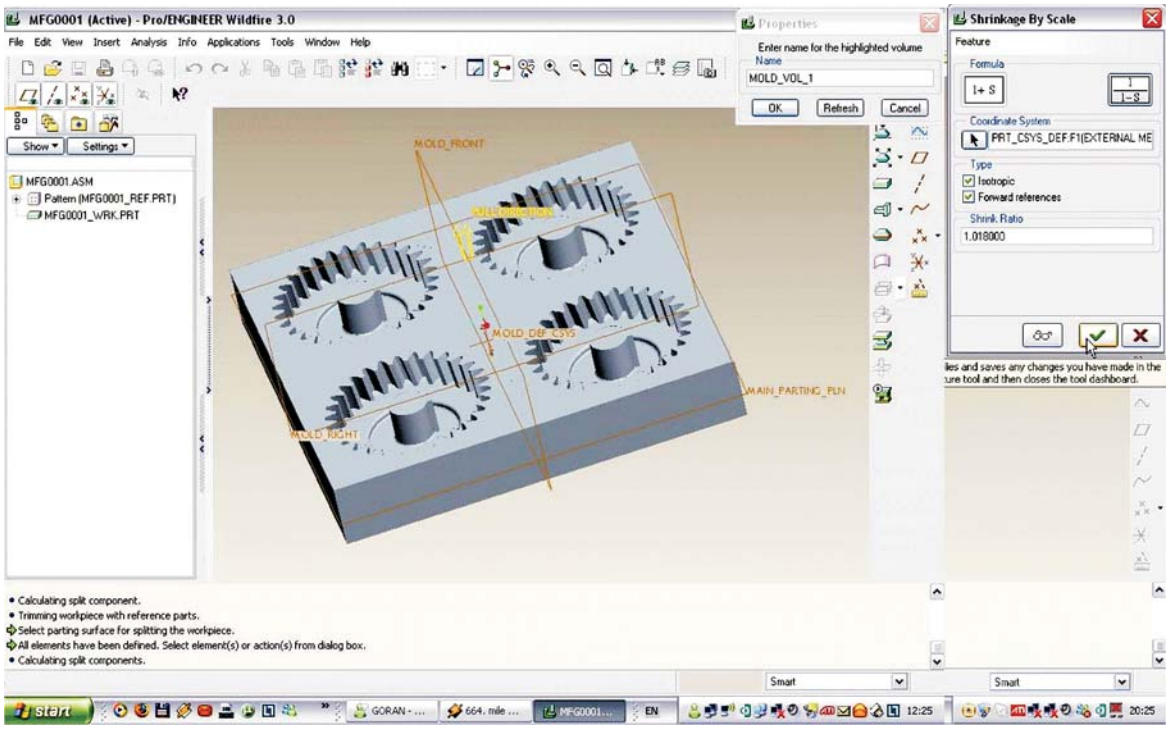


Figure 6 *The adopted "shrinkage" percentage of plastics based on which the final casting panel model was created*
Slika 6. *Prihvaćeni postotak "stezanja" plastike na osnovu kojega je stvoren završni model ljevačkog panela*

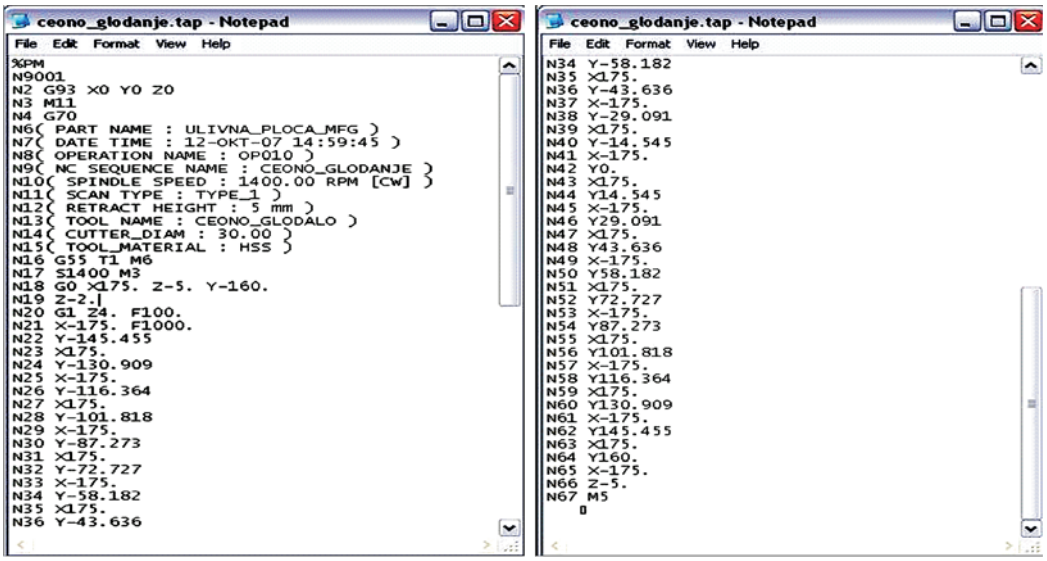


Figure 7 *The presented part of the G-code of the direct steering file*
Slika 7. *Predstavljeni dio G-koda direktne upravljačke datoteke*

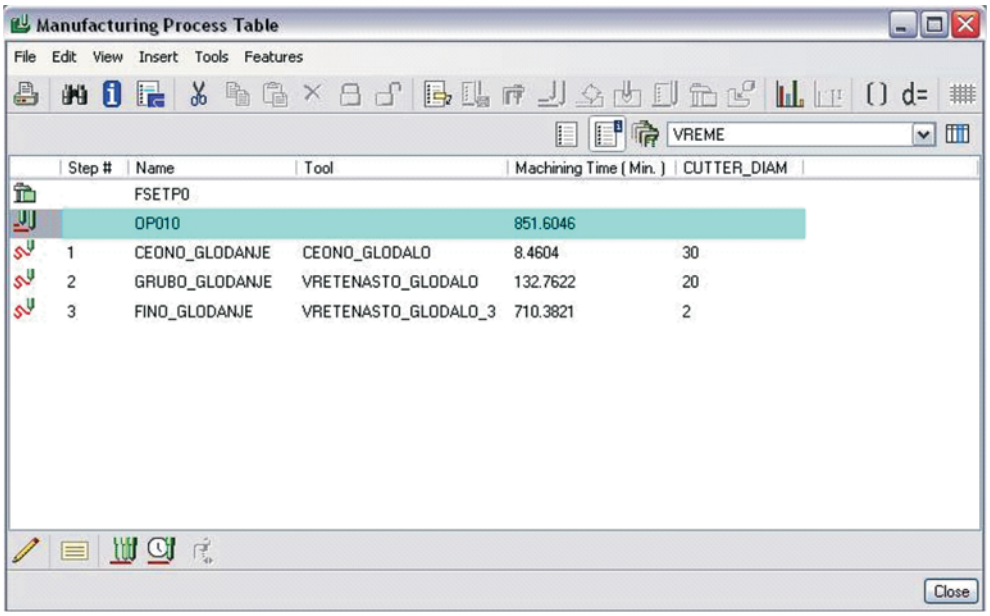


Figure 8 *Total machining time of the casting panel and individual time in a technological sequence*
Slika 8. *Ukupno vrijeme izrade ljevačkog panela i pojedinačno vrijeme u tehnološkom nizu*

2.2
Designing of casting panel
Projektiranje ljevačkog panela

The final task is the creating of the direct steering file in NC "Manufacturing" module for particularly chosen machine (milling machine – Mill) on which the casting panel is manufactured. Other tool elements are adopted through recommendation of the chosen manufacturer of standard parts – tool elements "HASCO". The adopted standard tool parts (and casting system), are implemented to the software on the level of module-parts in the functional assembly position. Thus it leaves us with creating the technological machining sequences for casting panel, according to the standard manufacturer recommendation, and the later post-processing i.e. creating the direct steering file (.tap files) through which on the level of G-code the direct operating of the chosen CNC machine is performed (Fig. 7).

3
Conclusion
Zaključak

The thesis shows the procedure of obtaining – designing tool casting panel for injecting of plastic gear wheels, from the gear wheel tooth evolute calculation stage, through designing the gear wheel 3D model, and then the casting panel, to creating technological machining sequences i.e. steering file (.tap file) for designing the casting panel on triaxial CNC milling machine.

Besides the description of particular procedures through all designing stages, the concept of time significance, in which the tool plate is obtained i.e. the beginning of production time, is interwoven in the thesis. The aim is to represent, through an example, the possibilities of interactively connected ProEngineer software modules, i.e. benefits gained through their use.

From the beginning of designing to the gear wheel production seven days elapsed, taking into account the ordering of standard tool parts from the "HASCO" company. The tool test series lasted also seven days, after which production output began. The presented timeline has enabled a sustainable production, because we were ahead of our competitors in quality and production time, in the example presented.

4
List of symbols
Popis simbola

Standard gear wheel module m_n, mm
Gear wheel teeth number z
The helix inclination angle β, deg (°)
Gear wheel width b, mm
The number of evolute points n
Casting panel temperature *Mold temp*, degC (°)
Cast temperature *Melt temp*, degC (°)
Injection time *Inj. time*, s
Injection pressure maximum *Max. inj. pres.*, MPa
Cast flow *Flow rate*, m^3/s
Elasticity module E, MPa
Machining time *Machin. Time*, min.

5
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Authors' addresses
Adrese autora

Milutin Ogrizović
Tehnička škola, Stara Pazova, Vojvodina, Srbija

Goran Duduković
SOLFINS, CAD/CAM Company, Beograd, Srbija