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Kalibracija simulirnih rezultatov

Calibration of Simulation Results

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Na konferenci ICIT '97 (International Conference on Industrial Tools) sta ista avtorja predstavila prispevek, ki je popisoval uvajanje tehnik RPN (računalniško podprto načrtovanje) v razvoj povsem novega izdelka. Kot logično nadaljevanje tega dela, v članku avtorja predstavljata, kako so bili ti rezultati prestavljeni v dejansko industrijsko okolje in kako natančno so bili določeni. V članku so prav tako predstavljeni rezultati kot funkcija geometrijske oblike orodja. Največji poudarek pri primerjavi rezultatov je bil dan na sliko polnjenja orodne votline, časa polnjenja, časa izmetavanja in pa najvišjih temperatur, ki nastajajo v orodju med zapolnjevanjem orodne votline. Prav tako je predstavljen napredek pri odločitvenem diagramu.

(Ključne besede: razvoj izdelkov, simuliranje, primerjava rezultatov, inženiring sočasni)

At the conference ICIT '97 (International Conference on Industrial Tools) the paper was presented by the same authors, where the introduction of CAE (Computer Aided Engineering) tehniques in the development of a completely new product was described. As a logical continuation of that work, in this paper the authors wish to present how these results were transferred to real life and how they were implemented. In this paper some results are presented as the function of mould geometry. The main results which we compare are the results of fill time, ejection time and peak temperature. Also the progress on the decision diagram is presented.

(Keywords: product development, simulation, comparison of results, concurrent engineering)

0 UVOD

Prispevek predstavlja primerjavo med rezultati raziskav, ki so bili objavljeni na konferenci ICIT'97 z rezultati v dejanskem industrijskem okolju [1]. V tem prispevku je bilo predstavljeno razvojno delo na zaslonki pralnega stroja.

Medtem je proizvodnja zaslonke pralnega stroja stekla. Prispevek opisuje, kako je bil izveden prenos znanja v industrijo, kako je stekla proizvodnja in kako naj bi v prihodnosti razvijali nove izdelke.

Za sodelavce pri projektu je bila velika priložnost, da smo sodelovali v vseh korakih razvoja izdelka in orodja, od zasnove izdelka, skozi razvoj in detajliranje orodja zanj, pa vse do izdelave. Prav tako smo sodelovali pri razvoju montaže zaslonke pralnega stroja na vrata pralnega stroja.

Kakšni sta naloga in funkcija zaslonke vrat? Naloga in funkcija zaslonke je v tem, da prepreči dostop do vročih vrat pralnega stroja, med pranjem perila (temperatura vrat se lahko zviša tudi do 95 °C) [1].

Zaslonka mora biti narejena iz termoplastičnega materiala, kot sta n.pr. SAN, Luran SAN 007 BK 072, proizvajalca BASF. Zahteve do zaslonke so precej velike, npr.:

0 INTRODUCTION

This paper presents a comparison with the results which were given in the ICIT'97 conference paper [1]. In that paper, the development of the door blind for the washing machine was presented.

Recently, the production of the blind was started. This paper presents how this production started and how the development of the new product should be implemented in the future.

It was a great opportunity for us to be able to follow the phases of the development of a new product, from the design phase of the product, through the mould design to the production of the product – the blind. We also observed how to mount the blind to the door of the washing machine.

What is the aim of this blind? It is to prevent access to the hot door of the washing machine during the operation (the temperature can increase up to 95 °C) [1].

The blind should be made of thermoplastic material, such as SAN, Luran SAN 007 BK 072, product of BASF. The quality requirements for the blind are relatively strict, as follows:

- na funkcionalni površini ne sme biti vidnih linij hladnih spojev;
- funkcijska površina mora biti bleščeča in brez napak;
- na funkcijski površini ne smejo biti vidne sledi dolivnega sistema;
- celoten izdelek mora biti izdelan znotraj dovoljenih toleranc.

Z upoštevanjem vseh teh omejitev in z upoštevanjem velikosti izdelka (izdelek je eliptične oblike dimenzij $a \cdot b = 341\text{mm} \cdot 287\text{mm}$) lahko ocenimo izdelek kot relativno zahteven [1].

Na skici orodja, ki je bila predvidena v prvi fazi razvoja, sta bila načrtovana dolivni in hladilni sistem orodjarne (Gorenje Orodjarna). Zaradi dimenzij izdelka in zaradi zahtevane količine izdelkov je bilo načrtovano samo eno oblikovno gnezdo. Naloga TECOSa je bila simuliranje zapolnjevanja orodne votline, preverjanje hladilnega sistema in ugotavljanje zvijanja in krčenja izdelkov po izdelavi v orodju zaradi predelovalnih parametrov [1].

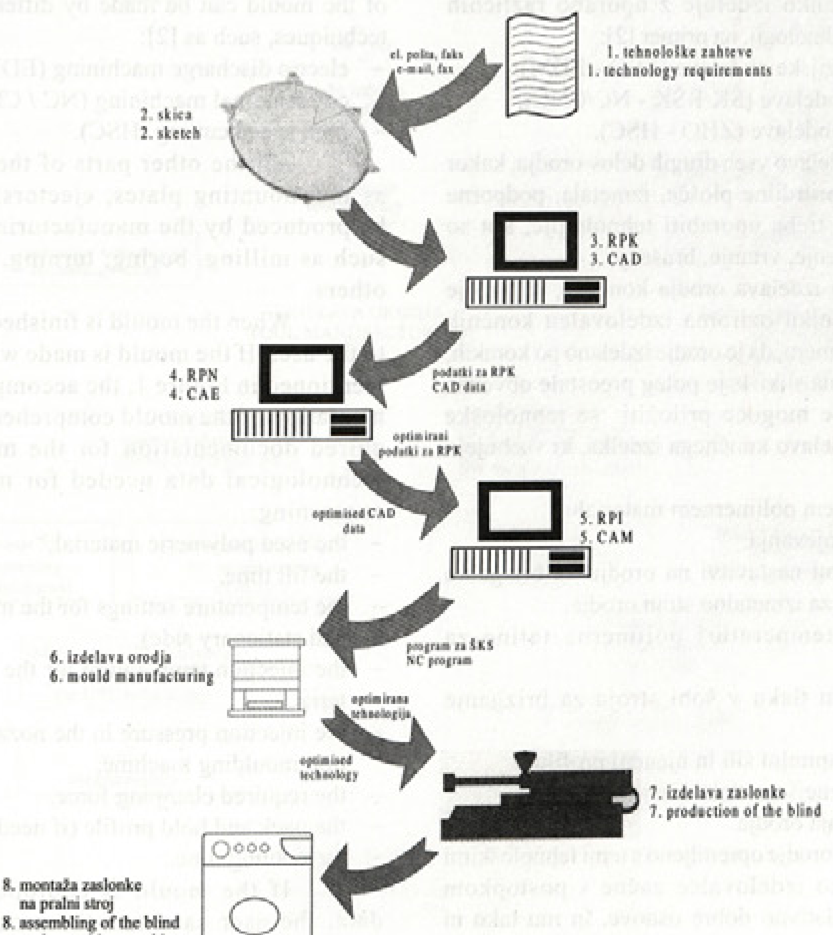
Pri razvoju novih izdelkov je treba izvesti določeno število in zaporedij korakov. Ti koraki so predstavljeni na sliki 1.

- there should be no signs of weld lines on the functional surfaces;
- the functional surface must be resplendent and without faults;
- on the functional surface there should be no signs of the runner system;
- the whole part must be made within the prescribed tolerances.

Considering these requirements and the dimensions of the product (elliptic dimensions $a \cdot b = 341\text{mm} \cdot 287\text{mm}$) the manufacturing should be relatively difficult [1].

On the sketch of the mould, the runner and cooling system were presented, as was planned by the mould maker (Gorenje Orodjarna). Because of the product dimensions and required quality only one cavity is foreseen for this mould. Our task was to simulate the filling of the mould, to control the cooling system and to evaluate the warping and shrinking of the door blind as the result of the processing conditions [1].

In the development of a new product several steps must be undertaken. These steps are presented in Figure 1.



Sl. 1. *Koraki v izdelavnem postopku*
Fig. 1. *Steps in the production cycle*

1 STOPNJE RAZVOJA ORODJA

Kakor se na sliki 1 lepo vidi, potrebujemo na različnih stopnjah razvoja in izdelave različne tipe prenosa podatkov. V prvi fazi, ko zamisel o izdelku spravljamo na papir, ne potrebujmo fizičnega prenosa podatkov.

Ko je skica izdelka gotova in sprejeta, mora biti takoj izdelan tridimenzionalni računalniški model. Modeliramo lahko s pomočjo različnih programskih paketov. Treba se je osredotočiti na čim bolj natančno izdelavo modela. Vse napake na modelu, ki se pojavijo v tej fazi, lahko povzročijo veliko izgubo časa in denarja v fazi izdelave orodja in proizvodnji končnega izdelka. Zato je treba tej fazi posvetiti posebej veliko pozornosti.

V [1] smo posvetili veliko pozornost fazi RPN, ki mora slediti fazam grobih konstrukcij izdelka in orodja. V tem prispevku se na fazo RPN ne bomo več vračali.

Korak, ki sledi fazi razvoja orodja RPN, je priprava orodja na izdelavo. Največji problem v tej fazi je nastajanje ustrezne kode za številsko krmiljeno izdelavo oblikovnega sistema orodja. Oblikovni sistem v orodju se lahko izdeluje z uporabo različnih obdelovalnih tehnologij, na primer [2]:

- elektro erozijske obdelave (EEO - EDM),
- običajne obdelave (ŠK/RŠK - NC/CNC),
- zelo hitre obdelave (ZHO - HSC).

Za izdelavo vseh drugih delov orodja, kakor so na primer pritrdilne plošče, izmetala, podporne plošče itn., je treba uporabiti tehnologije, kot so frezanje, struženje, vrtanje, brušenje.

Ko je izdelava orodja končana, se orodje dostavi naročniku oziroma izdelovalcu končnih izdelkov. V primeru, da je orodje izdelano po korakih, ki so narisani na sliki 1, je poleg preostale obvezne dokumentacije mogoče priložiti še tehnološke podatke za izdelavo končnega izdelka, ki vsebujejo podatke o:

- uporabljenem polimernem materialu,
- času zapolnjevanja,
- temperaturni nastavitvi na orodju za brizgalno kakor tudi za izmetalno stran orodja,
- potrebni temperaturi polimerne taline za brizganje,
- brizgalnem tlaku v šobi stroja za brizganje polimerov,
- potrebni zapiralni sili in njenem profilu,
- profilu poznejšega tlaka (če je potreben),
- času hlajenja orodja.

Če je orodje opremljeno s temi tehnološkimi podatki, lahko izdelovalec začne s postopkom brizganja z relativno dobre osnove, in mu tako ni treba na stroju iskati optimalnih procesnih parametrov, saj jih dobi kot rezultat analize na računalniku.

1 TOOL DEVELOPMENT PHASES

As we can see in Figure 1, we need different data exchange at different stages of the development phase. There is no physical data exchange from the idea to the sketch of the product.

After the sketch is done and accepted by the company, a 3D computer model has to be generated. This can be done using different software. We need to focus only on the precision of the modelling. A mistake in this phase can cause substantial loss of time and money in the manufacturing of the mould and in the final manufacturing of parts. That is why a lot of attention must be paid to this phase.

In [1] we paid great attention to the CAE phase, which should follow the stages of the design of the product and the rough sketch of the mould. These issues will not be dealt with in this paper.

The next step is the preparation for the mould manufacturing. The main problem here is to generate an appropriate NC code for the manufacturing of the active part of the mould. The active part of the mould can be made by different machining techniques, such as [2]:

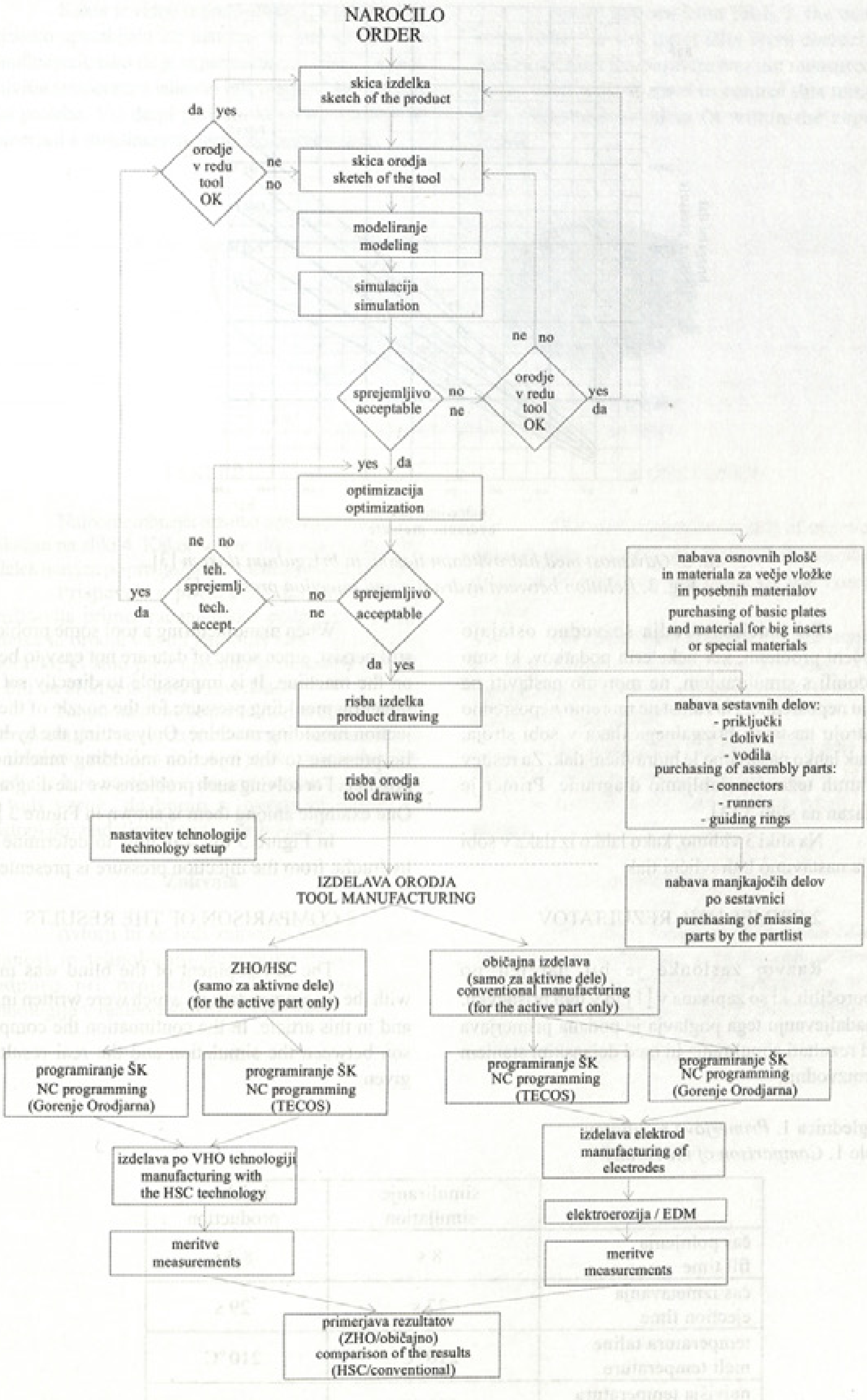
- electro discharge machining (EDM),
- conventional machining (NC / CNC),
- high speed cutting (HSC).

All the other parts of the mould, such as the mounting plates, ejectors, etc, have to be produced by the manufacturing procedures such as milling, boring, turning, grinding and others.

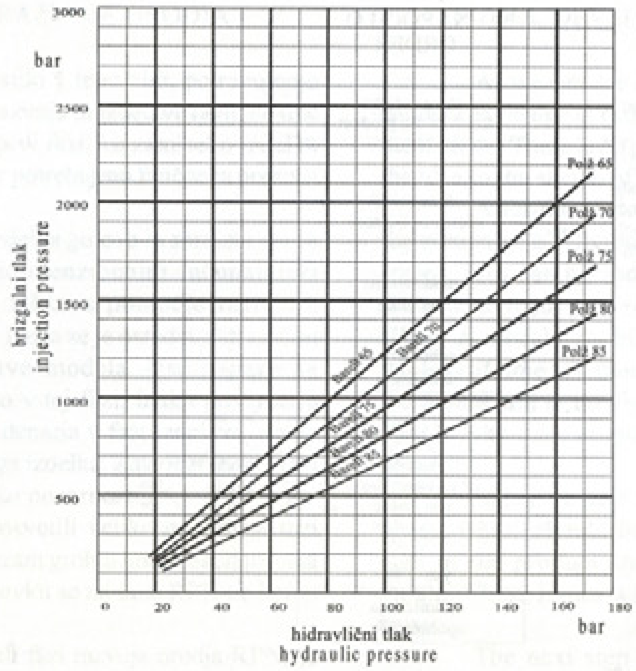
When the mould is finished, it is shipped to the user. If the mould is made within the steps mentioned in Figure 1, the accompanying documentation of the mould comprehend also the required documentation for the mould and the technological data needed for manufacturing concerning:

- the used polymeric material,
- the fill time,
- the temperature settings for the mould (movable and stationary side),
- the injection temperature for the polymeric material,
- the injection pressure in the nozzle of the injection moulding machine,
- the required clamping force,
- the pack and hold profile (if needed),
- the cooling time.

If the mould is equipped with these data, the user can start the production at the known level and no additional searching for the optimal injection moulding parameters is needed.



Sl. 2. *Odločitveni diagram za izdelavo orodij po običajnih in sodobnih postopkih obdelave*
Fig. 2. *Decision making diagram for manufacturing of the mould by the conventional and modern approach*



Sl. 3. *Odvisnost med hidravličnim tlakom in brizgalnim tlakom* [3]
Fig. 3. *Relation between hydraulic and injection pressure* [3]

Pri izdelavi orodja še vedno ostajajo določeni problemi, ker nekaterih podatkov, ki smo jih dobili s simuliranjem, ne moremo nastaviti na stroju neposredno. Na žalost ne moremo neposredno na stroju nastaviti brizgalnega tlaka v šobi stroja, ampak lahko nastavimo le hidravlični tlak. Za rešitev tovrstnih težav uporabljamo diagrame. Primer je prikazan na sliki 3 [3].

Na sliki 3 vidimo, kako lahko iz tlaka v šobi stroja nastavimo hidravlični tlak.

When manufacturing a tool some problems still persist, since some of data are not easy to be set on the machine. It is impossible to directly set the injection moulding pressure for the nozzle of the injection moulding machine. Only setting the hydraulic pressure to the injection moulding machine is possible. For solving such problems we use diagrams. One example among them is shown in Figure 3 [3].

In Figure 3 the way how to determine the hydraulic from the injection pressure is presented.

2 PRIMERJAVA REZULTATOV

Razvoj zaslonke je bil narejen po priporočilih, ki so zapisana v [1] in v tem prispevku. V nadaljevanju tega poglavja je podana primerjava med rezultati simuliranja in med dejanskim stanjem v proizvodnji.

2 COMPARISON OF THE RESULTS

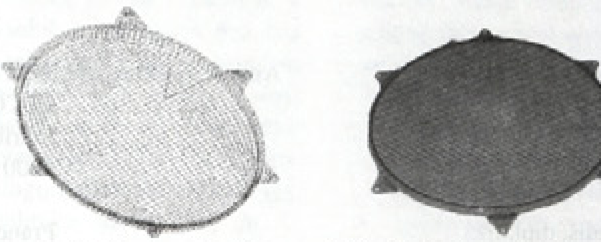
The development of the blind was made with the recommendations which were written in [1] and in this article. In the continuation the comparison between the simulation and the real results is given.

Preglednica 1. *Primerjava rezultatov*
Table 1. *Comparison of the results*

	simuliranje simulation	izdelava production
čas polnjenja fill time	8 s	8,3 s
čas izmetavanja ejection time	27 s	29 s
temperatura taline melt temperature	210 °C	210 °C
najvišja temperatura max. temperature	283 °C	/
material material	LURAN 007 BK 072	LURAN 007 BK 072

Kakor je vidno iz preglednice 1, v proizvodnji dejansko uporabljajo isti material, ki smo ga izbrali s simuliranjem, tako da je ta parameter pravilno določen. Najvišja temperatura taline ni bila merjena, ker za to ni bilo potrebe. Vsi drugi podatki, ki so bili merjeni in primerjani s simuliranjem, ustrezajo pričakovanju.

As we can see from Table 1, the material is the same, so the input data were correct. The maximum melt temperature was not measured, because there was no need to control this temperature. But the other data fit within the expected limits.



Sl. 4. *Od računalniškega modela do končnega izdelka*

Fig. 4. *From the computer model to the final product*

3 SKLEP

Najpomembnejši rezultat opravljenega dela je prikazan na sliki 4. Kakor se s te slike lepo vidi, je bil izdelek narejen po predloženem računalniškem modelu.

Prispevek v povezavi s prispevkom [1] predstavlja primer računalniško podprtega razvoja izdelka in orodja v svoji najboljši luči. Vsi potrebni popravki, ki smo jih z uporabo simuliranja odkrili, so bili na orodju dejansko izvedeni.

Najpomembnejše pri celotnem opravljenem razvojnem delu pa je, da je bilo orodje skonstruirano in izdelano pravilno in, kar je še pomembnejše, orodje je bilo narejeno v dogovorjenem času. To pa je tudi vzrok, da bomo s tovrstnim delom in postopkom nadaljevali tudi v prihodnosti.

3 CONCLUSION

The most important result of our work is presented in Figure 4. As Figure 4 shows, the real product in made on the basis of the computer model.

This paper is an example of CAE supported product design in the best possible way. All the needed corrections which were mediated by the computer were considered.

The mould for the door blind was made correctly and on time, and this is the reason, why we intend to do this kind of work in the future.

Zahvala

Avtorji bi se radi zahvalili Ministrstvu za znanost in tehnologijo Republike Slovenije za podporo pri projektu implementacija RPN tehnologije v realno industrijsko okolje.

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4 REFERENCES

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