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“Šest sigm” v razvoju postopka izdelave

Six Sigma in Process Design

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Prispevek se ukvarja z uporabo metodologije »šest sigm« v razvoju postopka izdelave. Na primeru obdelave okrova kompresorja je razložen razvoj postopka v Cimosovi tovarni v Buzetu in možnosti uporabe nekaterih orodij »šest sigm«, predvsem mape postopka in vzročno-posledične matrike. Prikazan je prilagojen razvoj poteka postopka z vgrajeno uporabo omenjenih orodij, narejena je primerjava sedanjega in novega načina poteka postopka in pojasnjeni so doseženi rezultati.

(Ključne besede: metodologija šest sigma, razvoj postopkov, mape postopkov, matrike vzročno-posledične)

This paper deals with the application of Six Sigma methodology in process design. Using an example of compressor-housing machining the process design and development at the Cimos facility in Buzet and the possibilities for some Six Sigma tools' applications are explained. The primary tools are the process map and the cause-and-effect matrix. A modified process design flow with incorporated applications of the mentioned tools are shown, a comparison of the old and the modified process-design flow is made and the obtained results are discussed.

(Keywords: Six Sigma methodology, process design, process maps, cause-and-effect matrix)

0 UVOD

»Šest sigm« je program izboljšanja kakovosti z namenom zmanjšati število napak pod 3,4 kose na milijon izdelanih. Pri tem se uporablja običajna porazdelitev in močna povezava med neustreznostmi izdelka oziroma napakami in številom izdelanih kosov, zanesljivostjo, časom izdelave, opremo, načrti itn. [1].

»Šest sigm« poudarja inteligentno mešanico modrosti organiziranja s preizkušenimi statističnimi orodji za izboljšanje tako učinkovitosti kakor zmožnosti organizacije pri upoštevanju potreb odjemalcev. Končni cilj ni izboljšanje zaradi izboljšanja, ampak bolj ustvarjanje ekonomske blaginje za odjemalca in prav tako dobavitelja [2] in [3]. To nakazuje, da “šest sigm” ne nadomešča znane in trajajoče pobude za kakovost v organizaciji, ampak da se najvišje vodstvo osredotoča na tiste postopke, ki so prepoznani kot ključni za kakovost v očeh odjemalcev. Ti kritični sistemi so nato predmet natančnih pregledov in močnih naporov za izboljšanja; uporaba najmočnejših “mehkih” in “trdih” veščin organizacije lahko pripelje do napredka [4].

»Šest sigm« projekti neprekinjenega postopka izboljšav so vodeni od zasnove do izvršitve,

0 INTRODUCTION

Six Sigma is a quality-improvement program that aims to reduce the number of defects to as low as 3.4 parts per million. It uses the normal distribution and the strong relationship between product nonconformities, or defects, and product yield, reliability, cycle time, inventory, schedule, etc. [1].

Six Sigma emphasizes an intelligent blending of the wisdom of an organization with proven statistical tools to improve both the efficiency and the effectiveness of the organization when it comes to meeting customer needs. The ultimate goal is not simply improvement for improvement's sake, but rather the creation of economic wealth for the customer and the provider alike. This does, not imply that Six Sigma replaces existing and ongoing quality initiatives in an organization, rather that senior management focuses on those processes identified as critical-to-quality in the eyes of customers. Those critical systems are then the subject of intense scrutiny and improvement efforts, using the most powerful soft and hard skills that the organization can bring to bear [2].

Six Sigma projects of continuous process improvement are led, from concept to completion, skozi pet projektno usmerjenih korakov ali faz, imenovanih DIAIK (definiraj, izmeri, analiziraj, izboljšaj in krmili) [5].

1 RAZVOJ IN PRIPRAVA POSTOPKA

Postopek razvoja in priprave postopka izdelave bodo razloženi na primeru obdelave okrova kompresorja, prikazanega na sliki 1. Ulitke naredijo v Cimosovi livarni v Roču iz aluminijeve zlitine. Celotna mehanska obdelava pa je opravljena v Cimosovi tovarni v Buzetu na Hrvaškem.

Običajno je razvoj postopka izdelave v Cimosovi tovarni v Buzetu razdeljen na pet korakov [6]:
- študij izvedljivosti postopka,
- načrtovanje postopka,
- priprava postopka,
- preizkusna proizvodnja in
- kvalifikacija postopka.

Postopki, ki imajo neposredni vpliv na kakovost izdelka, morajo biti natančno določeni. Zato je pri načrtovanju postopka izdelave treba prepoznati in utemeljiti ustrezne zahteve kakovosti. Za dosego teh pogojev je med drugim treba določiti:
- načrt razvoja postopka za nove ali spremenjene izdelke, skupaj z jasno dokumentiranimi proizvodnimi koraki in tokom materiala;
- ustrezno proizvodno opremo in delovno okolje;
- vzdrževanje in preventivno vzdrževanje opreme in delovnega okolja za zagotavljanje stalne razpoložljivosti proizvodnega sistema;
- postopke in metode za zagotavljanje kakovosti postopka izdelave;
- skladnost opravil s predpisi in standardi, zakoni, definiranimi odgovornostmi, načrtom menedžment kakovosti (MK) kakor tudi z zahtevami odjemalcev glede kakovosti;

through five project-management steps or phases named DMAIC (Define, Measure, Analyze, Improve, Control) [5].

1 PROCESS DESIGN AND DEVELOPMENT

The process design and development will be explained using the example of the compressor housing shown in Fig. 1. The castings are made in Cimos foundry Roč from aluminum alloy. All the machining is done in Cimos's facility in Buzet, Croatia.

At the Cimos facility in Buzet there are five basic steps in process design and development [3]:
- feasibility study of the process,
- process planning,
- process preparation,
- trial production,
- process qualification.

The processes with a major influence on product quality have to be identified. Therefore, in process planning it is necessary to recognize and establish relevant quality requirements. And in order to determine quality requirements it is first necessary to determine:
- A process developments plan for new and modified products, along with comprehensive documented production steps and material flow.
- The production equipment and the working environment.
- Maintenance and preventive maintenance for the equipment and the working environment to ensure the availability of the production system.
- The procedures and methods for process quality assurance.
- That the operation is in accordance with production rules and standards, laws, defined responsibilities, quality management (QM)-plans, as well as customer quality requirements.

Sl. 1. *Obdelan okrov kompresorja*
Fig. 1. *Machined compressor housings*

- opazovanje in dokumentiranje vseh parametrov postopka in karakteristik izdelka, ki mora biti na voljo vsem pristojnim službam in oddelkom;
- odobritev postopkov in opreme od vseh pristojnih oseb.

V fazi načrtovanja postopka je močno razširjena uporaba metode Analize izvora in vpliva napak (AIVP). Metoda AIVP ima velik vpliv na pripravo postopka, zato ker se izhodne veličine iz analiz AIVP uporabljajo za določanje, katere napake bi se verjetno pojavile ter kakšni popravni ukrepi so potrebni za njihovo preprečitev.

Da bi postopek razvoja in priprave postopka izdelave bil učinkovit, je treba v fazi načrtovanja postopka uporabiti še nekatera dodatna orodja, ki izhajajo iz metodologije »šest sigma«.

2 METODA »ŠEST SIGM« PRI RAZVOJU POSTOPKA

V fazi načrtovanja postopka v podjetju Cimos uporabljajo metodo AIVP. Problem, ki se pri tem pojavlja pri izvajanju postopka AIVP, je v tem, da se običajno obravnava preveliko število **KVSP** (ključne vstopne spremenljivke postopka), ki nimajo velikega vpliva, včasih pa sploh ne vplivajo, na **KISP** (ključne izstopne veličine postopka).

Da bi razvoj in načrtovanje postopka potekala hitreje, je treba v fazi načrtovanja postopka uporabiti še nekatera dodatna orodja. Metodologija "šest sigm" prinaša orodja in metode, s katerimi je mogoče število KVSP zmanjšati na minimum oz. le na tiste veličine, ki imajo velik vpliv na KISP. Orodja in metode, ki pomagajo zmanjšati število KVSP ter doseganje optimalnega postopka, so prikazani na sliki 2. V prispevku je predlagana uporaba *postopkovnega mapiranja* in izdelava *vzročno-posledične matrike*.

2.1 Mapa postopka izdelave

Mapa postopka izdelave je grafični prikaz poteka postopka s posameznimi koraki postopka, ki prikazuje vstopne in izstopne parametre postopka ter priložnosti za njegovo izboljšanje. Vsaka postopkovna mapa naj bi bila rezultat skupinskega dela, ker je nemogoče, da bi le ena oseba imela vsa znanja o postopku.

2.2 Vzročno-posledična matrika

Vzročno-posledična matrika podaja zvezo med ključnimi vstopnimi ter ključnimi izstopnimi veličinami (zahteve kupcev) pri čemer uporablja mapo postopka kot osnovni vir za vstopne informacije. Ključne izstopne veličine so razvrščene glede na njihovo pomembnost, medtem ko so ključne vstopne veličine izračunane iz medsebojnih odvisnosti vstopnih in izstopnih veličin [6].

- The monitoring and documenting of all process parameters and product characteristics, available to all competent services and departments.
- The approval for processes and equipment from all the responsible persons.

In the process planning stage the Failure mode and effect analysis (FMEA) method is widely used. The process FMEA method has great influence and significance on process preparation because outputs from the FMEA analysis are used to determine which failures are likely to appear and what corrective actions are necessary for failure prevention.

In order to have efficient process design and development some additional tools and methods should be used in the process planning phase. These tools can be derived from Six Sigma methodology.

2 SIX SIGMA METHODS IN PROCESS DESIGN

In the process planning phase in Cimos facilities the FMEA method is widely used. The problem that emerged with the application of the FMEA method is the large number of KPIV (Key Process Input Variables) that do not have a significant influence or have no influence on KPOV (Key Process Output Variables).

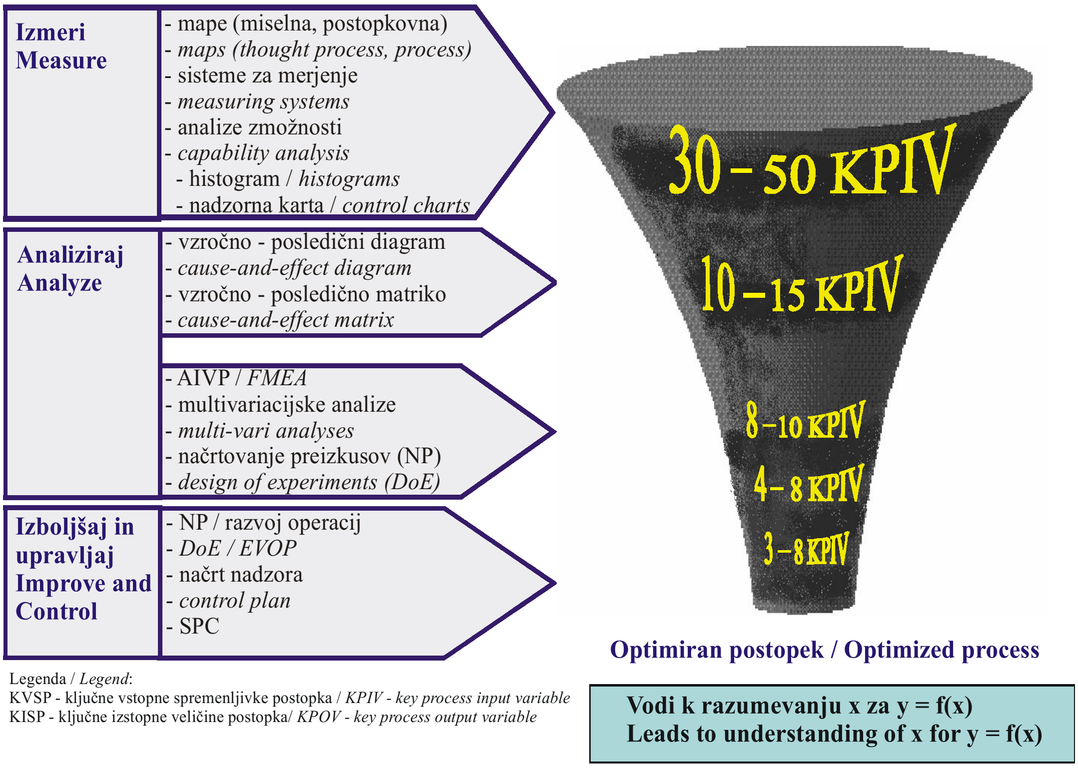
To have faster and more effective process design and development in the process planning stage it is necessary to apply some additional tools. Six Sigma methodology brings tools and methods with which the number of KPIV can be reduced to a minimum, or to those variables which have a major influence on KPOV. Tools and methods that help to decrease the number of KPIV and achieve an optimized process are shown in Fig. 2. In this paper the applications of process map and the cause-and-effect matrix are proposed.

2.1 Process map

In general, a process map is a graphical representation of a process flow that identifies the steps of the process, the input and output variables of a process and the opportunities for improvements. Every process map should be the result of teamwork, because it is impossible that just one person could have all the knowledge about the process.

2.2 The cause-and-effect matrix

A cause-and-effect matrix relates the key inputs to the key outputs (customer requirements) using a process map and a cause-and-effect diagram as the primary source of the input information. The key outputs are rated according to their importance, while the key inputs are scored in terms of their relationship to the key outputs [6].



Sl. 2. *Orodja in metode za optimizacijo postopka izdelave*
Fig. 2. *Tools and methods in process optimization*

Pri uporabi vzročno-posledične matrike sta značilni dve fazi. V prvi fazi so vstopni parametri povezani z izstopnimi, kar določa osnovo za analizo Pareto. V drugi fazi pa oblikujemo novo vzročno-posledično matriko s tremi oz. štirimi kritičnimi vstopnimi parametri iz matrike v prvi fazi.

V matriki je faktor pomembnosti za vsak parameter posebej razvrščen, vsak našteti vstopni parameter pa je povezan z vsakim izstopnim parametrom. Končna vrednost za vsak parameter je dobljena z množenjem nivoja pomembnosti z vrednostjo, ki je bila pripisana posameznim parametrom, ter s seštevanjem (vodoravno) prek vseh parametrov.

Da se prepričamo o nivoju vpliva parametrov, bo v nadaljevanju uporabljena analiza Pareto. Diagram Pareto jasno prikaže informacijo o relativni pomembnosti parametrov obravnavanega problema. Ta informacija pomaga razpoznati najpomembnejše parametre, ki bodo analizirani najprej. V diagramu Pareto se tudi jasno pokažejo področja mogočih izboljšav.

Pri uporabi vzročno-posledične matrike so vsi KVSP razvrščeni glede na pomembnost spremenljivke. Rezultati, dobljeni z vzročno-posledično matriko, se lahko uporabijo za različne analize in optimizacije, kakor so AIVP, multivariacijska analiza ter načrtovanje preizkusov.

In the application of a cause-and-effect matrix there are two phases. In the first phase the inputs are correlated to the outputs that provide the basis for a Pareto analysis. In the second phase, a new cause-and-effect matrix is started with three or four critical inputs from the first-phase matrix.

In the matrix a factor of importance for each parameter is rank ordered and every listed input parameter is correlated to every output parameter. Finally, a total value for each parameter is obtained by multiplying the rating of importance with the value given to the parameters and adding across for each parameter.

To be very certain about the level of a parameter's influence an additional Pareto analysis is applied. The Pareto diagram clearly displays information about the relative importance of the factors of a certain problem. This information helps to identify the most important factors, which will be analyzed first. With the help of the Pareto diagram domains, of possible improvement are clearly identified.

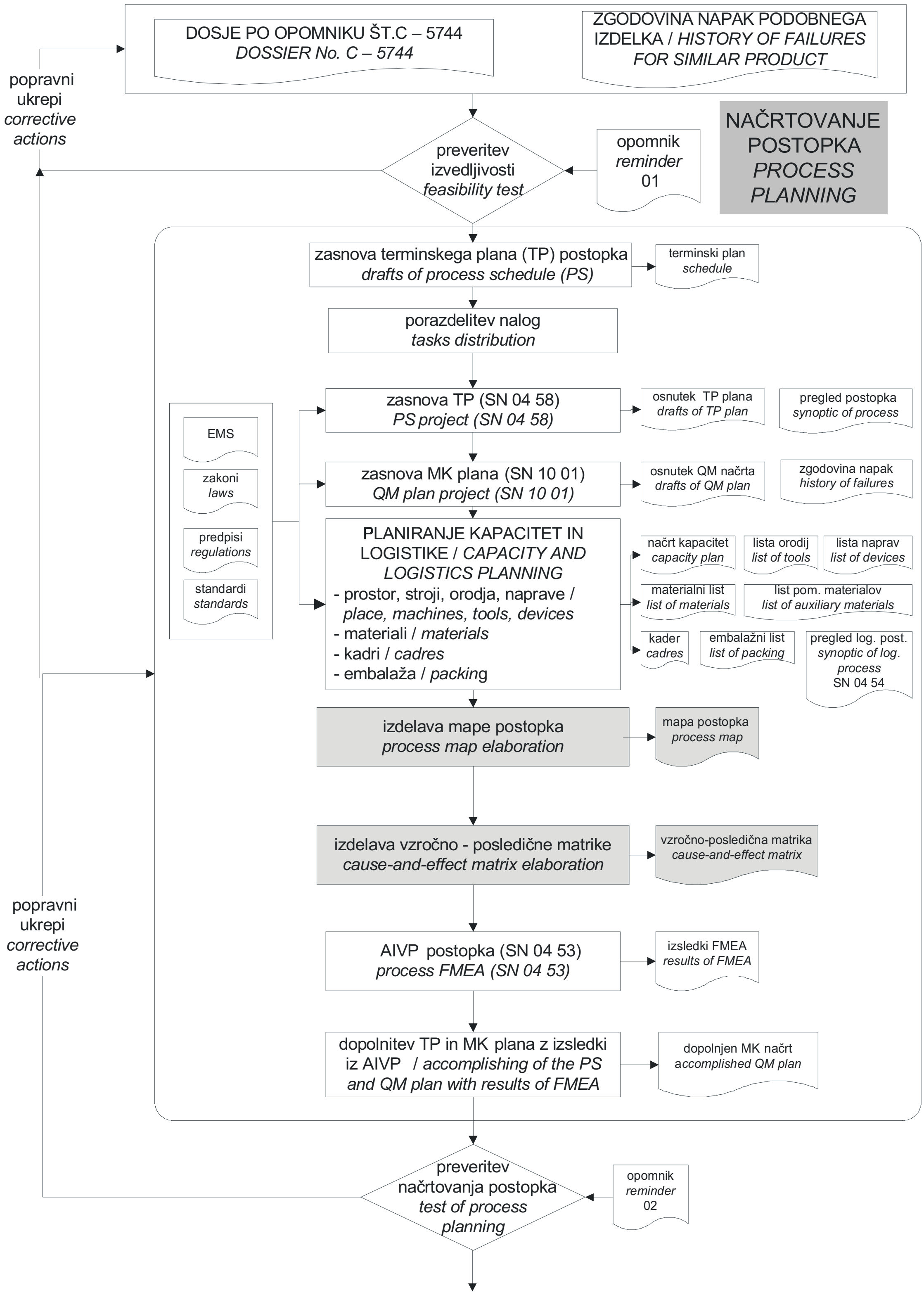
Using a cause-and-effect matrix all the KPIV can be rank ordered with respect to the importance of the variable. The results obtained with the cause-and-effect matrix can be used for other analyses and optimizations such as FMEA, multi-vari analysis and design of experiments.

2.3 Prilagojena oblika poteka postopka

Predlog prirejenega sinoptika načrtovanja postopka izdelave je prikazan na sliki 3.

2.3 Modified process design flow

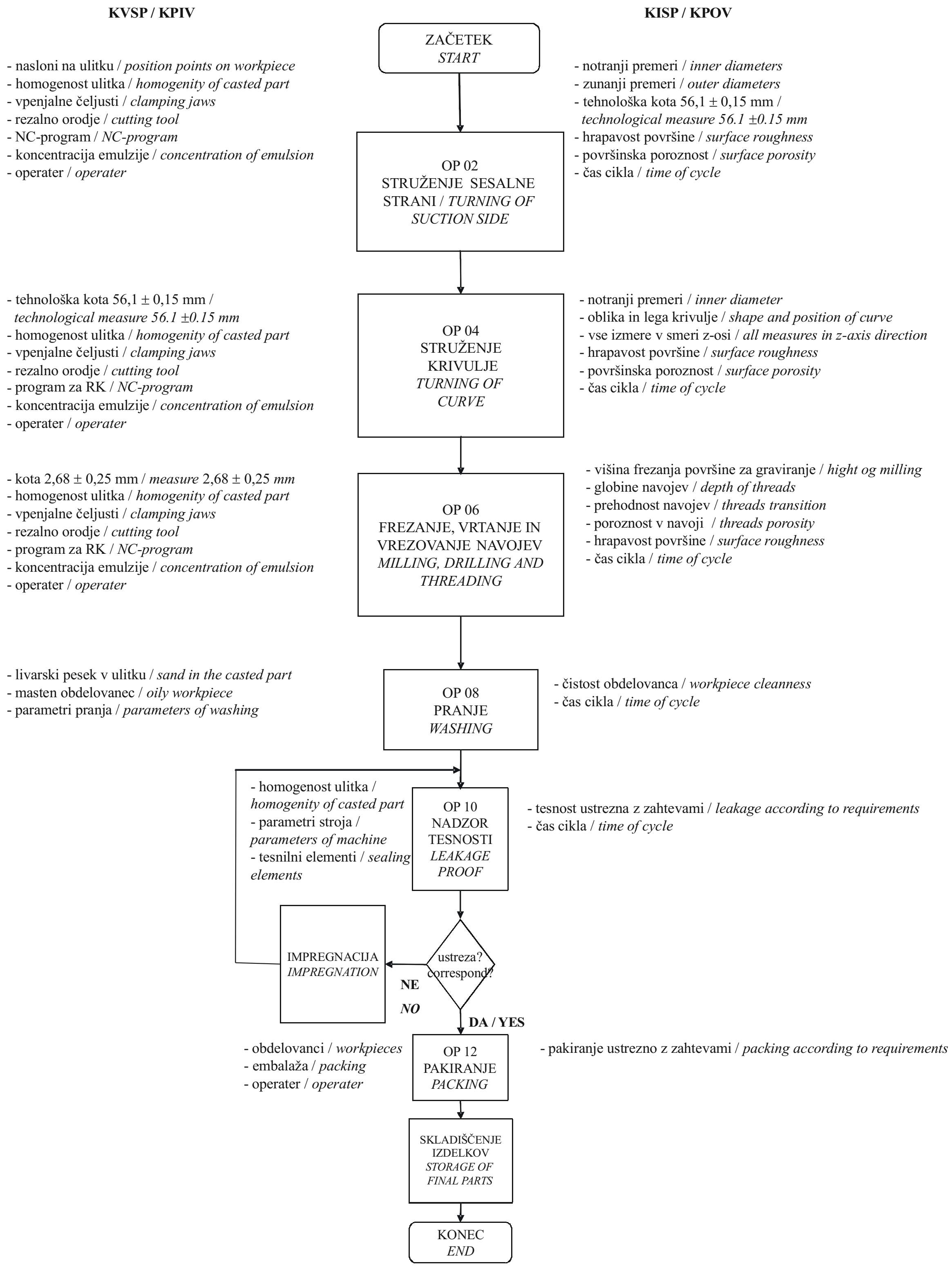
By applying the presented method at the process planning stage the process-design flow is modified, Fig. 3.



Sl. 3. *Modificirana oblika poteka postopka izdelave*
Fig. 3. *Modified process-design flow*

Nova, prilagojena mapa postopka za potek izdelave okrova kompresorja, skupaj z vsemi KVSP in KISP, je prikazana na sliki 4.

A new, modified process map for compressor-housing production is developed and shown in Fig. 4, along with all the KPIV and KPOV.



Sl. 4. *Modificirana mapa postopka za potek izdelave okrova kompresorja*
Fig. 4. *Modified process map for compressor-housing production*

Na sliki 4 so KVSP našteti na levi strani diagrama, medtem ko so KISP podani na desni strani diagrama. Včasih so KISP pri enem opravilu obenem tudi KVSP za naslednje opravilo, kakor v primeru opravil OP 02 in OP 04. Našteti KVSP in KISP v mapi postopka bodo uporabljeni kot vstopni parametri za analizo v vzročno-posledični matriki (sl. 5).

Rezultati iz vzročno-posledične matrike so v nadaljevanju analizirani v diagramu Pareto. KISP so razvrščeni v skladu s številom točk iz vzročno-posledične matrike. Diagram Pareto za najbolj vplivne KISP je prikazan na sliki 6.

KVSP so analizirani na enak način kakor KISP (sl. 7).

In Fig. 4 the KPIV are listed on the left-hand side, while the KPOV are listed on the right-hand side of the diagram. In some cases the KPIV from one step are the KPOV for the next step, for example OP 02 and OP 04. The KPIV and KPOV listed in the process map will be used as inputs for the analysis in the cause-and-effect matrix, shown in Fig. 5.

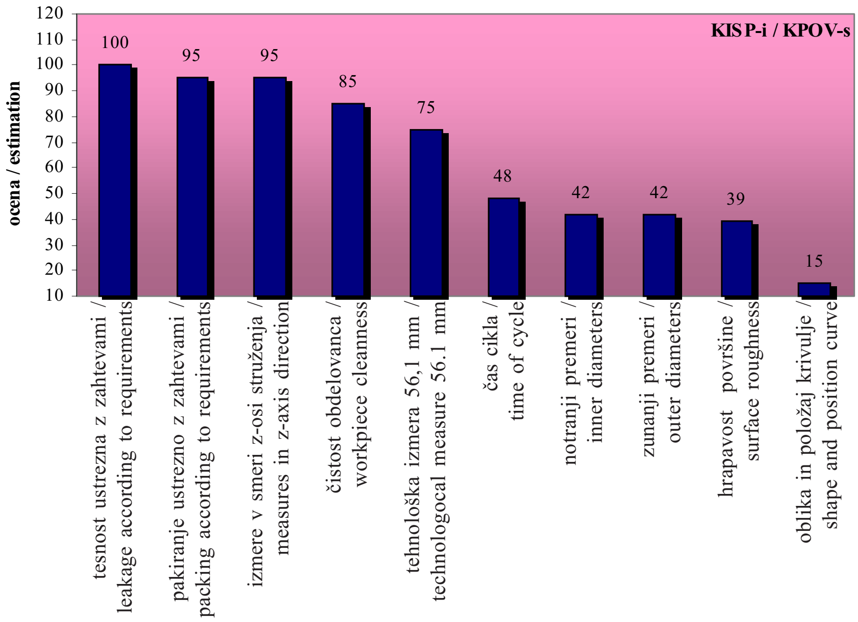
The results the cause-and-effect matrix are further analyzed with the Pareto diagram. The KPOV are rank ordered in accordance with the number of points from the cause-and-effect matrix. The Pareto diagram for the most influential KPOV is shown in Fig. 6.

The KPIV are analyzed in the same manner as the KPOV, Fig. 7.

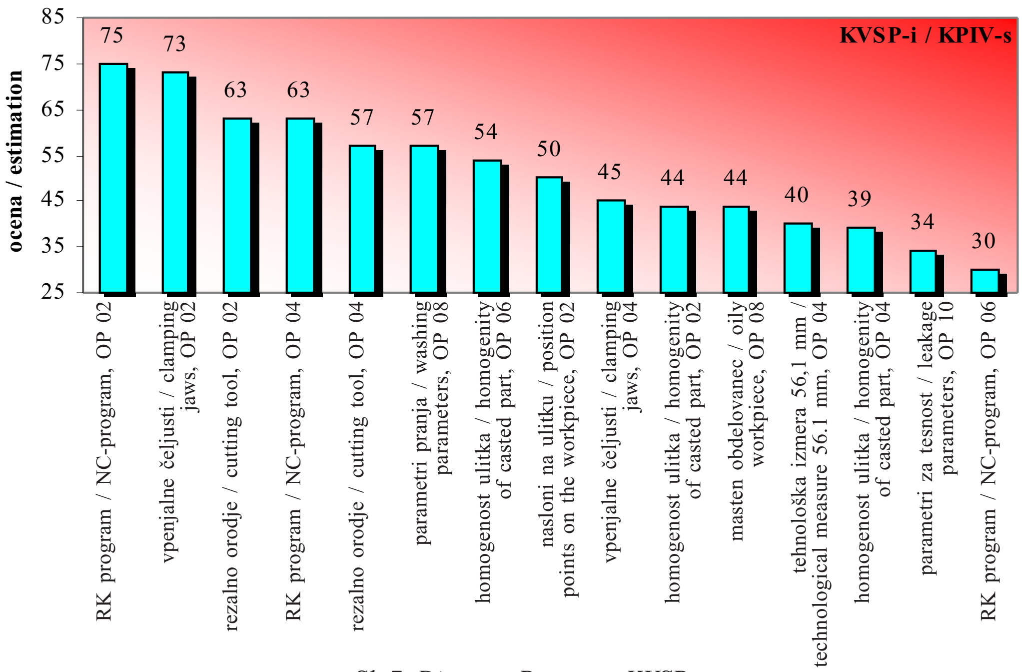
Tek. štev. / Cur. No.	OPERACIJA V PROCESU / PROCESSING OPERATION	KISP / KPOV — KVSP - KPIV	notranji premeri / inner diamaters	zunanji premeri / outer diameters	tehnološka kota 56,1 mm / technological measure 56.1 mm	hrapavost površine / surface roughness	površinska poroznost / surface porosity	čas cikla / time of cycle	oblika in položaj krivulje / shape and position of curve	kote v smeri z-osi struženja / measures in the z-axis direction	višina površine za graviranje / hight of milled surface	globine navojev / depth of threads	prehodnost navojev / transition of threads	poroznost v navojih / porosity of threads	čistota obdelovanca / workpiece cleanness	tesnost ustrezna z zahtevami / leakage according to requirements	pakiranje ustrezno z zahtevami / packing according to	Skupaj Sum
		Ocena pomembnosti za odjemalca procesa / Importance of estimation for process customer	3	3	5	3	1	3	3	5	1	1	3	3	5	5	5	
		Tek. štev. / cur. No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
1	02	nasloni na ulitku / position points on workpiece	0	0	5	0	0	0	0	5	0	0	0	0	0	0	0	50
2	02	homogenost ulitka / homogenity of casted part	0	0	1	3	5	0	0	0	0	0	0	0	0	5	0	44
3	02	vpenjalne čeljusti / clamping jars	5	5	5	1	0	0	0	3	0	0	0	0	0	0	0	73
4	02	rezalno orodje / cutting tool	5	5	1	3	1	1	0	3	0	0	0	0	0	0	0	63
5	02	program za RK / NC-program	3	3	3	3	0	5	0	3	0	3	0	0	0	0	0	75
6	02	koncentracija emulzije / emulsion concentration	1	1	0	3	0	0	0	0	0	0	0	0	1	0	0	20
7	02	operater / operator	0	0	0	0	0	3	0	0	0	0	0	0	1	0	0	14
8	04	tehnološka kota 56,1 mm / technological measure 56.1 mm	0	0	0	0	0	0	5	5	0	0	0	0	0	0	0	40
9	04	homogenost ulitka / homogenity of casted part	0	0	0	3	5	0	0	0	0	0	0	0	0	5	0	39
10	04	vpenjalne čeljusti / clamping jars	5	0	0	0	0	0	5	3	0	0	0	0	0	0	0	45
11	04	rezalno orodje / cutting tool	5	0	0	3	0	1	5	3	0	0	0	0	0	0	0	57
12	04	program za RK / NC-program	3	0	0	3	0	5	5	3	0	0	0	0	0	0	0	63
13	04	koncentracija emulzije	1	0	0	3	0	0	0	0	0	0	0	0	1	0	0	17
14	04	operater / operator	0	0	0	0	0	3	0	0	0	0	0	0	1	0	0	14
15	06	kota 2,68 mm / measure 2.68 mm	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	5
16	06	homogenost ulitka / homogenity of casted part	0	0	0	3	5	0	0	0	0	0	0	5	0	5	0	54
17	06	vpenjalna naprava / clamping device	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	2
18	06	rezalno orodje / cutting tool	0	0	0	0	0	0	0	0	1	3	0	0	0	0	0	4
19	06	program za RK / NC-program	0	0	0	3	0	5	0	0	3	3	0	0	0	0	0	30
20	06	koncentracija emulzije / emulsion concentration	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	5
21	06	operater / operator	0	0	0	0	0	0	0	0	0	0	5	0	1	0	0	20
22	08	livarski pesek v ulitku / sand in the casted part	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	25
23	08	masten obdelovanec / oily workpiece	0	0	0	0	0	0	0	0	0	0	3	0	5	1	1	44
24	08	parametri pranja / washing parameters	0	0	0	0	0	3	0	0	0	0	1	0	5	1	3	57
25	10	homogenost ulitka / homogenity of casted part	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	25
26	10	parametri tesnosti / leakage parameters	0	0	0	0	0	3	0	0	0	0	0	0	0	5	0	34
27	10	tesnilni elementi / sealing parameters	0	0	0	0	0	1	0	0	0	0	0	0	0	3	0	18
28	12	končani obdelovanci	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	25
29	12	embalaža / packing	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	25
30	12	operater / operator	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	25
		Skupaj / Sum	42	42	75	39	6	48	15	95	1	9	12	0	85	100	95	

Sl. 5. *Vzročno-posledična matrika za postopek izdelave okrova kompresorja*

Fig. 5. *Cause-and-effect matrix for compressor-housing production*



Sl. 6. *Diagram Pareto za KISP*
Fig. 6. *Pareto diagram for the KPOV*



Sl. 7. *Diagram Pareto za KVSP*
Fig. 7. *Pareto diagram for the KPIV*

3 PRIMERJAVA SEDANJEGA IN NOVEGA POTEKA POSTOPKA

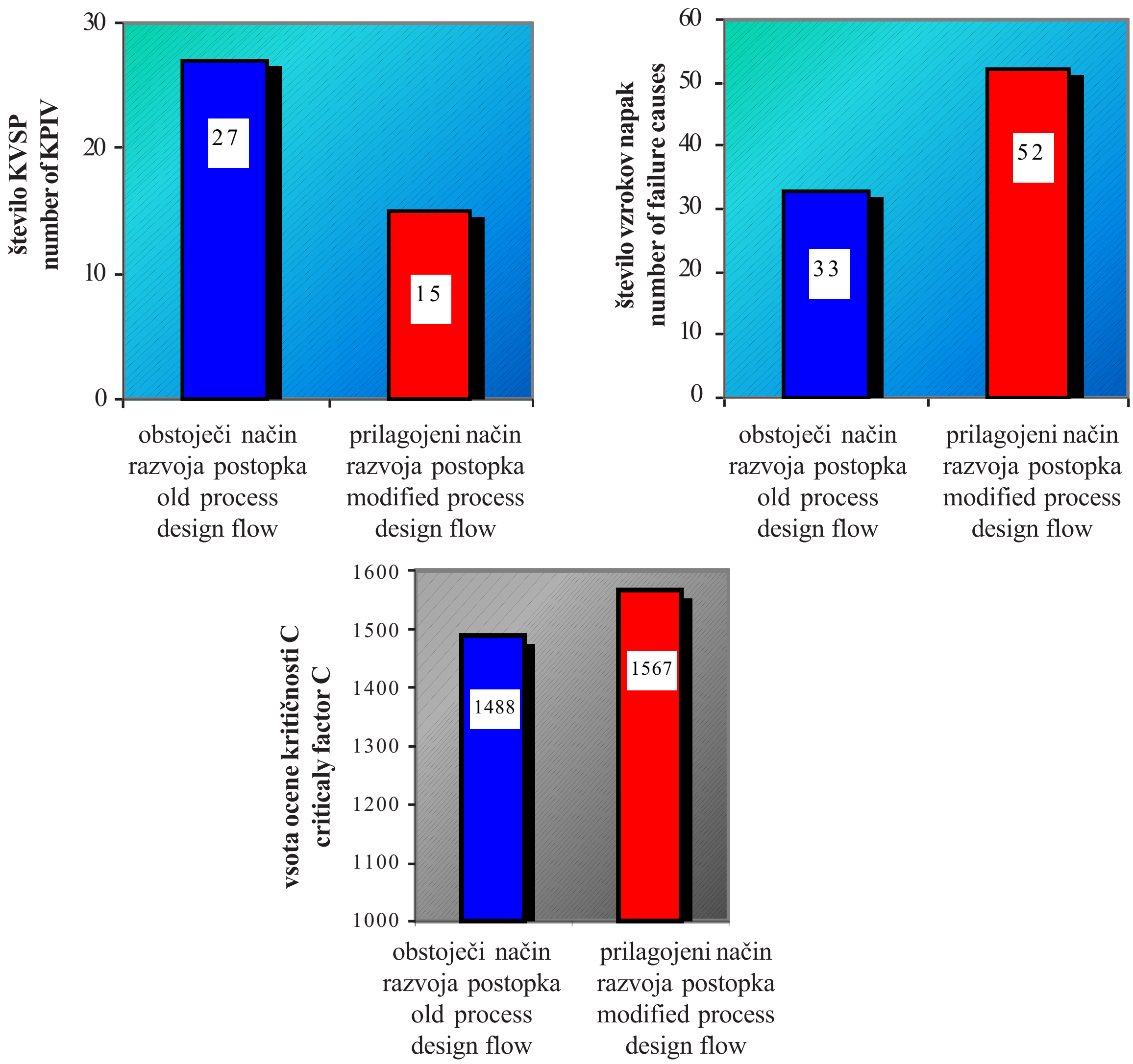
Za primerjavo med sedanjim in novim načinom razvoja postopka bodo v nadaljevanju analizirani parametri, to so: število KVSP, število vzrokov napak v AIVP-postopku ter faktor ocene kritičnosti "C".

S slike 8 je razvidno, da je pri sedanjem načinu razvoja postopka obravnavano večje število KVSP. Pri tem je to število KVSP zajelo celo manjše število vzrokov napak kakor pri novem načinu. Pri primerjavi se še opaža, da je

3 COMPARISON OF THE OLD AND THE MODIFIED PROCESS-DESIGN FLOW

To compare the old and the modified process-design flow, the number of KPIV, the number of failure causes in the FMEA analysis, and the criticality factor, both in the old and the modified process-design flow, will be analyzed.

As shown in Fig. 8, in the old process-design flow there were greater numbers of KPIV. At the same time the number of failure causes analyzed in the old process-design flow was significantly lower than in the modified one. Furthermore, the criticality factors



Sl. 8. *Primerjava parametrov med sedanjim in novim razvojem poteka postopka*
Fig. 8. *Comparisons of the old and the modified process-design flow*

vsota ocen kritičnosti “C” pri novem načinu razvoja postopka večja. To pomeni, da je z manjšim številom KVSP odkritih več mogočih vzrokov za napake, na katere lahko preprosto korektivno delujemo in s tem preprečimo dejansko nastajanje napak v postopku proizvodnje.

Če primerjamo uporabljen čas in stroške, lahko ugotovimo, da so razmere malo drugačne. Analiza porabljenega časa za oba poteka postopka je prikazana na sliki 9, medtem ko slika 10 prikazuje analizo stroškov.

S slike 9 je razvidno, da je za pripravo po novem načinu razvoja postopka uporabljeno več časa, približno 42,5 %. Hkrati so po novem načinu (sl. 10) stroški večji.

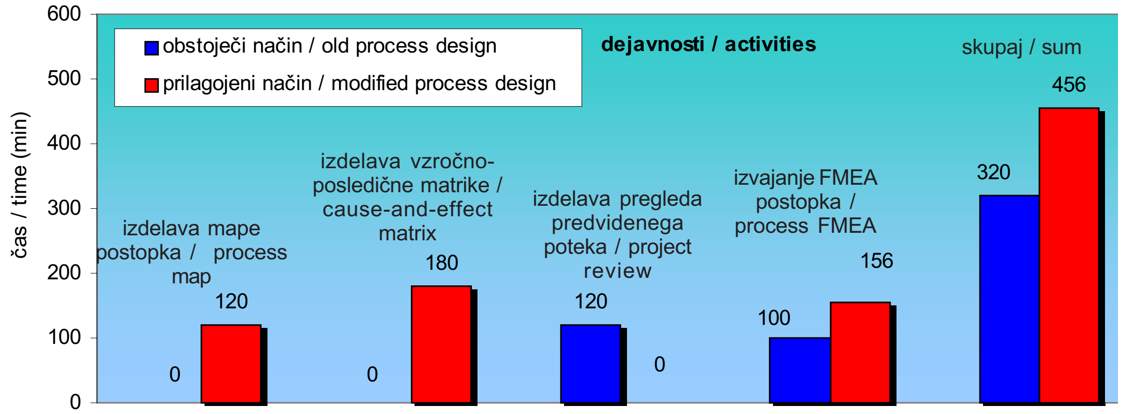
Dejansko sliko novega načina poteka postopka dobimo, če le-tega projeciramo na enomesečno proizvedeno količino. Na sliki 11 so podani dejanski stroški slabe kakovosti za enomesečno proizvodnjo okrovov kompresorja.

are greater in the modified than in the old process-design flow. In the modified process-design flow with a smaller number of KPIV there are a greater number of failure causes determined which could be easily acted upon, corrective action defined and the appearance of failure in production prevented.

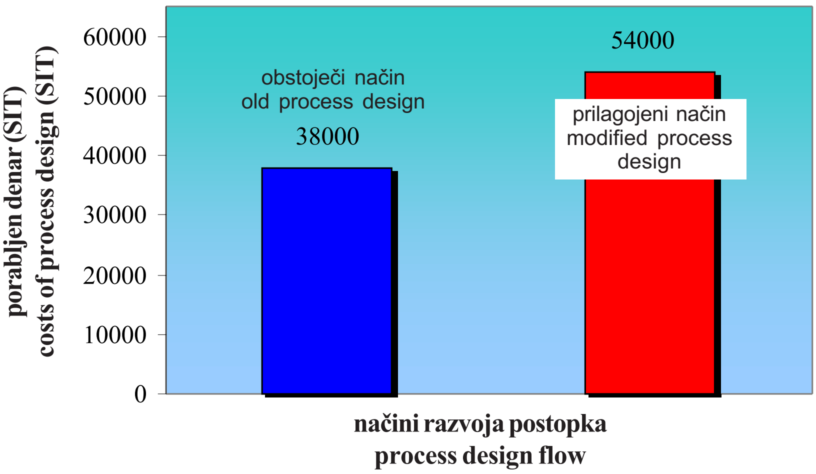
The results of these analyses are slightly different if we analyze the times spent and the costs. Time analyses for both process-design flows are shown in Fig. 9, while the cost analyses are shown in Fig. 10.

From Fig. 9 it can be concluded that in the modified process-design flow more time is used: approximately 42.5 %. At the same time, in the modified process-design flow more money is spent. The costs were greater in the modified than in the old process-design flow.

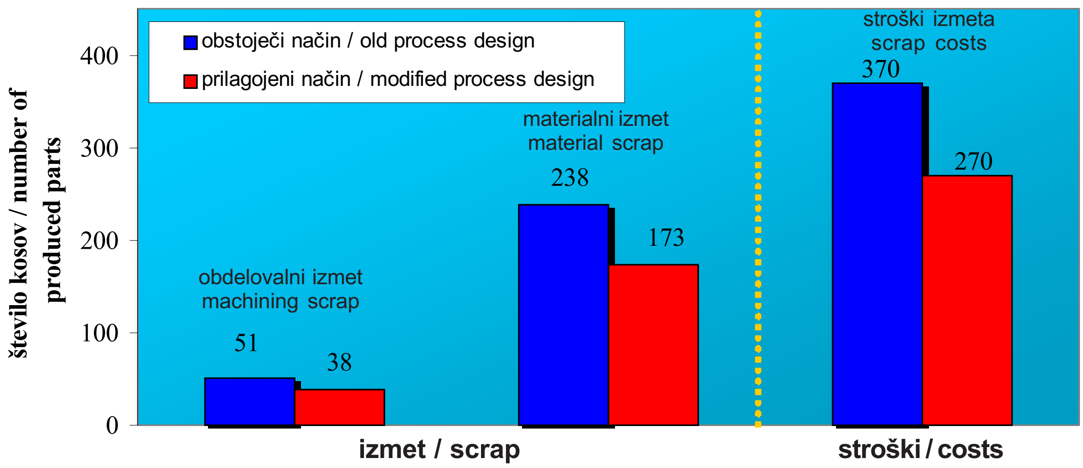
A true picture can be obtained by projecting a modified process-design flow on a one-month production volume. Fig. 11 shows the real poor-quality costs of one month’s compressor-housing production.



Sl. 9. *Analiza porabljenega časa za sedanji in novi način poteka postopka*
Fig. 9. *Spent-time analysis of the old and the modified design flow*



Sl. 10. *Analiza stroškov za sedanji in novi način poteka postopka*
Fig. 10. *Costs analysis of the old and the modified design flow*



Sl. 11. *Stroški slabe kakovosti pri enomesečni proizvodnji okrovov kompresorja*
Fig. 11. *Poor-quality costs of one month's compressor-housing production*

Ob upoštevanju večjih stroškov novega načina poteka postopka ter prihrankov na račun manjšega obdelovalnega in materialnega izmeta v proizvodnji lahko dosežemo znaten celoten prihranek pri uvajanju novega načina.

Taking into account the higher costs of the modified process-design flow and the savings in machining and materials scrap in production, a significant overall saving can be achieved by the application of the modified process-design flow.

4 SKLEPNE UGOTOVITVE

Razvoj postopka, posebej faza načrtovanja postopka je zelo pomembna faza v pripravi proizvodnje avtomobilskih delov. Zaradi velikih serij izdelkov tudi majhni odstotki izmeta povzročajo ogromne stroške. Najmanj, kar lahko naredimo v fazi načrtovanja postopka, je, da uporabimo orodja za izboljšanje postopka, tj. mapo postopka izdelave in vzročno-posledično matriko.

Iz pričujočega prispevka je razvidno, da uporabljeni orodji odkrivata veliko število možnih vzrokov za napake, na katere se lahko deluje in s tem prepreči nastajanje napak v postopku proizvodnje. Za uporabo metode AIVP po novem načinu poteka postopka je bilo porabljeno več časa kakor pri sedanjem načinu. Poleg tega sta bila tudi razvoj in priprava novega poteka postopka precej dražja. Vendar je ocena, da bi z zmanjšanjem stroškov obdelovalnega ter materialnega izmeta (v takšnem obsegu) pokrili vse dodatne stroške v fazi priprave; še več, dosegli bi prihranke, ki bi bili nekajkrat večji, kakor je začetno povečanje stroškov.

Sklenimo z ugotovitvijo, da celo uporaba posameznih, izoliranih orodij iz metodologije »šest sigm« zagotavlja koristi v izboljšanju postopka. Ti rezultati bodo še boljši s širšo uporabo orodij »šest sigm« in metodologije v celoti.

4 CONCLUSION

Process design and development, especially the process planning stage, is a very important phase in the preparation or automotive-part production. Due to the very high production volume, even low scrap levels result in high costs.

What we can do in the process planning stage is to apply process-improvement tools such as a process map and a cause-and-effect matrix.

From this study it is evident that the applied tools detect a greater number of possible failure causes, so that failures in the production process can be prevented. With the application of the FMEA method more time is spent in the new than in the old process flow. Furthermore, the new process design and development is more costly than the old one. Hence, due to better production preparation the machining and material scrap will be decreased to such a level as to cover all the additional costs in the preparation stage and, furthermore, to produce savings that are several times greater than the initial cost increase.

In conclusion, even the application of some isolated tools from Six Sigma methodology provide benefits in process improvement. These results could be improved with more widespread use of Six Sigma tools and methodology.

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