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Model za učinkovito upravljanje podatkov iz uporabe – primer proizvodnje izdelkov bele tehnike

A Model of Effective Data Management From Exploitation – A Case of Domestic-Appliance Production

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Podjetje, ki želi ostati konkurenčno, mora stalno spremljati kakovost izdelkov na trgu in odpravljati napake na kritičnih izdelkih. V ta namen potrebujejo proizvajalci glede na svojo velikost in dejavnost specifičen model informacijske integracije podatkov iz faze uporabe. Strukturirani podatki iz uporabe izboljšajo kakovost dela in vključevanje izkušenj iz preteklih krogov izdelkov pri razvoju oz. izboljšavah sedanjih izdelkov.

Za potrebe menedžmenta kakovosti je bila povratna zveza dopolnjena z inženirskim modelom delovnega naloga, ki vključuje popis mehanizmov okvar. Na primeru proizvodnega podjetja so prikazani informacijski tokovi med izvajalci popravil na terenu in podjetjem. Specifikacija podatkovnega modela, ki temelji na predstavitvi napake, predstavlja znanje o mehanizmih in vzrokih okvar. Uporabljen je bil model kodifikacije okvar, ki pokriva celotni nabor stanj in vzrokov v strukturirani obliki, ki podjetju omogoča preprosto zbiranje podatkov ter urejeno znanje na osnovi tipiziranih okvar, ki se pojavljajo v dobi trajanja izdelka. Na enem mestu dostopne informacije o popravilih na izdelku omogočajo neposredno preoblikovanje podatkov v povratno zvezo podjetja. V prispevku predstavljen postopek ponuja podporo metodam menedžmenta kakovosti ter podlago za izvedbo izboljševalnih ukrepov v proizvodnem podjetju. V modelu delovnega naloga sestavljeni podatki omogočajo navigacijo v omrežjih stanj izdelkov.

(Ključne besede: kakovost izdelkov, zanesljivost, garancije, analize podatkov, tehnični servisi)

A company that wants to stay competitive has to keep up to date with the quality of products on the market, and constantly has to remove all the defects from its critical products. For this reason companies, depending on their size and type of activity, need a specific data-information integration model for the exploitation phase. Structured exploitation data increases the level of work quality and incorporates experience from former lines of products in the process of development or improving current products.

For the needs of management quality the recurrent feedback loop was supplemented with the engineer model of service order, which includes an inventory of defect mechanisms. The information flow between fieldwork repairers and the company is illustrated in the case of a production company. The specification of the data model, which is based on defect presentation, presents the knowledge of defect mechanisms and causes. We used the model of the codification of defects. It covers the total area of states and causes in the structured form, which enables the company to easily acquire data as well as organized knowledge on the basis of typified defects that occur in the product lifecycle. Product-repair data available in one place enables a direct data transformation back to the feedback loop of the company. The model presented in this paper offers support to the TQM methods as well as the basis for carrying out correction measures in the production company. The structured data in the service-order model make it possible to navigate in the product-failure net.

(Keywords: product quality, reliability, warranty analysis, technical services)

0 UVOD

V zvezi z naraščajočimi zahtevami glede izdelkov od zakonodajalcev se proizvodna podjetja vse bolj spoprijemajo z vedno večjimi pričakovanji v zvezi s kakovostjo svojih izdelkov. Upravljanje kakovosti skozi celotno dobo trajanja izdelka, še posebej na področjih, ki so na zunanjih mejah področja proizvodnega menedžmenta, postaja vse bolj pomembno področje raziskav, tudi na področju faze uporabe izdelkov.

Obvladovanje kakovosti izdelkov v uporabi pomeni razvijati zamisli, s katerimi je v danem primeru mogoče modelirati informacijske tokove in modele, ki pomembno prispevajo k obvladovanju povratnih zvez kakovosti in metod menedžmenta kakovosti.

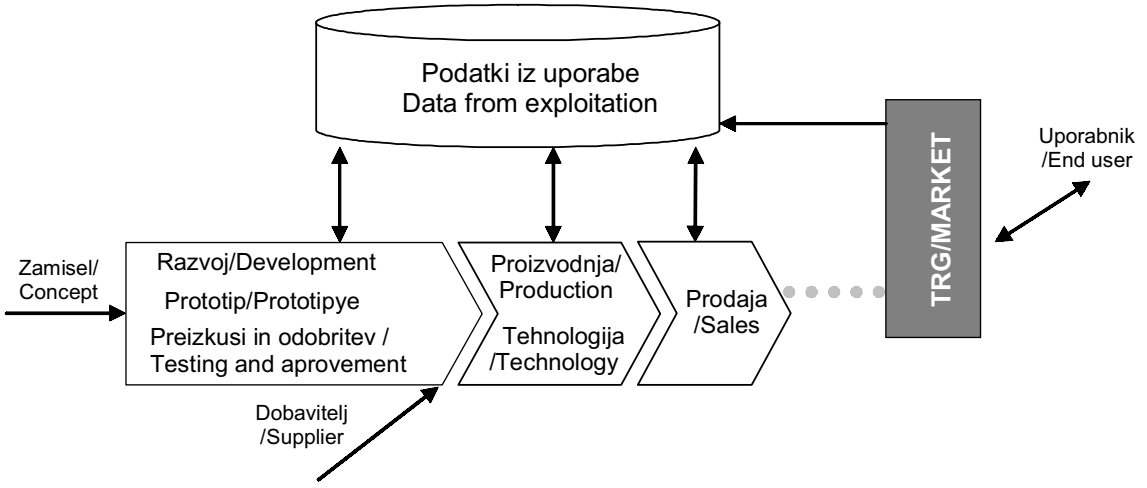
Prispevek obravnava kakovost izdelkov v uporabi. Glavni namen je, da se v okviru razvoja izdelkov uporabljajo informacije, ki se pridobivajo med samo uporabo izdelka, se pravi tiste, ki kažejo obnašanje izdelka in nastajanje napak med njegovo uporabo. To je smiselno, saj leži ključna točka dejavnosti razvoja v prilagajanju in izboljšanju že znanih izdelkov. Z vidika menedžmenta kakovosti, kakor tudi z vidika stroškov in časa, je ta enostranska naravnanost tokov informacij zelo vprašljiva. Še posebej velja izpostaviti informacije o posledicah odločitev s področij načrtovanja, ki se na primer pokažejo kot napake in šibke točke v uporabi izdelka. V smislu povratne zveze se lahko tako ustvarjajo krmilne zanke kakovosti [1]. Za to se morajo v predhodnih fazah uporabljati podatki iz uporab, ki pomenijo obnašanje izdelkov v uporabi (sl. 1).

0 INTRODUCTION

Due to the increasing number of legal requirements regarding products, manufacturers are faced with higher expectations connected with the quality of their products. Quality management in the product lifecycle, especially in the areas bordering on production management, has become an essential element of a product's exploitation-phase research.

Quality management in product exploitation stands for the development of concepts that can be used for modelling information flows and the models necessary to command the managing of quality feedback loops and quality-management methods.

This paper deals with the product quality in exploitation. The main goal is to use the information acquired during product application in the process of product development. It aims to use the information that reflects a product's behaviour and the faults emerging during the application. That is reasonable because the key point of the development activity lies in adapting and improving existing products. From the point of view of management quality, like from the point of view of expenses and time, this one-way orientation can be very problematic. In particular, one has to expose the information on the consequences of decisions regarding the area of planning, which can turn out to be wrong or to be weak points in the exploitation of the product. In the sense of feedback, controlled quality loops can emerge [1]. That is why exploitation data representing product behaviour in exploitation have to be used in the preliminary phases (Fig. 1).



Sl. 1. *Uporaba podatkov iz uporab med dobo trajanja izdelka*
Fig. 1. *Use of exploitation data during the product lifecycle*

1 VZPOSTAVITEV KROGA KAKOVOSTI S KRMILJENJEM POVRATNIH INFORMACIJ IZ UPORABE IZDELKA

Podjetje, ki se zaveda, da je kakovost usmerjena k potrebam in zahtevam trga, oblikuje integralni sistem kakovosti. Glede na dejavnosti v proizvodnem podjetju je treba postaviti tok informacij, v katerem so udeleženi ustvarjalci v vrednostni verigi.

Zamisli za podporo preventivnega menedžmenta kakovosti na podlagi povratnih podatkov iz uporabe temeljijo na pridobivanju podatkov o zanesljivosti. Uporaba podatkov iz uporabe prek skupne baze podatkov ali standardizirani vmesniki še ne obstajajo [5]. Kljub temu, da ima menedžment kakovosti v podjetju že dalj časa vlogo presečne funkcije, so na tem področju opažena prizadevanja za gradnjo enotnih podatkovnih formatov. V okviru celotnega menedžmenta kakovosti (CMK) so podana izhodišča za spremljanje podatkov iz uporabe. Ko proizvodno podjetje skušamo nadzorovati in usklajevati kakovost izdelkov na trgu, hkrati urejamo tudi zanesljivost izdelkov. V proizvodnem podjetju je treba nenehno spremljati elemente zanesljivosti in kakovosti na trgu za potrebe metod in orodij menedžmenta kakovosti.

Zanesljivost in kakovost v uporabi obsega stanje o okvarah na izdelkih na trgu [4]. Gre za ocenjevanje mehanizmov okvar, ki jih povežemo z viri. To je ocenjevanje stanja in učinkov na posameznih programih od vrha navzdol, pri čemer se lahko poizveduje na generični ali specifični ravni izdelka.

Prizadevanja za prepoznavanje tveganja zaradi slabe kakovosti na trgu lahko obsegajo tudi dejavnosti, ki pomagajo pri določitvi pogostosti okvar (zanesljivosti) ali posledic elementa tveganja (stroški zaradi slabe kakovosti na trgu) [3]. Kritična tveganja, ki se kažejo v slabi kakovosti na trgu, je treba zapisati, kakor zahteva CMK. Tako se kakovost na trgu obvladuje in se sproti nadzira oziroma ureja skozi dobe trajanja izdelkov. Stanja na trgu je treba preudarno pripraviti, da bi preprečili ključne posledice dejavnosti in da se posamezna dejanska stanja ne bi "izmuznila" iz analiz. Namena prepoznavanja stanja izdelkov v uporabi sta določanje in izbira vzrokov na podlagi opazovanj stanja okvar na izdelkih. To terja temeljito poznavanje trga, organizacije podjetja, izdelkov in mehanizmov okvar. Na podlagi postopkov ocenjevanja z

1 QUALITY-LOOP ESTABLISHMENT BASED ON THE REGULATION OF FEEDBACK DATA FROM PRODUCT EXPLOITATION

The company, which realized that quality is directed to market demands, implemented an integral quality system. Due to activities in manufacturing the company needs to make information flow, and there should be participation from all parties in the value chain.

The preventive quality-management control concepts based on feedback exploitation data (i.e., data on the product-exploitation phase) rely on obtaining reliable data. However, the possibility to use the exploitation data over a common database or standardized interfaces does not exist yet [5]. Although quality management has had a cross-section function in the company for a long time, there have been efforts in this field to set up unified data formats. Within total quality management (TQM), the starting points have been defined for monitoring the exploitation data. By trying to control the manufacturing company (enterprise) and the quality of products in the market, product reliability is controlled at the same time. In a manufacturing enterprise, constant monitoring of the reliability and quality elements in the market is necessary to meet the requirements of the methods and quality-management tools.

Reliability and quality in the product-exploitation phase involves the faults status of products in the market [4]. The issue at hand is evaluating the fault mechanisms, which are then linked to their respective sources. This includes evaluating the situation and effects in respective programs from the top down, where a query on a generic or a specific product level can be carried out.

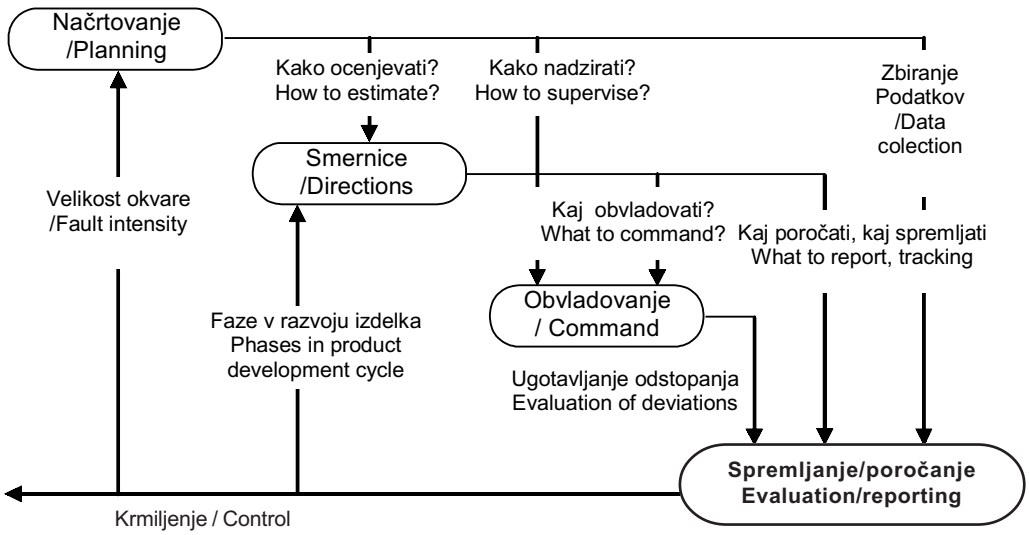
The efforts to identify the risks due to poor quality in the market can also comprise activities to aid the recognition of fault frequency (reliability) or the consequences of the risk element (costs due to poor quality in the market) [3]. Critical risks that are evident in poor quality in the market have to be documented as required by TQM. In this way, the quality in the market is managed and controlled for "along the way" (i.e., simultaneously), or it is controlled through the product lifecycles. Market conditions/situations data should be carefully prepared to avoid overlooking the key activities and particular actual conditions in the analysis. The purpose of recognizing the product conditions in the exploitation period is identifying and selecting the causes based on observations of the product fault status. On the basis

dopolnjevanjem opisov dejanskih stanj z izločitvijo vzroka, je treba ugotoviti, katere podatke potrebujejo skupine strokovnjakov.

Temeljna izhodišča postopka menedžmenta napak je preprečevanje ponavljanja napak v proizvodnem podjetju ("Učiti se iz napak") z ustreznimi metodami in programskimi orodji. Upoštevati je treba celotno verigo izdelka, to pomeni postopke od razvoja izdelka do prodaje končnemu uporabniku (notranje upravljanje napak), kakor tudi uporabo izdelka od uporabnika izdelka (zunanje upravljanje napak) [7]. Pri razvoju takšne osnove za rešitev je zelo pomembno vključevanje znanih informacijsko tehničnih podsestav posameznih podjetij in širjenje načela preprečevanja ponavljanja napak v krogu kakovosti. Za gradnjo računalniško podprtih krogov kakovosti, ki izboljšujejo postopek razvoja izdelka na podlagi analize napak, se morajo vzpostaviti sistemi povratnih informacij o mehanizmih okvar [4]. Napak, ki se ne dajo prikazati številčno, z matematično-statističnimi metodami ni mogoče zgostiti in pripraviti do stopnje, ki bi omogočala izpeljavo neposrednih nastavnih vrednosti za neko uredbo, npr. krogih na področjih izdelave, ki se urejajo na podlagi primerjave rezultatov meritev z idealno vrednostjo strojnih parametrov [6]. Za kakovostno opisane napake je za krmiljenje kakovosti razvoja izdelka potrebna metoda, s katero se omogoči postopek optimizacije (sl. 2).

of evaluation procedures that complement the actual state descriptions by isolating the cause, data sets required by expert teams should be identified.

The basic starting point of the fault-management approach is the support of repeated fault prevention in a manufacturing enterprise, i.e., to learn from one's own mistakes, by applying suitable methods and program tools. The entire product chain should be considered, i.e., the processes from the product development to the end-user sale (internal fault management), as well as the application of the product by the end-user (external fault management) [7]. When developing such a solution base, it is essential to include the existing informational-technical infrastructures of individual companies and extend the principle of repeated fault prevention within the quality loop. To set up computer-aided quality loops that improve the product-development process based on fault analysis, systems of feedback information about the fault mechanisms have to be established [4]. Faults that cannot be quantified by mathematical-statistical methods cannot be compressed and prepared to a level that would enable the derivation of direct setup values for a certain layout, as, for example, with loops in the field of manufacturing, which are regulated based on comparisons of measurements results with an ideal value of engineering parameters [6]. For qualitatively described faults, the control of the product development quality requires a method that would enable an optimization process (Fig. 2).



Sl. 2. *Uporaba podatkov iz uporabe v krogu kakovosti*
Fig. 2. *Use of data from exploitation in the quality circle*

Na podlagi poizvedb v bazi primerov se uporabniku v obravnavanem osnutku ponudijo različne možnosti za podporo, s čimer je omogočena uporaba pri različnih nalogah. V pomoč je tudi zagotovitev celotnega poteka nastanka izdelka, ki je potreben za analizo napak, vzrokov in izpeljavo ustreznih ukrepov. Zgodovina izdelka mora (predvsem pri zahtevnih izdelkih) obsegati naslednje točke:

- seznam vseh okvar in njihovih mehanizmov,
- dokumentacijo vseh dejavnosti popravil, vključno s seznamom vseh zamenjanih elementov, z navedbo časa popravila in
- podatke o izdelkih (serijska številka, datum nakupa, pogoji uporabe itn.).

Nadaljnja pomembna točka v zvezi s sistemsko tehnično podporo izvajalcev popravil je zagotovitev mehanizmov za analizo vzrokov in razpoznavo primernih ukrepov. V proizvodnem podjetju se pojavlja zahteva po sistemu, ki temelji na načelu sklepanja iz primerov; to je natančen opis napak in stanja izdelka, ki je odpovedal na trgu. Na tej podlagi se lahko iz baze pomembnih podatkov pridobijo podobni primeri, za katere so že zapisani uspešni ukrepi. Tako pridobljene ukrepe je nato treba še oceniti in jih prilagoditi prisotnemu problemu.

2 ZASNOVA PODATKOVNEGA MODELA ZA OBVLADOVANJE PODATKOV IZ UPORABE

Pred sistematično obravnavo pretoka informacij pri izvajanju popravil tehničnega servisa na izdelkih v uporabi je treba celovito poznati dogajanje in potrebe v proizvodnem podjetju. Primer izvedbe popravil izdelkov bele tehnike je izbran za podrobnejšo obravnavo zaradi svoje razširjenosti. Analizirali smo informacijske tokove, ki se pojavljajo pri izvajanju popravil v garanciji s poudarkom na izhodnih tokovih. Glede na ugotovitve je podana izhodna struktura podatkov iz uporabe v delovnem nalogu kot zbirniku vseh pomembnih informacij. Podane niso podrobnosti trenutnega stanja znane organizacije, poudarek je na predlogih, ki temeljijo na tehničnem in poslovnem informacijskem sistemu in predstavitvi metod analize. Razmerja izvajanja popravil z drugimi funkcijami v proizvodnem podjetju z vidika informacijskih in materialnih tokov so prikazane na sliki 3.

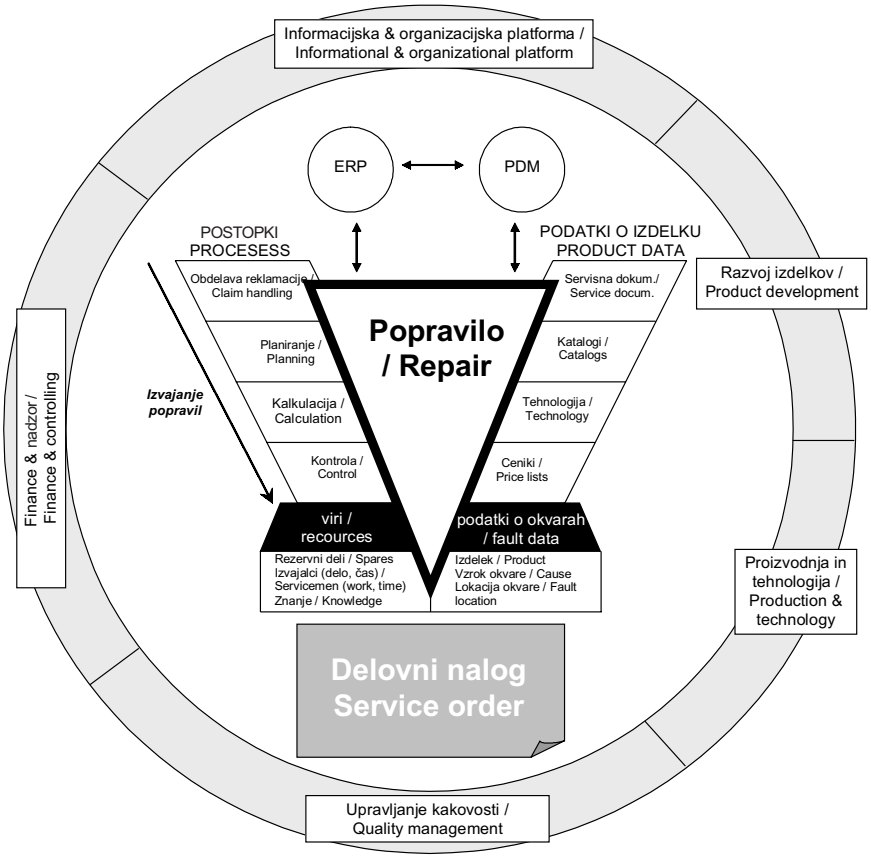
Based on queries in the examples database, the user is offered several support options for the concept considered. This also enables application in different tasks. Another aid for the process is the provision of the entire product history, which is required for the analysis of faults, causes, as well as the derivation of appropriate measures. The product history has to (especially with complex products) involve the following elements:

- A list of all faults and their mechanisms,
- documentation on all repair activities, including the list of all the substituted elements, stating the time of repair,
- the product information (serial number, date of purchase, conditions of use, etc.).

A further important point regarding the system technical support by the repair personnel is the provision of mechanisms for cause analysis and the identification of suitable measures. A manufacturing company is faced with the requirement for a system that is based on the principle of drawing conclusions from individual sets of examples (induction). The foundation for such a system is an exact description of the faults and the condition of the product that failed in the market. Based on this, similar examples can be obtained from the relevant database, for which successful measures have already been defined. Measures that were arrived at in this way only have to be evaluated and adjusted to the current problem.

2 OUTLINE OF A DATA MODEL FOR EXPLOITATION DATA MANAGEMENT

Before any systematic consideration can be made of the information flow about the performance of technical service repairs on products in service, the activities and requirements in a manufacturing company should be thoroughly and wholly recognized. An example of white-goods product repair has been chosen for detailed consideration because of its frequent occurrence. We have analyzed the information flows that take place when performing repairs in the warranty period, with an emphasis on the outgoing flows. Considering the findings and conclusions, the outgoing exploitation data structure has been defined in the work order as a collecting point for all the relevant information. Details from the current condition of a particular organization have not been stated, the emphasis lies on suggestions based on technical and business-information systems, as well as on the presentation of the analysis method. The relations of repair performance with other functions in a manufacturing company from the information and material-flows viewpoint are shown in Figure 3.



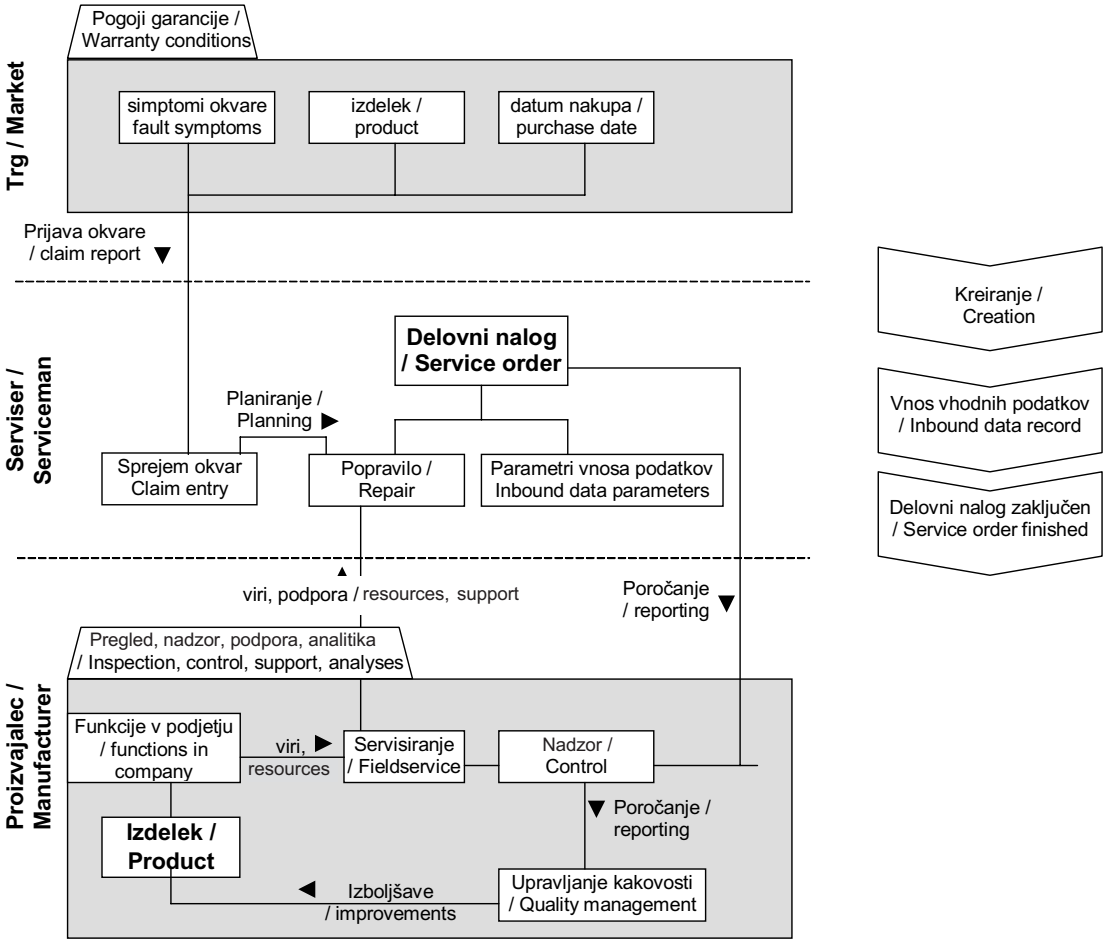
Sl. 3. *Informacijski in materialni tokovi v postopku popravila*
Fig. 3. *Information and material flow in the repair process*

Zahtevnost izdelkov in stopnja posplošitve okvare zmanjšujejo preglednost informacij o stanju izdelka. Izvajalci del so specializirani za izvedbo del (znanje, tehnologija), ki je pri izdelku uporabljena. Dinamika razvoja izdelkov (število izvedenk), prodane količine, zanesljivost izdelkov in razpoložljivost rezervnih delov pomembno vplivajo na izvajanje popravil [8]. Izdelki znotraj posameznih skupin izdelkov se razlikujejo v izmerah, funkcijah in pripadajočih rezervnih delih, medtem ko v sami funkciji in delovanju ni velikega odstopanja. Visoka stopnja standardizacije in poenotenja rezervnih delov zmanjšuje zapletenost poslovanja z rezervnimi deli in poenostavi izvajanje popravil.

Znani so poizkusi informacijske podpore tehničnega servisa izdelkov v uporabi [2], vendar na tržišču ni komercialnih programov, ki bi bili preprosti za uporabo in dovolj prilagodljivi za dinamiko dela pri izvajanju popravil na terenu. Temeljni postopki, ki se pojavijo v uporabi, so za potrebe gradnje končnega modela predstavljeni na sliki 4.

Product complexity and fault abstraction level obscure the transparency of the product condition information. The personnel are specialized for particular tasks (knowledge, technology) that are applied during the product manufacturing. The product-development dynamics (number of versions), quantity sold, product reliability and spare-part availability influence significantly the repair performance [8]. The products within particular product groups differ in dimensions, functions and relevant spare parts, while the variance of function and operation itself is not large. A high standardization and unification level of spare parts reduces the complexity of spare-part management and simplifies the repair procedures.

There have been attempts to establish information support for the technical service of products in use [2], but there are no commercial programs (software) available in the market that would be easy to use and flexible enough for the dynamics of field repairs. Figure 4 presents the basic processes that take place in the exploitation, for the purpose of setting up the final model.



Sl. 4. *Model razvoja delovnega naloga*
Fig. 4. *Model of service-order evaluation*

Prepoznavanje dejanskih stanj izdelkov je zelo pomembno, saj prisili organizacijo, da upošteva povezave med vsemi dejavniki kakovosti na trgu in lahko tako določi mogoča problematična področja, ki bi jih sicer lahko spregledali. Ena najmočnejših prednosti formalnega trajnega postopka upravljanja podatkov iz uporabe je dejavno prizadevanje, da bi ugotovili vzroke za okvare in jih pripravili za izboljšave v krogu kakovosti.

Razvojne skupine potrebujejo pri izvajanju konstrukcijskih izboljšav, ki za svoja izhodišča uporablja podatke iz uporabe, sestavljene informacije s podrobnimi opisi. Težko in najverjetneje nemogoče je oceniti vsako mogoče napako v prihodnosti.

3 REZULTATI IN RAZPRAVA

Strnimo osnovne predpostavke, s katerimi je s preglednostjo povratnih informacij s trgov mogoče

Identifying the actual product conditions is very important, since it forces the organization to account for the connections between all the quality factors in the market, thus being able to define the potential problematic fields, which could otherwise be overlooked. One of the strongest advantages on a formal permanent exploitation data management process is a proactive effort to identify the fault causes and prepare them for the purpose of improvements in the quality loop.

Development teams that are performing the construction improvements using the exploitation data as their starting points need structured information with detailed descriptions. It is very difficult – if not impossible – to evaluate every potential fault in the future.

3 RESULTS AND DISCUSSION

Let us sum up the basic assumptions that, together with the transparency of feedback informa-

doseči, da se razvojni timi osredotočijo na tista kritična področja – izdelke, kjer obstajajo možnosti izboljšav. V ta namen je treba zagotoviti sisteme poročanja in dokumentiranja ter pripraviti zahteve in merila spremljanja podatkov iz uporabe.

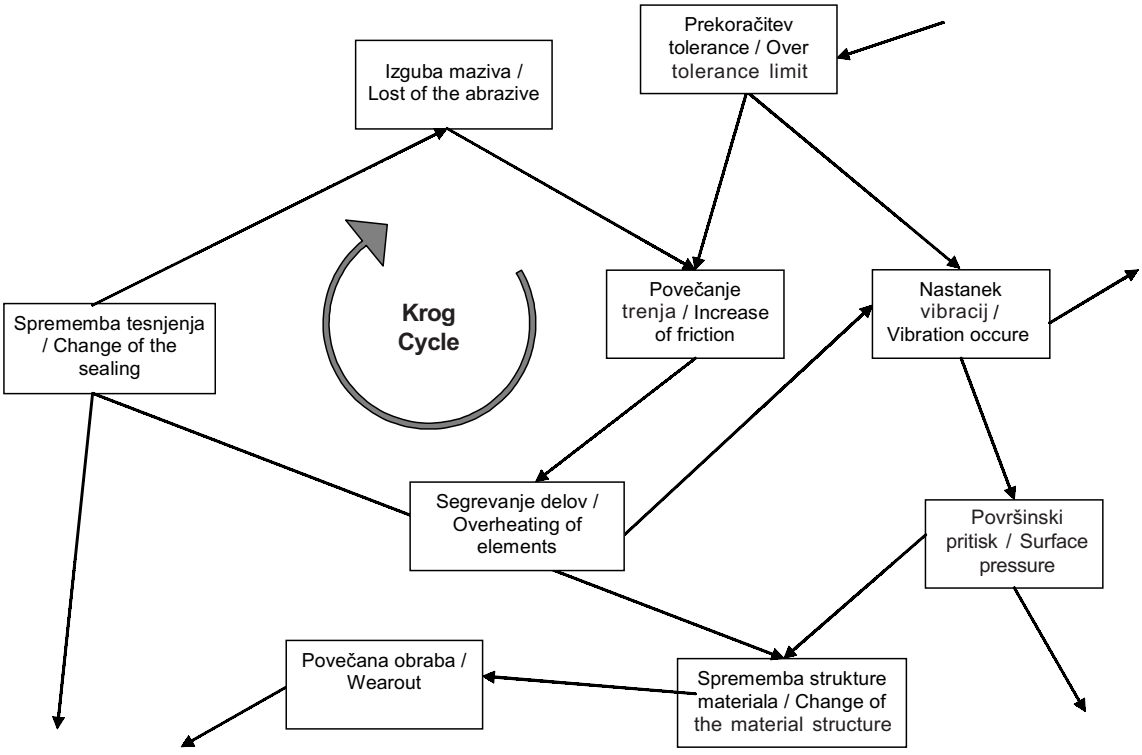
Prvi pogoj, ki je potreben za zagotavljanje sistemsko-tehnične podpore upravljanju napak, je ustrezna predstavitev napak. Dodelitev napak izdelkom, sklopom ali posameznim delom je sicer za izvajanje ukrepov nujno potrebna, vendar velikokrat nezadostna. Prav tako je tekstovni opis napake in spremljevalnih okoliščin treba razširiti za ciljno iskanje ali sklepanje na podlagi primerov. Jasno morajo biti predstavljene vzročno-posledične povezave med posameznimi napakami, da bi se lahko upodobile povezave vzroka in učinka. Na temelju teh povezav se mora ustvariti možnost, da se napake ne dodelijo samo drevesnim sestavom temveč tudi mrežnim sestavom. Tako so znotraj teh mrežnih sestavov mogoče tudi krožne povezave, ki upodabljajo vzajemno delovanje napak in njihovih posledic. Ustrezen primer je predstavljen na sliki 5.

Podpora zbiranja podatkov iz uporab od izvajalcev popravil/servisa je pomembna predvsem

tion from the markets, enable the development teams to focus on the critical fields, i.e., products, where the improvement potentials exist. To do this, it is essential to provide the reporting and documentation systems, as well as the preparation of requirements and the metrics of exploitation data monitoring.

A precondition for providing a system technical support of fault management is an appropriate fault presentation. Attributing faults to products, sets or individual parts is required for performing the measures, but this is often insufficient. A textual description of the fault and pertaining conditions should also be extended for targeted searching or drawing conclusions based on sets of examples. Causal-consequential relationships between particular faults/errors should be clearly presented to enable the visualization of the relationship between cause and effect. Based on these relations a capacity/possibility has to be established to prevent attributing the faults solely to tree-structures, but also to network structures. This would enable identifying cyclical relations within these network structures, showing the simultaneous occurrence of faults and their consequences. An appropriate example is shown in Figure 5.

Exploitation data acquisition support by the repair/service personnel is important, especially from



Sl. 5. *Krog v mreži napak*
Fig. 5. *Cycle in fault net*

z vidika neposredne povezave izvajalcev popravil z izdelki in uporabniki. Zbirajo se številne pomembne informacije – informacije, ki se zapisujejo skozi postopke izvajanja popravil in so, poleg zapisov o porabljenih virih (stroški, material itn.) ter mehanizmih okvar, potrebne za potrdilo o opravljenem delu, oziroma so na delovnih nalogih o opravljenih popravilih. Sem spadajo na primer:

- napake in vzroki zanje,
- mogoči viri napak,
- načrtovani in izpeljani ukrepi,
- zamenjani (rezervni) deli,
- informacije o uporabi in podatki o stroju.

Po natančni preučitvi informacijskih tokov v uporabi in potreb proizvodnega podjetja pri zmanjševanju stroškov zaradi slabe kakovosti na trgu smo želeli ugotoviti, kako zbirati podatke o odpovedih izdelkov za potrebe optimizacije skupinam v konstrukciji.

Zaradi velikega števila izdelkov, njihove zapletenosti in načrtne delitve trgov je težišče raziskave na zbiranju in opisu stanj izdelkov na trgu. Delovni nalog o opravljenem popravilu ponuja stvarno možnost za zbiranje pomembnih informacij. Za doseganje ciljev raziskave je treba delovni nalog razširiti z vključenjem vseh izrazitih značilnosti ali posebnosti izdelka, ne da bi jih bilo treba neposredno povezati z neko motnjo. Na ta način se lahko na primer dokumentirajo izrecno ali posredno podane informacije o zanesljivosti izdelkov na trgu.

Subjektivnosti zbiranja podatkov o okvarah, ki načelno obstajajo, če so bili kakovostni podatki zbrani od izvajalcev del, ni mogoče izključiti, vendar je mogoče s primerno definicijo stavka okvare doseči podroben popis stanja. Pomanjkljivostim, kakor so različna uporaba pojmov posameznih oseb, se je mogoče izogniti tako, da se zagotovi običajni sistem zbiranja. V tem pogledu mora biti zagotovljen mehanizem, ki omogoča logično jasno dodelitev različnih pojmov k vsakokratnemu pomenu.

Na podlagi naših ugotovitev smo zgradili model primerjalnega sistema kodifikacije okvar, ki lahko vsakemu logičnemu objektu dodelijo zadostno število pojmov. Zapis stavka okvare se uporablja tudi za omogočanje večjezičnosti informacijskih sistemov. Ta model omogoča popis in nadaljnjo analizo stanj preteklih dogodkov, ki so strukturirani v pomembnih bazah podjetja. Rezultati so podlaga za večino predlogov in dejanj pri optimizaciji konstrukcij izdelkov.

the viewpoint of a direct interaction of repair personnel and end-users. A lot of important information is gathered – information that is documented through the processes of repair performance – which is, apart from the documentation on resources used (costs, material etc.), required for a receipt of the work preformed or is listed in repair work orders. The information includes:

- errors and their causes,
- potential error sources,
- planned and actually applied measures,
- substituted (spare) parts,
- information about the use/application and machine information.

Following a detailed study of information flows in the exploitation and of the requirements of a manufacturing company for reducing the costs due to poor market quality, we wanted to find how to acquire data about product faults for the optimization purposes of construction teams.

Due to a large number of products, their complexity and market allocation, the research was focused on acquiring and describing the product conditions in the market. A repair work order offers a real possibility to acquire relevant information. To achieve the research goals, the work order has to be extended by including all the significant characteristics or specific properties of a product, without having to link them to a particular fault or error. In this way it is possible to document the explicitly or implicitly stated information regarding the reliability of products in the market.

The subjectivity of fault data acquisition (capturing) in the cases where quality data have been provided by repair personnel cannot be eliminated; it is, however, possible to attain a detailed description of the situation by an appropriate definition of the error string. The shortcomings, such as different use of terms by different persons, can be avoided by providing a standard data-acquisition system. In this respect a mechanism has to be provided that will enable a logically clear attribution of different terms to a particular meaning.

Based on our findings we have established a model of a reference fault codification system that can attribute a sufficient number of terms to every logical object. The formation of a fault/error string is also used to enable multilingual information systems. This model enables listing and the further analysis of previous event conditions, which are structured in relevant company bases. The results represent a foundation for the majority of suggestions and actions regarding the optimization of product constructions.

Prepoznavanje šibkih mest se prične z zbiranjem in obdelavo pomembnih podatkov s trga – informacije o opravljenih popravilih v servisih. V prvi fazi se zbira informacije s trga. V nadaljevanju je treba preučiti in razpoznati podatke, kar izvedemo z omejitvijo na podrobnejšo raven, ki omogoča podjetju prepozanavnje tveganj, razvojnim skupinam pa razumevanje stanj vplivnih dejavnikov in razlago mehanizmov okvar. To je zelo učinkovit način razčlenitve v mreži napak.

Šibka mesta na izdelkih v uporabi so tisti dogodki/stanja na izdelkih, ki pomenijo za podjetje škodljive učinke. Menedžment v proizvodnem podjetju na podlagi poročil o stanju kakovosti na trgu ugotavlja tveganje in z dejavnostmi upravlja zvezo kakovosti. Na podlagi sestavljenih podatkov iz uporabe potekajo dejavnosti:

- izdelava tehnične osnove zbiranja podatkov,
- določanje dejavnosti in informacije s tehničnega in stroškovnega področja,
- priprava poročil in presoj,
- predlog popravnih dejavnosti,
- nadzor,
- zapisovanje časovnega načrta in vrednotenje učinkov.

Iskanje informacij pomeni pomemben delež v delovnem času zaposlenih. Analiza pretoka informacij v proizvodnem podjetju je pokazala, da strokovne službe intenzivno uporabljajo podatke iz sistemov za upravljanje podatkov iz uporabe, pridobljenih od izvajalcev popravil. Sestavljeni podatki iz uporabe sicer ne morejo zagotoviti dokončanega izdelka in nadomestiti nadarjenega konstrukterja. Lahko pa izboljšata kakovost dela in vključevanje izkušenj iz preteklih krogov izdelkov pri razvoju oziroma izboljšavah sedanjih izdelkov. Z ustrezno podporo se lahko pomembno pospeši faza razvoja in izboljša komunikacija med prodajo in razvojem izdelkov.

Znanje in izkušnje iz uporabe smo uredili v pregledno drevesno sestavo, ki uporabnikom omogoča prehajanje med različnimi stopnjami posplošitve izdelkov, od tehničnih načel do določene izvedbe. Za dopolnitev je predstavljen razširjeni inženirski model predstavitve/zbiranja napake (sl. 6), ki združuje servisno dokumentacijo, pri kateri so mehanizmi okvar sestavljeni za potrebe proizvodnega podjetja, vključno z uporabljenimi viri in organizacijskimi podatki.

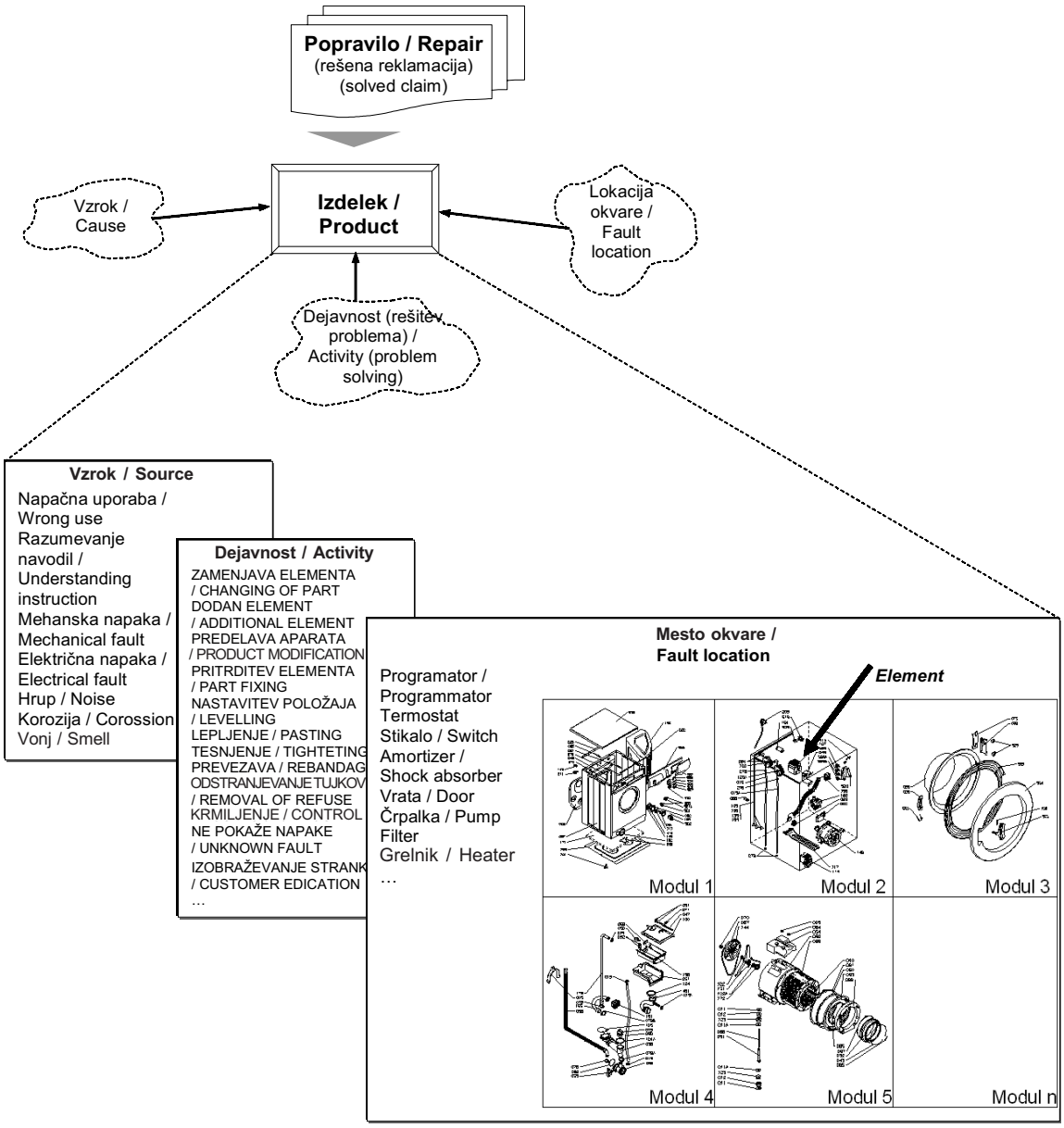
Identifying the weak points starts by collecting and processing the relevant market data – information about the repairs performed by service workshops. In the first phase the market information is acquired. After this, the data has to be studied and identified, which is performed by a reduction to a more detailed level that enables the company to recognize the risks, and enables the development teams to understand the conditions – influential factors and interpretation of the fault mechanisms. This is a very efficient way of segmentation in a fault/error network.

The weak points in the products in exploitation are those product events/conditions that imply negative or harmful effects for the company. Based on reports about the quality situation in the market, the management determines the risks and regulates the quality loop by appropriate activities. Based on structured exploitation data the activities take place:

- providing technical foundations of data acquisition,
- determining activities and information in the technical and cost field,
- preparing reports and judgments,
- suggesting corrective activities,
- control,
- documenting the schedule and evaluating the results/effects.

Searching for information represents an important fraction of the working hours of he personnel. An analysis of information flows in a manufacturing company has shown that professional departments intensively use the data from exploitation data management systems, which are acquired by repair personnel. Structured exploitation data cannot provide for an elaborate or perfect product or replace a talented designer/constructor. It can, however, improve the quality of work performed and include the experience from previous product cycles in the development or improvement process of new products. Appropriate control can significantly accelerate the development phase and improve the communication between after-sales and product development.

Knowledge and experience from the exploitation phase have been sorted into a transparent tree structure that enables the users to switch between different levels of product abstraction – from technical principles to particular applications. To complement this, an extended engineering model of fault presentation/data acquisition is presented (Figure 6), joining the service documentation where the fault mechanisms are structured to meet the requirements of a manufacturing company, including the used resources and the organization data.



Sl.6. *Model zapisa stavka okvare*
Fig. 6. *Model of fault sentence description*

Pri postavljanju osnutka smo upoštevali faze in informacijske potrebe v proizvodnem podjetju. Znano je, da sistemi ERP podpirajo predvsem materialne in finančne tokove in so omejeni predvsem na postopke v primarni vrednostni veri proizvodnega podjetja. Naš cilj je podpreti in razširiti informacijske tokove iz uporabe z vključevanjem in zbiranjem informacij o mehanizmih okvar.

Delovni nalog o opravljenih popravilih mora vključevati pomembne podatke, ne samo z vidika

When establishing the concept, the phases and informational requirements in a manufacturing company are accounted for. It is commonly known that ERP systems support mainly material and financial flows and are limited to processes in the primary value chain of a manufacturing company. Our goal is to support and extend the information flows from the exploitation phase by including and acquiring (capturing) the information about fault mechanisms.

A work order about repairs performed must comprise all the relevant data, not only from the view-

potreb izvajalcev popravil, temveč tudi za druge oddelke v proizvodnem podjetju (računovodstvo, kakovost, razvoj itn.). Npr. pri vnosu podatkov o opravljenih delih v delovni nalog potrebujejo izvajalci popravil poleg potrebnih informacij in virov tudi specifikacijo podatkov za vnose. Za vzdrževanje izdelkov splošne rabe je značilen velik obseg dela, zato so pomembna orodja, ki avtomatizirajo vsakdanja opravila. Pri obliki podpore je potrebno upoštevanje ravni dela. Trdimo lahko, da imamo opravka s ponavljajočimi se dejavnostmi, pri katerih imamo opravka s ponavljajočimi se izdelki, okvarami in potrebnimi viri. Serviser poleg svojega znanja o razpoznavanju uporablja preverjene tehnične rešitve in vire in je sposoben prepoznati vzroke in mehanizme okvar. Zato v tem primeru izvajalci popravil ne potrebujejo podpore z delovnimi načeli ali razčlenitve funkcijske strukture. Dobrodošli pa so različni pripomočki, ki omogočajo čim bolj učinkovito delo, npr. knjižnice tipiziranih tehničnih objektov in specifikacije za vnose mehanizmov okvar.

Pri obvladovanju kakovosti na trgu je ključnega pomena spremljanje stroškov popravil in mehanizmov okvar. Zaradi tega je potrebno stalno spremljanje kakovosti na trgu in odpravljanje napak na kritičnih izdelkih. Količina podatkov pri izdelkih splošne rabe je bistveno širša kakor pri posamičnem vzdrževanju tehničnih objektov investicijske narave. Temu primerna morata biti tudi ustrezen vhodni in izhodni tok informacij, npr. podatki o različnih materialih, izdelkih ter pregled in nabor napak in lokacij, ki dajejo pregledni okvir povratnim informacijam. Pomemben izziv pri oblikovanju sestave povratnih informacij iz uporabe je oblikovanje formata, ki bo omogočal hitro in učinkovito zbiranje podatkov ter hkrati zadoščal potrebam menedžmenta kakovosti. Tukaj je cilj odkriti doslej neznana načela, ki pa seveda morajo biti skladna s prakso v proizvodnem podjetju.

Pri poizvedbah vzrokov za reklamacije obstajajo številne možnosti. Da se ohrani pregled nad izvajanjem popravil ter analiza mehanizmov okvar, je uporabljen opis okvare v štirih skupinah. Običajno so trg, izdelek/proizvodni program ter kritični elementi izhodišče za nadaljnje poizvedbe. V naslednjih korakih se določi topologijo oz. kodifikacijo virov. Opisana struktura ni obvezujoča. Kriteriji opisa okvare so uporabljeni kot vir navdiha za izboljšave ali pa kot kazalo o stanju kakovosti/ zanesljivosti izdelkov. Kot zelo primerna se je pokazala drevesna sestava.

point of repair personnel, but also for other departments in a manufacturing company (accounting, quality management, development, etc.). For instance, when entering the data about work performed into the work order, the repair personnel need the data specification for the entries, in addition to the required information and sources. The maintenance of the products for general use involves a large amount of work, which makes the tools for the automatic performing of routine tasks even more important. When considering the form of support, the work levels have to be considered. It can be claimed that since we are dealing with repeated activities, we are also dealing with repeating products, faults and required resources. Apart from the diagnostics knowledge, the serviceman also employs established technical solutions and sources and is capable of identifying the fault causes and mechanisms. Thus, in this case the repair personnel do not require support by working principles or by analyzing the functional structure. However, various accessories that enable more efficient work are welcome, such as libraries of typified technical objects and specifications for entering the fault mechanisms.

When dealing with market quality management, monitoring the repair costs and fault mechanisms is of key importance. This requires the constant monitoring of market quality and eliminating the critical product errors. The quantity of data with the general use products is significantly more extensive than with the individual maintenance of technical investment-character objects. Therefore, the in - and outgoing information flows have to be adjusted accordingly, e.g., the data on different materials and products, an overview and an array of errors and locations providing a transparent framework for feedback information, etc. An important challenge when designing the exploitation feedback information structure is designing a format that will enable quick and efficient data acquisition (capturing), meeting at the same time the requirements of the quality management. Here, the goal is to discover some hitherto unknown principles, which should, however, comply with the manufacturing company practice.

Regarding the queries about the warranty claim causes, there are several possibilities. To maintain the overview of the repair performance and the fault mechanism analysis, a fault description in four groups is employed. Usually, the market, the product/product line and the critical elements are the starting point for further queries. In the following steps the topology or the codification of sources is defined. The described structure is not default (or mandatory). The fault description criteria are used as a source of inspiration for improvements or as an index table about the product quality/reliability. The tree structure has proven to be very appropriate.

Pri popravilu izdelkov se uporabljene dejavnosti in viri (material, delo, čas, stroški) vpišejo v delovni nalog. Jedro je dokument, tj. delovni nalog z vnesenimi podatki po sistemu kodifikacije okvar. Vsak material/rezervni del nosi podatke, ki podrobneje določajo mehanizme okvar. Pri tem je prepoznavanje elementov, ki so nosilo okvar, ključnega pomena za obvladovanje vzročno-posledičnih verig. Na delovnih nalogih so navedeni organizacijski parametri, ki razširijo mogoče analize in poizvedbe. Navedene so vse mogoče različice in tudi pravila, ki osnovnim odločitvam priredijo ustrezne gradnike. Tako se lahko hitro izdela analizo za določen trg oziroma izdelek.

V razširjenem inženirskem modelu delovnega naloga so definirani vnosi podatkov. Podatki o kupcu in izdelek so predstavljeni ločeno od mehanizmov okvar. Za boljše razumevanje mehanizmov okvar se navaja okvaro kot kodiran stavek "Vzrok/Dejavnost/Lokacija", kar je prikazano na sliki 6.

4 SKLEPI

Poglavitni namen prispevka je bil predstaviti model zbiranja podakov iz uporabe. Predstavljeni osnutki sledijo uporabi detajliranih podatkov iz uporabe izdelkov, ki so specifični za določen izdelek. Sestavni element obvladovanja kakovosti v proizvodnem podjetju je ustrezen popis stanj izdelka v uporabi. Za zbiranje in obdelavo se upoštevajo predvsem zahteve glede izdelka kakor tudi dejanska stanja, povezana z izdelkom, to so na primer napake, pozitivna stanja in njihove vzročno-posledične povezave v obliki verige vzroka in učinka.

Za doseganje ciljev je bila potrebna definicija podatkovnega modela zapisa okvare, ki omogoča zbiranje podatkov v zahtevani obliki in poenostavlja izmenjavo podatkov. V prispevku predstavljen model kodifikacije okvar vsebuje definicijo popravila izdelka na delovnem nalogu. Kodifikacija okvar pokriva celotni nabor stanj in vzrokov v sestavni obliki, ki podjetju omogoča preprosto zbiranje podatkov ter urejeno znanje na podlagi tipiziranih okvar, ki se pojavljajo v dobi trajanja izdelka. Na enem mestu so dostopne vse informacije o popravilih na izdelku. S tem se izognemo dolgim zapisnikom o opravljenih popravilih. Omogočeno je neposredno preoblikovanje podatkov o opravljenih popravilih v informacijske baze.

The activities performed and the resources used during the repairs (material, work, time, costs) are entered into the work order. The core document is the work order with entered data, following the system of fault. Every material/spare part contains information that can further specify the fault mechanisms. The recognition of elements that act as potential fault causes is of key importance for controlling the cause-and-effect chains. Organizational parameters are stated on the work orders, extending the analysis and query possibilities. All possible variants and rules that attribute appropriate construction elements to the basic decisions are stated. This way, analysis for a particular market or product can be performed quite quickly.

In the expanded engineering model of work order, the data entries are pre-defined. The data about the customer and the product are presented separately from the fault mechanisms. For a better understanding of fault mechanisms every fault is stated as a codified string "cause/activity/location", as shown in Figure 6.

4 CONCLUSIONS

The main purpose of this paper was to present a model of exploitation data acquisition (capturing). The concepts presented follow the application of detailed data from the product exploitation, which are specific to a particular product. The elements of quality control in a manufacturing company are stated on an appropriate list of product conditions during its exploitation phase. When capturing (or acquiring) and processing the data, the requirements regarding the product are considered, as well as the actual conditions connected with the product, such as errors/faults, positive conditions and their causal relations in the form of cause-and-effect chains.

To attain the goals set ahead, it was necessary to define the data model of the fault record, thus enabling the acquisition (capturing) of data in the required form and simplifying the data exchange. The fault codification model that is presented in the article contains the definition of product repair in the work order. Fault codification covers the entire array of conditions and causes in a structured form that enables the company to have a simple data acquisition (capturing), and organizing the accumulated knowledge on the basis of typified faults that occur during the product lifecycle. All information about the product repairs is accessible at one location. In this way, lengthy textual records of the repairs performed are avoided. Thus, a direct real time transformation of the repair data into the information databases is enabled.

5 LITERATURA
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