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Model za učinkovito upravljanje proizvodnje po naročilu

A Model for the Effective Management of Order-Based Production

Iztok Palčič - Andrej Polajnar - Krsto Pandža

V današnjem času postajajo kupci vse bolj zahtevni oziroma vedno težje je zadovoljiti njihove želje in zahteve. Proizvodnja po naročilu s svojo prilagodljivostjo za te želje in zahteve vedno bolj pridobiva veljavo. V teoretičnem delu prispevka so tako predstavljene bistvene značilnosti te proizvodnje, kakor tudi osnovne zahteve in ovire za učinkovito načrtovanje in upravljanje proizvodnje po naročilu. V nadaljevanju je prikazana raziskava, ki s svojimi izsledki pomaga pri gradnji novega modela za učinkovito načrtovanje in upravljanje naročniške proizvodnje. Raziskava je bila izvedena v dveh slovenskih podjetjih. V zadnjem poglavju je podana zgradba predlaganega modela in predpostavke, ki jih mora podjetje izpolnjevati za učinkovito načrtovanje in upravljanje proizvodnje.

(Ključne besede: sistemi proizvodni, proizvodnja po naročilih, načrtovanje proizvodnje, upravljanje proizvodnje)

Customers are becoming increasingly more selective, and their requirements are harder to fulfil. This is why an order-based production, with its customisation to meet customers' requirements, is becoming of great importance. The theoretical part of this paper presents the basic characteristics of this type of production and some of the main requirements and obstacles for effective planning and control. In addition, research is presented with results that add to the building of a new model for the successful planning and control of order-based production. The research was performed in two Slovenian companies. The last section presents the structure of a proposed model and the requirements that a company has to fulfil in order to plan and control its production effectively.

(Keywords: production systems, order based production, production planning, production control)

0 UVOD

Velik del proizvodnih podjetij dandanes izdeluje po naročilu, vsako naročilo pomeni izdelek, s katerim želi kupec zadovoljiti svoje želje in zahteve. Podjetje se odziva na povpraševanje kupca s ceno in dobavnim rokom, čeprav ju lahko včasih določa kupec. Če podjetje naročilo sprejme, lahko to povzroči mnogo težav pri načrtovanju in upravljanju proizvodnje, posledično pa tudi pri stroških in ne nazadnje lahko negativno vpliva na dobro ime podjetja, če se to ne drži obljubljenih dobavnih rokov. Največje težave se pojavijo zaradi zahtev po doseganju kratkih dobavnih rokov ter majhnih procesnih zalog in zahtev po čim boljši izrabi virov, kar lahko privede do navzkrižnih situacij. Učinkoviti menedžment mora biti zmožen vzdrževati ravnotežje med zgoraj navedenimi nasprotujočimi si cilji.

Za proizvodna podjetja, ki proizvajajo izdelke po naročilu, je značilna proizvodnja v majhnih in

0 INTRODUCTION

Today, a significant fraction of manufacturing companies produces according to customers' orders, where each order is for a special product that meets the customers' wishes and requirements. A company responds to customers' enquiries with a price and delivery date, although sometimes either may be fixed by the customer. If the company accepts an order, then this order may cause problems with production planning and control and hence to the cost and to the loss of a company's good name, if the company does not meet the promised delivery dates. The biggest problems are due to the requirements of meeting the due dates, dealing with the large amount of work-in-process (WIP) inventory and minimising the possibility of low resource utilisation, which often leads to a conflicting environment. An efficient management system should be able to maintain the balance between these conflicting objectives.

Manufacturing firms that deal with order-based products produce in batches or small lots.

srednje velikih serijah. Ta podjetja v večini primerov nimajo zaloge gotovih izdelkov (imajo pa zalogo standardnih delov, komponent, modulov). Po prejemu naročila kupca se sprožijo razvojne, proizvodne ali montažne dejavnosti, v odvisnosti od vrste naročila. Za ta tip podjetij je značilna funkcionalna razporeditev proizvodne opreme in njena velika prilagodljivost, da bi podjetje imelo možnost izdelave širokega spektra izdelkov. Pretočni čas vseh operacij je navadno dolg, procesni časi pa so zelo negotovi. Velika negotovost, ki se nanaša na delovni potek operacij in procesne čase ter na negotovost pri napovedovanju naročil kupcev, je posledica nepoznavanja kupčevih zahtev in značilnosti izdelka in hkrati eden izmed vzrokov za težave pri načrtovanju in upravljanju proizvodnje [1].

Amaro in drugi [2] ugotavljajo, da je obseg literature, ki bi obravnavala potrebe podjetij, ki izdelujejo po naročilu, presenetljivo skromen. Večina objavljenih raziskav v operacijskem menedžmentu obravnava vsa podjetja enako; kot podjetja, ki izdelujejo za zalogo, in zanemarjajo potrebe naročniške proizvodnje ([3] in [4]). Podobno ([5] in [6]) poudarjajo, da je analiza takšnih podjetij na strateški ravni znotraj področja proizvodnih strategij prav tako zelo skromna.

Hill [6] razdeli konkurenčne kriterije na tiste, s katerimi podjetje pridobiva naročila, in na uvrstitvene kriterije. Poglavitni konkurenčni kriteriji, s katerimi podjetje pridobiva naročila, so hitrost dobave ter zanesljivost, cena, kakovost in prilagodljivost, vendar so nekateri izmed njih medsebojno izključujoči. Hitrost dobave pomeni, da se morajo podjetja hitro odzivati na spreminjajoče se potrebe tržišča in kupcev, kar pomeni, da morajo imeti kratke dostopne čase na tržišče, kratke pretočne čase in da morajo krajšati čas vseh svojih poslovnih procesov. Hitrost sloni na dveh temeljih: na organizacijskem okolju, kjer prihaja do sprememb in inovacij spontano; ter na tehnologiji, ki daje zaposlenim najnovejša in preizkušena orodja za opravljanje njihovega dela. Sem spadata tudi informacijska in komunikacijska tehnologija. Material ne potuje hitreje od informacije, potrebne za proizvodnjo izdelka, zato je postala hitrost informacij, ki se pretakajo med proizvodnimi in podpornimi oddelki v podjetju, izredno pomembna za krajšanje časa. Komunikacijske ovire so mnogokrat vzrok za pomanjkanje združevanja med funkcionalnimi področji, kar pa je velika ovira za krajšanje časa. Dodamo lahko še en temelj, in sicer decentralizacijo načrtovanja in upravljanja proizvodnje. To omogoča dve nujno potrebni dejavnosti za krajšanje časa: prvo, pooblastitev zaposlenih (v proizvodnih obratih), da pravočasno odpravljajo motnje in težave v proizvodnem procesu na samem mestu in v trenutku njihovega nastanka (prilagodljivi način), ter drugo; gladko, hitro in prilagodljivo komunikacijo med primarnimi in ostalimi podpornimi oddelki [7].

These firms tend not to hold a finished-goods inventory (they have an inventory of standardised parts, components, modules). After the customer's order is received, the design, the manufacturing or the assembly activities are started, depending on the type of order. These types of production environment are characterised by a functional layout of the equipment and very flexible production facilities to cater for a wide range of products. The lead time required to complete these types of jobs is high, and the processing times are highly uncertain. The high level of uncertainty, with respect to routings and processing times and the uncertainty of the customer orders, is a consequence of the difficulty in predicting customers' requirements and product specifications, and at the same time one of the reasons for making the production planning and control a difficult problem [1].

Amaro et al [2] argue that the literature addressing the needs of companies that produce in response to customers' orders is astonishingly modest. Most of the published research in the operations-management area has tended to treat all companies in the same way, as make-to-stock (MTS) companies, and has neglected the needs of the order-based sector ([3] and [4]). Hayes and Wheelwright [5] and Hill [6] emphasize that the analysis of such companies at the strategic level has also been neglected within the manufacturing strategy field.

Hill [6] divides the competitive criteria between order-winners and order-qualifiers. The main order-winners are delivery speed and dependability, price, quality and flexibility, but some of them are mutually exclusive. Delivery speed means that the companies must react quickly to a changing market and customer needs, which means that they must have short lead times to market, short manufacturing lead times and they must shrink the time of all their business activities. The speed is based on two premises: an organizational environment where change and innovation come naturally; and technology that gives employees the most current, proven tools to perform their jobs. The latter also includes both information and communication technology. As material travels no faster than the information needed to produce the product, the speed of information that must be shared between manufacturing and supporting departments has become increasingly important for time compression. Communication barriers are often cited as the cause of a lack of integration among functional areas, which is a major threat to time compression. We can add another premise: a decentralized manufacturing planning and control framework. Such a framework enables two necessities for time compression: first, the empowerment of (shop-floor) employees to resolve disturbances and problems in the manufacturing process at the time and place they arise, in a flexible fashion; and second, a smooth, fast and flexible communication between and within primary and supporting departments [7].

Tehnični in običajni sistemi za načrtovanje in upravljanje proizvodnje so neprimerni za podjetja, ki izdelujejo po naročilu. Tehnični sistemi so razviti za računalniško-integrirano proizvodnjo, ki poudarja predvsem tehnične vidike proizvodnje [8], močno pa zanemarjajo logistične, sociološko-tehnične ter poslovne vidike, kakor je npr. obdelava naročil kupcev in načrtovanje proizvodnje. Običajni sistemi so bili razviti za proizvodne organizacije z različnimi funkcionalnimi področji in majhnim medsebojnim vplivanjem med njimi [9]. Funkcionalne organizacije ne težijo k združevanju različnih sistemov, ampak temeljijo na taylorizmu, ki zagovarja specializacijo kot način za povečanje učinkovitosti. V teh sistemih so vsa področja in oddelki upravljani z enim samim osrednjim hierarhičnim sistemom za načrtovanje in upravljanje proizvodnje, kar ima za posledico neuresničljiv in nenatančen načrt proizvodnje na nižjih proizvodnih ravneh ter veliko negotovost pri določanju potrebnih parametrov v vseh fazah, skozi katere gre naročilo, če se ta določitev izvede na najvišji ravni [7].

Uspešno načrtovanje in upravljanje proizvodnje v podjetjih s proizvodnjo po naročilu tako terja drugačen sistem oziroma model, ki upošteva vse prej navedene vidike, h katerim pa bomo raziskovalci in hkrati avtorji članka dodali še nekatere nove.

1 TEORETIČNO OZADJE

Kakor smo že dejali, tehnični in običajni sistemi niso primerni za uspešno načrtovanje in upravljanje proizvodnje po naročilu. Nekateri vzroki so že bili podani, sedaj pa bomo bolj natančno pojasnili, zakaj niso učinkoviti nekateri v svetu najbolj uveljavljeni sistemi, kakor so model načrtovanja materialnih potreb (NMP - MRP), model načrtovanja proizvodnih virov (NPV - MRP II), načelo pravočasne oskrbe (NPO - JIT) in model optimizirane proizvodne tehnologije (OPT).

NMP uporablja glavni urnik proizvodnje, s katerim ugotovi, katere materiale potrebujemo in kateri deli morajo biti izdelani za izdelavo končnega izdelka. Izhodišče za proizvodnjo novih delov so deli na zalogi, z retrogradnim terminiranjem pa določimo urnik izdelave potrebnih delov. Največja kritika tega pristopa so nespremenljivi in trdno določeni pretočni časi, neupoštevanje omejitev kapacitet, zanemarjanje trenutnega stanja v proizvodnih obratih in to, da temelji na dolgoročnih napovedih proizvodnje. Da bi ga lahko uporabili v naročniški proizvodnji, mu moramo dodati določen modul, ki skuša uskladiti kapacietete s povpraševanjem, ter modul za terminiranje naročil [12].

NPV je razširjen koncept NMP-ja, ki upošteva tudi načrtovanje kapacitet in upravljanje proizvodnih obratov. Prav tako skuša združiti proizvodno in tržno funkcijo. Zagotavlja tudi dovolj podatkov za upravljanje celotnega podjetja, vendar pa nima

Technical and traditional production-planning and control systems are inappropriate for companies with order-based production. Technical systems were designed for the computer-integrated manufacturing environment, as they emphasize the technical aspects of manufacturing [8], but on the other hand, they strongly neglect logistics, socio-technical and business-oriented aspects, such as customer-order processing and production planning. Traditional systems were designed for manufacturing organizations with various functional areas and little interaction between them [9]. Functional organizations do not aim at the integration of separate tasks and systems, but are based on Taylorism, which advocates distributed functional specialization as the way to increase overall efficiency. In these systems, all the different manufacturing stages and departments are controlled by the same hierarchical planning-and-control model that causes unfeasible and inaccurate production plan at a lower level and a lot of an uncertainty in all the stages that an order has to go through when specifying the parameters in the first stage [7].

We can see that successful production planning and control in companies with order-based production requires a different system or a model that considers all the aspects described above, but the authors of this paper will also add some new aspects.

1 THEORETICAL BACKGROUND

As we have already pointed out, technical and traditional systems are not appropriate for successful production planning and control in order-based production. Some of the reasons have already been described, but now let us explain why we consider that some of the most widely recognized systems, such as Materials Requirements Planning (MRP), Manufacturing Resource Planning (MRP II), Just-In-Time (JIT) in Optimised Production Technology (OPT), are inappropriate.

MRP uses a master production schedule to determine which materials are needed and which parts need to be produced for the planned production of end items. Parts already in stock are taken into consideration in determining which parts still need to be manufactured, backwards scheduling is then used to calculate when the production of these required parts should commence. The main criticisms of this approach are that it assumes that the lead time for each part is fixed, that it neglects capacity constraints and the current state in the job shop and it is based on long-term production forecasts. If we want this system to be useful in the order-based environment, an additional module is needed to try to match available capacities with demand and a scheduling module [12].

MRP II is an extended MRP concept that also considers capacity planning and shop-floor control. It also aims to integrate production and marketing functions and provides enough data to control the

ustreznih modulov, s katerimi bi uporabniki te podatke lahko dovolj učinkovito uporabili. Glavna pomanjkljivost v naročniški proizvodnji je nezmožnost načrtovanja kapacitet že v fazi povpraševanja kupca. Zato uporabljamo sistem vstopno-izstopnega nadzora (VIN - IOC), ki hkrati določi urnik proizvodnje in kapacitet in ne izdela najprej urnika in šele nato upošteva kapacitet. Ta sistem hkrati pomaga tudi pri upravljanju pretočnih časov in posledično dobavnih rokov ob razpoložljivih kapacitetah in sposobnostih. Pretočne čase upravljamo z nadzorom hierarhije obremenitev na agregatni ravni, ob tem pa upoštevamo skupni pritok, stanje naročil ter skupni odtok. Sistem VIN-a krmili stopnjo pritokov in odtokov s posameznih delovnih mest z namenom, da ne bi čakalne vrste postale predolge. Pod pritoki imamo v mislih načrtovana naročila, pod odtoki pa kapacitete. Da bi zagotovili nadzor, mora biti načrtovan pritok manjši ali enak načrtovanemu odtoku. Kingsman [10] definira štiri stopnje nadzora obremenitve:

- prihod naročila v podjetje,
- sprejem naročila – po prihodu naročila si kupec in podjetje vzameta čas za premislek o sprejemu ponudbe,
- lansiranje naročila,
- razpošiljanje glede na prej določene prioritete.

Glavni cilj takšnega nadzora obremenitev je uravnavanje čakalnih vrst pred posameznimi delovnimi mesti. Da bi to lahko dosegli, moramo upoštevati naročila kupcev že v fazi povpraševanja, zato je nujno, da združimo tržno in proizvodno funkcijo.

Pri NVP uporabimo VIN šele po lansiranju naročil v proizvodne obrate. To je prepozno, saj v tej fazi ne moremo spreminjati dobavnih rokov. Pri NPV prav tako pogrešamo lansirni mehanizem. Potreben je tudi ustrezen nadzor lansiranja naročil v proizvodne obrate in še prej v bazen naročil, ki pomeni niz potencialno lansiranih naročil, ki še čakajo na potreben material in ustrezen trenutek za lansiranje v proizvodne obrate. Shimoyashiro in drugi [11] ugotavljajo, da neposredno lansiranje v proizvodne obrate povzroča rast zalog prek normalne meje, pretok se ne zvečuje več, celotni pretočni čas pa se še vedno povečuje. Po tej ugotovitvi lahko sklenemo, da zadrževanje naročil v bazenu ne povzroča večanja proizvodnega pretočnega časa, saj če bi bilo v proizvodnjo lansiranih preveč naročil, bi le-ta prav tako čakala v vrsti v samih proizvodnih obratih na posameznih obdelovalnih mestih. Pri lansiranju naročil si pomagamo s prednostnimi pravili in tehnikami pregleda in lansiranja naročil (TPN - ORR). Te tehnike so vezni člen med načrtovanjem proizvodnje in upravljanjem proizvodnje, glavni cilj pa je upravljanje ravni zalog in neprestano uravnavanje ravnotežja obremenitev delovnih mest skozi čas. Za učinkovit nadzor obremenitev je treba dobro razumeti razmerje med zalogami, pretočnimi časi

entire company. However, insufficient control modules are provided to enable the user to gain the maximum benefit from the data available. The main disadvantage in order-based production is the inability of the capacity planning at the customer-enquiry stage. This is why we use the Input/Output Control (IOC) concept, which determines the master production schedule and the capacity at the same time; rather than plan the schedule and then consider the capacity. This system also helps us in the management of lead times and consequently delivery dates, according to available capacities and capabilities. Lead times are managed on an aggregate level considering a cumulative input, backlog and cumulative output. The IOC system controls the level of inputs and outputs from individual work places in order to keep the queues short. When we say input, we mean planned jobs; and when we say output, we mean capacities. In order to provide control, the planned input must be less than or equal to the planned output. Kingsman [10] defines four levels of work control:

- order entry at the enquiry stage,
- order acceptance – customer and company can take a long time to consider and accept the bid,
- job release,
- priority dispatching.

The main goal of such work control is to regulate the length of queues in front of each work place. To achieve that, we must consider the customer order in the enquiry stage, and that is why it is necessary to integrate the marketing and production functions.

In MRP II, the IOC is not exercised until the work is released onto the shop floor. This is too late, as delivery dates cannot be changed at this stage. Another missing element is a realising mechanism. We must also use the appropriate mechanism for job release onto shop floors and a pool, which is a potential released backlog of work waiting for the material to be available, and for an appropriate moment to be released onto the shop floor. Shimoyashiro et al. [11] argue that the direct release of jobs onto the shop floor causes the WIP to rise beyond a certain point, the throughput ceases to increase while the manufacturing lead time (MLT) continues to rise. This evidence supported the conclusion that applying an appropriate delay to orders by inserting them inside a pre-shop pool may not cause any increase in MLT because the time they spend in the pool would otherwise be spent queuing at work places on the shop floor. We must use the priority rules and Order Review-Release (ORR) techniques when releasing jobs. These ORR techniques are considered as a link between production planning and production control, their major objective is the control of the WIP level and the workload balance, both among work places and over time. A starting point for effective workload control is a good understanding of the relationship between WIP, MLT and the throughput

proizvodnje in pretokom, hkrati pa je treba upoštevati dejstvo, da obstaja medsebojna odvisnost med tremi dejavnostmi pri odločitvah o terminiranju; določitvijo dobavnega roka, pregledom in lansiranjem naročila ter razpošiljanjem naročil, zato je treba oceniti vpliv vseh treh omenjenih dejavnosti, ko sprejemamo odločitve o terminiranju.

Cilj metode NPO je koordinacija dejavnosti, da bi zagotovili kar najboljšo časovno uskladitev v vsaki fazi proizvodnega procesa. To vključuje prihod surovin, prenos obdelovancev iz enega stroja na drugega in dobavo gotovih izdelkov do kupca. Cilj je, kakor trdi Hutchins [13], doseči nične zaloge – brez zalog surovin, brez varnostnih zalog in brez zalog končanih izdelkov. Lee in Ebrahimpour [14] sta definirala štiri glavne elemente NPO: doseči enakomernost proizvodnje, večopravilna delovna sila, standardizacija dela in načelo kanban. Prvi element se nanaša na skrajševanje pripravljalnih časov in uporabo manjših serij; želja je postavitev čimbolj racionalnega proizvodnega obrata. Ta element je v naročniški proizvodnji neuresničljiv, saj tukaj nimamo vedno standardnih izdelkov. Drugi element je obvezen, če je pravilno izveden. Tretji element v naročniški proizvodnji znova ni mogoč (vsaj ne v zadostni meri). Načelo kanban pa lahko do določene mere izkoristimo tudi v naročniški proizvodnji, kjer lahko rabi za upravljanje proizvodnih obratov in zmanjševanje zalog.

Model OPT temelji na načelih teorije omejitev, zamisel pa je upravljanje celotne proizvodnje z uporabo ozkih grl. OPT pokaže najboljše rezultate v proizvodnji, kjer imamo stabilno obremenjenost delovnih mest in stalna ozka grla. V naročniški proizvodnji imamo lahko več ozkih grl, ki neprestano menjavajo svoj položaj, kar zmanjšuje uporabnost modela OPT. Hkrati pa tudi OPT zanemarja fazo povpraševanja, kar je velika pomanjkljivost.

Vsi obravnavani sistemi imajo določene lastnosti, ki prispevajo svoj delež pri upravljanju proizvodnje. Večinoma so namenjeni podjetjem MTS, vendar jih je mogoče do določene mere uporabiti v podjetjih z naročniško proizvodnjo. Žal noben izmed njih ne omogoča uporabniku določanje dobavnih rokov in kapacitet ob sočasnem upoštevanju prihajajočih naročil. Prav tako ne zagotavljajo hierarhičnega sistema VIN-a. Lahko pa te sisteme izkoristimo, če jim dodamo določene module, s katerimi zagotovimo naročniški proizvodnji nadzorne sisteme, ki jih ta potrebuje. Najboljši sistem za podjetja z naročniško proizvodnjo je torej še vedno VIN, ki ima ustrezne nadzorne module v fazi povpraševanja kupca in njihovo hierarhično povezavo do odločitvenega sistema v fazi lansiranja naročil. Tako zagotovimo funkcionalno integracijo med proizvodnim in tržnim oddelkom [4]. Zanimivo je tudi, da vsi ti sistemi ne govorijo o možnostih, ki jih danes ponujajo nekatere nove informacijske tehnologije, predvsem medmrežje.

rate, but at the same time we must consider the fact that there exists an interaction among the three activities of a job scheduling policy – due-date assignment, order review and release, and dispatching. As a consequence, the impact of these three activities should be evaluated while considering all the relevant scheduling decisions.

The aim of the JIT concept is to coordinate activities in order to achieve perfect timing at each stage of the production process. This includes the arrival of raw materials, the transfer of a production lot from one machine to another and the delivery of finished goods to the customer. The goal, as argued by Hutchins [13], is to achieve a zero inventory – no raw material stocks, no buffer stocks on the shop floor and no warehouses full of finished goods. Lee and Ebrahimpour [14] defined the four elements of JIT: production smoothing, multifunction workers, standardisation of jobs and kanban. The first element is achieved by cutting up set-up times and using smaller lot sizes – we want to achieve a rationalised job shop. This cannot be applied in order-based companies, where we do not always have standard products. The second element is necessary when it is implemented effectively. The third element is also not possible in the order-based production (at least not in a sufficient way). The Kanban concept can be used in the order-based environment up to a certain point – it can help us with job-shop control and for a reduction of WIP.

The OPT concept is based on the principles of the theory of constraints; the idea is to manage the whole production through bottlenecks. OPT has its best results in production environments with stable capacity loading and stable bottlenecks. In the order-based environment there are many bottlenecks that are continually changing their position, and this is what reduces the applicability of this concept. At the same time OPT neglects the enquiry stage and this is a huge deficiency.

The systems discussed in this section all have something to contribute to production control. They are more appropriate in MTS companies, although they have been also implemented in some order-based firms. However, none of them enables the user to determine delivery dates and capacity whilst considering incoming orders. Neither do they provide a hierarchical IOC system. On the other hand, these systems can be used, but additional modules are essential in order to provide the order-based sector with the control system they require. The best system for order-based companies is still the IOC system, since it provides the required control modules at the customer-enquiry stage and a hierarchical link with the decisions made at the job-release stage. This is how a functional integration between production and marketing is established [4]. It is also interesting that these systems do not deal with the possibilities that new informational technologies, especially the internet, give us.

Van Assen in drugi [7] predlagajo naslednjo zgradbo modela za načrtovanje in upravljanje proizvodnje (sl. 1). Vsebovati mora osrednji sistem za načrtovanje in upravljanje proizvodnje, ki je odgovoren za obdelavo naročil kupcev in dolgoročne odločitve v zvezi z načrtovanjem kapacitet. Decentralizirani sistemi za načrtovanje in upravljanje proizvodnje predstavljajo nadaljnje elemente za načrtovanje in upravljanje proizvodnje v proizvodni organizaciji. Vsako področje v podjetju, vključujoč inženirsko, proizvodno, montažno in distribucijsko področje, ima svoj sistem za načrtovanje in upravljanje proizvodnje, lahko pa ga imajo tudi posamezni oddelki znotraj enega področja. Vsak izmed decentraliziranih sistemov ima nalogo pomagati pri reševanju motenj v proizvodnem procesu, ko se te pojavijo na določenem mestu. Celotni sistem je zasnovan tako, da se posledice odločitev v enem področju upoštevajo tudi v preostalih področjih. Vsak izmed decentraliziranih sistemov ima enako strukturo: zgrajen je iz modulov za pregled stanja naročil, lansiranje naročil, pregled stanja kapacitet in nadzor dejavnosti. Vsi moduli in sistemi so povezani z informacijskim sistemom, ki ima dve nalogi: upravljanje z vstopnimi in izstopnimi podatki vseh modulov in skrb za povratne informacije med proizvodnimi področji.

Takšna zgradba sama po sebi ne zadostuje, zato smo želeli avtorji razširiti model z določenimi predpostavkami, za katere verjamemo, da jih mora podjetje upoštevati in sprejeti, da bi lahko uspešno upravljalo svojo proizvodnjo.

2 METODOLOGIJA

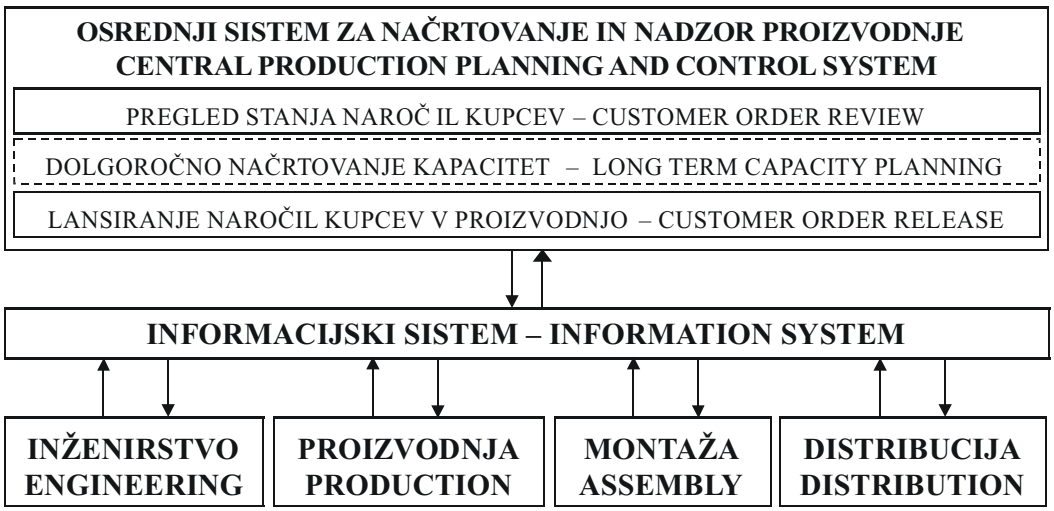
Objekt raziskave je bil postopek izvedbe naročila v podjetju. Za izvedbo raziskave je bila izbrana metodologija študije primera. Izbrana metodologija je ustrezna, ko je treba raziskovati zapleten organizacijski pojav. Načrtovanje in nadzor proizvodnje ter njuna

Van Assen et al. [7] assume the following framework for the production planning and control model (Figure 1). It must include a central-planning and control system that is responsible for customer-order processing and long-term capacity-planning decisions. Decentralized planning-and-control systems constitute further the planning-and-control architecture of the manufacturing organization. Each manufacturing stage, including engineering, production, assembly, and distribution, has its own planning-and-control system, or different departments that together constitute a manufacturing stage all have decentralized planning-and-control systems. The framework is designed so that the consequences of a decision in one manufacturing stage for the other stages are taken into account. All decentralized systems have the same structure: they all contain a planned-order review module, a planned-order release module, a capacity-review module and an activity-control module. All modules and systems are linked to the information system, which has two main tasks: to manage the input and output of all the modules and to take care of the feedback between the manufacturing stages.

But such a framework is not sufficient and that is why the authors decided to extend the model with some presumptions that the company must consider and capture in order to manage its production effectively.

2 METHODOLOGY

The object of this research was the process of order execution in the company. A case-study methodology was used to conduct the research. The chosen methodology is appropriate when we have to explore a complex organizational phenomenon. Pro-



Sl. 1. *Splošni model za načrtovanje in nadzor naročniške proizvodnje*
Fig. 1. *A generic model for order-based production planning and control*

povezanost s preostalimi funkcijami v podjetju in vpetost v širše poslovno okolje vsekakor sta takšen organizacijski pojav.

V okviru študij primerov smo avtorji kombinirali deduktivno testiranje predpostavk, induktivno oblikovanje ugotovitev in segmente akcijskega raziskovanja [15]. Dosedanja teoretična spoznanja smo združili v nabor predpostavk, ki smo jih testirali v dveh proizvodnih podjetjih, ki imata proizvodnjo organizirano pretežno po naročilu. Posamezne predpostavke smo ocenili z uporabo Likertove lestvice (ocene od 1 do 5, pri čemer je 1 najnižja ocena in 5 najvišja). Rezultati so predstavili stanje v podjetjih in rabili kot podlaga za primerjavo s teoretičnimi spoznanji. Vzorec dveh podjetij seveda ne zadošča za splošna sklepanja na podlagi statistične veljavnosti, vendar to tudi ni bil cilj raziskave. Namerno je bil izbran manjši vzorec podjetij, saj smo menili, da bi raziskava velikega vzorca z vprašalniki in z neosebnim pridobivanjem informacij bila premalo poglobljena. Model, razvit v raziskavi, ima zato značilnosti rezultata akcijske raziskave, saj poskuša zraven prispevka k teoretičnemu znanju reševati tudi dejanske probleme načrtovanja in nadzora proizvodnje.

Razgovore smo posneli na magnetofonski trak ter nato analizirali rezultate skupaj z odgovornimi v podjetju, da bi ugotovili, katere so dejanske težave pri načrtovanju in upravljanju proizvodnje. Na podlagi pripravljenega vprašalnika je bilo mogoče zbrati primerne informacije, ki so osvetlile potek odvijanja naročila v resničnosti. Da bi dobili čim bolj popolno sliko o procesu izvedbe naročila, smo želeli izvedeti čim več informacij o podjetju. Ob splošnih informacijah, kakor so dejavnost podjetja, proizvodni program, organizacija, tržišče, velikost podjetja itn., smo želeli temeljito preučiti, kakšno prilagodljivost ponuja podjetje kupcu, katere odgovornosti in dejavnosti prevzame za izvedbo naročila (od razvoja do dostave ali samo del te vrednostne verige), ali gre za enkratna ali ponavljajoča se naročila, en izdelek ali serijo izdelkov, kakšno vlogo ima podjetje pri določitvi cene in dobavnega roka, kako se pripravljajo ponudbe ter stroškovni predračuni, kakšna je računalniška, informacijska in komunikacijska opremljenost podjetij ter, ali uporabljajo projektno vodenje za izvedbo naročil. Nato smo postavili določene predpostavke, ki naj bi jih podjetje izpolnjevalo, da bi lahko govorili o uspešnem obvladovanju načrtovanja in upravljanja proizvodnje po naročilu. Na ta način smo testirali tudi predlagani model za načrtovanje in upravljanje proizvodnje. Naše ugotovitve so prikazane v poglavju "Rezultati in razprava".

Prvo preučevano podjetje je bilo Strojna Nova. Njegova dejavnost je projektiranje, razvoj in konstruiranje ter proizvodnja najrazličnejših vrst gonil (zobniška, polžasta, torna itn.). Strojna Nova je tipično

duction planning and control and their connection with other company's functions and their integration in the wider business environment are, by any measure, such an organizational phenomenon.

In the scope of case studies the authors have combined a deductive testing of presumptions, inductive interpretation of findings and the segments of action research [15]. Recent theoretical knowledge has been gathered into a set of presumptions, which were tested in two companies with mostly order-based production. All the presumptions were graded with Likert's scale (grade from 1 to 5, where 1 is the lowest grade and 5 the highest). The results showed the situation in the companies and provided a basic comparison with theoretical knowledge. The sample of two companies is of course not big enough to obtain some general conclusions with statistical validity, but that was not the primary goal of the research. A smaller sample of only two companies was chosen deliberately, as we assumed that research of a large sample with questionnaires and impersonal data acquisition would not be thorough enough. That is why the model developed in this research has the characteristics of a result from an action research, since besides its contribution to theoretical knowledge it also tries to solve concrete production planning and control issues.

The interviews were recorded and then the results were analysed together with managers in the company in order to find out the actual problems concerning production planning and control. With the help of a prepared questionnaire all the necessary information that revealed the process of order execution was obtained. To get a picture of the process of order execution as clearly as possible, we wanted to obtain a lot of company-relevant information. Along with basic information, such as company activity, production programme, organization, market, the company's size, etc., we wanted to thoroughly study the customisation offered by the company: which responsibilities and activities are carried out by the company for order execution (from design to delivery or just a part of this value chain); does the company deal with individual or repeated orders, one product or a batch of products; what is the role of the company in price and delivery date assignment; how are the bids and cost pre-calculations prepared; what is the level of the information and communication equipment at the company; and if they are using project-management techniques for order execution. After that we set some presumptions that the company should fulfil in order to successfully plan and control order-based production. In this way we also tested the proposed model for production planning and control. Our findings are presented in results and discussion section.

The first studied company was Strojna Nova. The basic activities of this company are planning, designing, engineering and production of different

podjetje s proizvodnjo po naročilu kupca. Največkrat gre za naročila standardiziranih izdelkov, kar pomeni, da ima podjetje na zalogi tipizirane module in elemente (zobniki, gredi, elektromotorji, okrovi, itn.), ki jih sestavlja v gonilo po željah kupca. Vendar to ni njihov edini način poslovanja, saj včasih prejmejo tudi naročilo, ki ga je treba izvajati od samega razvoja gonila naprej (razvoj po naročilu - RPN) ali pa obstoječi izdelek prilagoditi (prilagoditev po naročilu - PPN). V večini primerov je naročilo vezano na manjšo serijo gonil, so pa tudi primeri naročila za eno samo gonilo – posamična proizvodnja.

Podjetje Primat je edini slovenski izdelovalec varnostne opreme. Proizvodni program podjetja obsega proizvodnjo varnostne opreme (bankomati, blagajne), kovinskega pohištva ter skladiščne in manipulativne opreme. Podjetje Primat je prav tako podjetje s proizvodnjo po naročilu. Pri njem pa je bilo najbolj zanimivo dejstvo, da zajema vse tipe naročil – RPN, PPN, izdelava po naročilu (IPN) in montaža po naročilu (MPN), kakor tudi proizvodnjo za zalogo. To pomeni, da se morajo v podjetju spopasti z obema poglavitnima tipoma proizvodnje – posamično in maloserijsko po naročilu ter serijsko za zalogo.

3 REZULTATI IN RAZPRAVA

Strnimo osnovne predpostavke, ki bi jih naj podjetje izpolnjevalo za uspešno načrtovanje in upravljanje proizvodnje po naročilu:

- Temelj za obvladovanje naročil je že opisan sistem VIN, ki poudarja neprestano sodelovanje med tržnim in proizvodnim oddelkom v podjetju. To pomeni, da moramo venomer ugotavljati (simulirati) vpliv novega naročila na sedanje stanje v proizvodnih obratih. Pri tem ne gre le za pridobljena naročila, ampak tudi za tista, za katera smo dali ponudbo in še sploh ni rečeno, da jih bomo pridobili. Kaj podjetju pomaga, če določeno naročilo pridobi, nato pa se izkaže da ga ni zmožno izvesti v ustreznem času ali pa ga izvede na račun slabše izvedbe naročil, ki so že v proizvodnih obratih?
- Podjetje mora venomer imeti na voljo vse potrebne informacije o razmerah v vseh bistvenih področjih v podjetju. Na podlagi teh svežih informacij lahko uspešno simulira vpliv novega (morda celo prednostnega) naročila na trenutno stanje v proizvodnih obratih ter tako določi nov proizvodni urnik.
- Podjetje potrebuje informacijski sistem, ki je povezan z vsemi področji v podjetju. Področja konstrukcije, tehnologije, izdelave, montaže, distribucije morajo imeti svoje module za neprestano komunikacijo z informacijskim sistemom in med sabo. Informacijski sistem seveda stalno komunicira tudi s preostalimi področji v podjetju –

gear units (helical, worm, friction, etc.). Strojna Nova is a typical company with order-based production. In most cases the company fulfils orders with standardised products, which means that the company has an inventory of modules and parts (gears, shafts, electromotors, houses) that are assembled according to the customer's needs. But this is not their only production type: sometimes they receive an order for a product that has to be designed from scratch (design-to-order – DTO) or slightly adapted (engineer-to-order – ETO). They usually deal with orders for a small batch of products, but sometimes they also deal with orders for just one product – individual production.

Primat is the only Slovenian producer of safety equipment. Their manufacturing programme includes the production of safety equipment (cash-machines, strongboxes), metal furniture and warehouse and manipulative equipment. Primat is also a company with order-based production. The most interesting thing about Primat is the fact that it has all the order types – DTO, ETO, MTO (make-to-order), ATO (assemble-to-order) and also MTS production. That means that the company must cope with both production types – order-based individual and small-batch production and MTS production.

3 RESULTS AND DISCUSSION

Let us sum up the presumptions that a company should fulfil for successful order-based production planning and control:

- The basis for managing orders is the previously described IOC system, which emphasizes constant cooperation between the marketing and production departments in the company. This means that we continually have to determine (simulate) the impact of a new order on the situation on the shop floor. We do not mean just already accepted orders, but also about orders at the enquiry stage, and that we are not certain of winning. What good would it do if the company wins an order and then cannot execute it by stated delivery date, or executes at the expense of poor execution of other orders already on the shop floor?
- The company must have up-to-date information about the situation in all relevant areas of the company. Based on this up-to-date information the company can successfully simulate the impact of a new order (maybe even a priority order) on the situation on the shop floor and make a new production schedule.
- The company needs an information system linked with all areas in the company. The design area, the technology area, the manufacturing area, the assembly area and the distribution area must have modules for continuous communication with the information system and between themselves. The

tržni oddelek (prodaja, nabava), projektna služba, računovodstvo itn.
- Načrtovanje in upravljanje proizvodnje mora biti organizirano decentralizirano, kar pomeni, da so vsa področja medsebojno povezana – medsebojna združenost področij, vendar imajo tudi svojo avtonomijo, da lahko samostojno pomagajo pri reševanju motenj v proizvodnem procesu, ko se te pojavijo na določenem mestu. Ko je treba, sami sprejemajo ukrepe, ne da bi pri tem potrebovali odobritev z vrha hierarhije podjetja, saj takšno početje zelo podaljšuje pretočne čase.
- V osrednjem sistemu za načrtovanje in upravljanje proizvodnje (OSNUP) se naj zbirajo vse informacije, ki so potrebne za določitev stanja naročil v podjetju in za odločitev o sprejemu novih naročil. Prav tako mora biti venomer povezan z informacijskim sistemom podjetja.
- V okviru informacijskega sistema potrebujemo še odločitveni sistem, ki je dejansko računalniški sistem, namenjen za podporo vodstvu podjetja pri sprejemanju poslovnih odločitev, s katerim izdelujemo urnik izvajanja naročil ter določamo način njihovega lansiranja v proizvodne obrate ali še prej v bazen. Omogočati mora najrazličnejše računalniške simulacije terminiranja, načrtovanja kapacitet, urnikov proizvodnje, s katerimi določimo vpliv naročila kupca z določenim dobavnim rokom na sedanje stanje naročil v proizvodnih obratih.
- Podjetje mora vzdrževati računalniško bazo podatkov, v kateri je shranjena celotna dokumentacija za vsa pretekla in sedanja naročila, načrti in kosovnice izdelkov v obliki računalniško podprtega načrtovanja. Baza podatkov mora vsebovati tudi čim več tehnoloških podatkov, potrebnih za določitev delovnih potekov. Vsebuje naj tudi cene standardiziranih komponent in izdelkov za pripravo stroškovnih predračunov.
- Iz vseh do sedaj naštetih točk lahko ugotovimo, da je informatizacija podjetja ena izmed ključnih zahtev za uspešno načrtovanje in upravljanje proizvodnje, kar se še posebej kaže v podjetjih s proizvodnjo po naročilu. Zato potrebuje podjetje ustrezno računalniško opremo, tako glede strojne opreme (osebni računalniki, strežniki, komunikacijska oprema, periferna oprema) kakor tudi programske opreme (ustrezni računalniški programi za razvoj in konstruiranje izdelkov, programi za razne simulacije – kapacitet, urniki, baze podatkov, programi za upravljanje materiala, zalog itn.). Dejansko potrebuje podjetje integrirano programsko opremo za načrtovanje in upravljanje proizvodnje (NUP - ERP), ki povezuje vsa področja v podjetju, za kar mora biti vzpostavljena vsaj notranja računalniška mrežna komunikacija v podjetju – Intranet. Danes obstaja že veliko razvijalcev opreme za NUP, tudi takšne, ki je namenjena podjetjem s proizvodnjo po naročilu. Podjetje mora samo ugotoviti, kakšno

information system constantly communicates with other areas – marketing (sales, purchase), project office, accounting, etc.
- Production planning and control must be organised in a decentralized way, which means that all of the areas are interlinked – integration of all areas – but these areas must have the autonomy to independently help with solving disturbances in the production process when they occur at a specific place. When needed they take the measures without waiting for consent from the top management since that would lengthen the lead times.
- A central production planning and control system gathers all the information that is required to determine the backlog in the company and to make decisions about accepting new orders. This system must also be linked with the information system.
- The company needs a decision-support system (DSS) within the information system framework and this DDS is in fact a computer-based system that helps the top management in the company to make business decisions and it helps them to make the schedule of order execution and to make decisions, about releasing the orders onto the shop floor or the pool. It must enable various computer-based scheduling simulations, capacity planning simulations, production schedule simulations, etc., that enable us to determine the impact of a new order with a certain delivery date on a situation on the shop floor.
- The company must maintain a database that contains complete documentation for all the past and present orders, designs, bill of materials (computer-aided design – CAD). The database must also contain the technological data that are needed for routings. It must also include the prices of standardised parts and products to prepare a cost precalculation.
- From all the above-listed items we can establish that the informatization of the company is one of the key requirements for successful production planning and control, which is particularly the case in companies with order-based production. This is why the company needs appropriate computer equipment in terms of hardware (PC, servers, communication equipment, peripherals) and software (computer software to design and engineer products, simulation software (capacities, schedules), databases, software for inventory control, etc.). The company actually needs an integrated enterprise resource planning (ERP) system that links together all the areas in the company, and this is why at least an internal computer network communication (Intranet) must be established. There are many ERP system developers, also for such ERP systems that are appropriate for companies with order-based production. The company has to find out what kind of ERP

opremo potrebuje. Starbek in Grum [16] nazorno opišeta postopek izbire te opreme. Ob tem ne pozabimo na še eno nujnost v današnjem času – uporabo medmrežja, ki je orodje za iskanje informacij (stanje na tržišču, nove tehnologije, novi izdelki itn.) ter za neposredno komunikacijo s kooperanti, dobavitelji in predvsem kupci.

- Najboljšo možnost za obvladovanje vseh dejavnosti, ki so potrebne za izvedbo naročila, ponuja projekt. Zaradi tega bi morala podjetja vsako naročilo obravnavati kot projekt – projektno upravljanje proizvodnje. Za vsako naročilo bi se tako pripravila projektna dokumentacija. Da pa ne bi za vsako novo naročilo izdelovali dokumentacije popolnoma na novo, se naj v podjetju izdelajo in uporabljajo referenčni modeli za podobna naročila.
- Da bi podjetje lahko uravnavalo spremembe pri povpraševanju kupcev, izpolnjevalo načrtovani urnik proizvodnje, skrajševalo pretočne čase, čim bolj optimiralo proizvodnjo in bilo hkrati čim bolj prilagodljivo za spreminjajoče se zahteve kupca, mora vzdrževati na strateških mestih v podjetju primerno veliko varnostno zalogo oziroma blažilnike motenj. Ta blažilnik se lahko kaže v obliki dodatnih kapacitet (delovna sila, procesi), zalog materiala ali pa kot kombinacija obeh.

system it needs. Starbek and Grum [16] clearly describe the process of ERP system selection. We must not forget about one more necessity today – the use of the internet, which is a tool for data searching (market situation, new technologies, new products, etc.) and for direct communication with co-operators, suppliers, in particular, customers.

- The best way to manage all the activities needed for order execution is offered by a project. For this reason all companies should treat each order as a project – project production control and project documentation should be prepared for each order. The company should create and use reference models for similar types of orders so that new documentation is not made when a new order arrives.
- The company must maintain an appropriate size of safety stock or buffer barrier at a strategic location in order to protect itself from variation in demand, fulfil its production schedule, shorten lead times, optimise its production and be flexible enough to respond quickly to changing customer demands. This buffer barrier or safety stock can be the capacity (including workers and processes), the inventory or a combination of both.

Preglednica 1. *Ocena predpostavk*
Table 1. *Evaluation of presumptions*

Predpostavka **Presumption**	**Strojna Nova**	**Primat**
sodelovanje med tržno in proizvodno funkcijo cooperation between marketing and production function	2	2
svežost informacij up-to-date information	4	4
informacijski sistem information system	4	1
decentralizacija in integracija področij v podjetju decentralization and integration of all the areas in the company	3	3
osrednji sistem za načrtovanje in upravljanje proizvodnje central production planning and control system	4	4
odločitveni sistem decision support system	1	1
baza podatkov database	5	4
informatizacija – računalniška opremljenost informatization – computer equipment	4	2
integrirana programska oprema za načrtovanje in upravljanje proizvodnje enterprise resource planning	3	1
projektni menedžment project management	1	4
uporaba blažilnikov motenj na ustreznih mestih v proizvodnem procesu use of buffer barriers at the appropriate stages in the production cycle	2	3
vsota ocen sum of marks	33	29
povprečna ocena avarage mark	**3**	**2,63**

Po natančni preučitvi procesa izvedbe naročila v podjetju, smo želeli ugotoviti, kako podjetje izpolnjuje zgoraj navedene in opisane predpostavke. Ocene prikazujejo stanje podjetja na posameznih področjih, kakor smo ga videli raziskovalci in izprašani, oziroma kako podjetje izpolnjuje posamezne predpostavke. Preglednica 1 prikazuje naše ugotovitve.

Pri obeh podjetjih lahko opazimo precejšnje odstopanje od idealne ocene, oziroma da gre za velik odmik od predlaganega teoretičnega modela in njegovih predpostavk. Strojna Nova je dobila višjo oceno zaradi mnogo boljše informatizacije svojega poslovanja, v primerjavi s podjetjem Primat pa Strojni Novi skupno oceno zbija odklonilen odnos za projektno obvladovanje proizvodnje. Obema podjetjema so skupne največje pomanjkljivosti: slabo sodelovanje med proizvodno in tržno funkcijo v zgodnji fazi obravnave naročila, odsotnost odločitvenega sistema in blažilnikov motenj v proizvodnem procesu. Treba je poudariti, da se podjetji zavedata svojih pomanjkljivosti in potrjujeta ustreznost modela ter njegovih zahtev.

Tržni oddelek in oddelek za načrtovanje in upravljanje proizvodnje ne sodelujeta v zadostni meri, kar pomeni, da podjetji zanemarjata vpliv možnih naročil na trenutno stanje v proizvodnih obratih in ne uporabljata sistema VIN. Vzrokov za to je več; podjetje sprejme vsa naročila in jih izvede za vsako ceno, podjetje samo določa dobavne roke, enakomerna obremenjenost kapacitet zaradi premalo naročil in majhnega števila prednostnih naročil. V tem pogledu podjetji nista bili primerni za proučevanje tega vidika uspešnega načrtovanja in upravljanja proizvodnje po naročilu. Neupoštevanje splošno priznanega sistema VIN pa je velika pomanjkljivost za obe podjetji. Svežost informacij je v obeh podjetjih zadovoljiva. Informacije se sicer ne nadzorujejo v računalniški obliki z informacijskim sistemom, ampak ročno. Medsebojna informacijska povezava različnih področij v podjetju, ki omogoča še boljši pregled dogajanja v podjetju in zagotavlja še bolj sveže informacije, je pri enem podjetju urejena dobro (Strojna Nova), pri drugem pa za zdaj še ne (je v pripravi). Obe podjetji priznavata, da je to zelo pomemben dejavnik za uspešno načrtovanje in upravljanje proizvodnje. Razpršitev področij v podjetju se kaže v tem, da lahko vodje posameznih obratov sami vodijo procese v svojih oddelkih in po potrebi ukrepajo v primeru motenj in težav, ne da bi morali čakati na odobritev vodstva podjetja. Podjetji imata osrednji sistem za načrtovanje in upravljanje proizvodnje vgrajen v inženirski oddelek (konstrukcijo) oziroma tehnologijo. Njegove naloge se sicer nekoliko razlikujejo od nalog predlaganega osrednjega sistema v našem modelu, oziroma jih je manj. Podjetji ne uporabljata odločitvenega sistema, saj ocenjujeta, da ga ne potrebujeta. Prvi vzrok je uporaba preprostih prednostnih pravil, drugi vzrok pa je dejstvo, da so preobremenitve kapacitet redkost. Podjetji prav tako ne uporabljata računalniških simulacij za

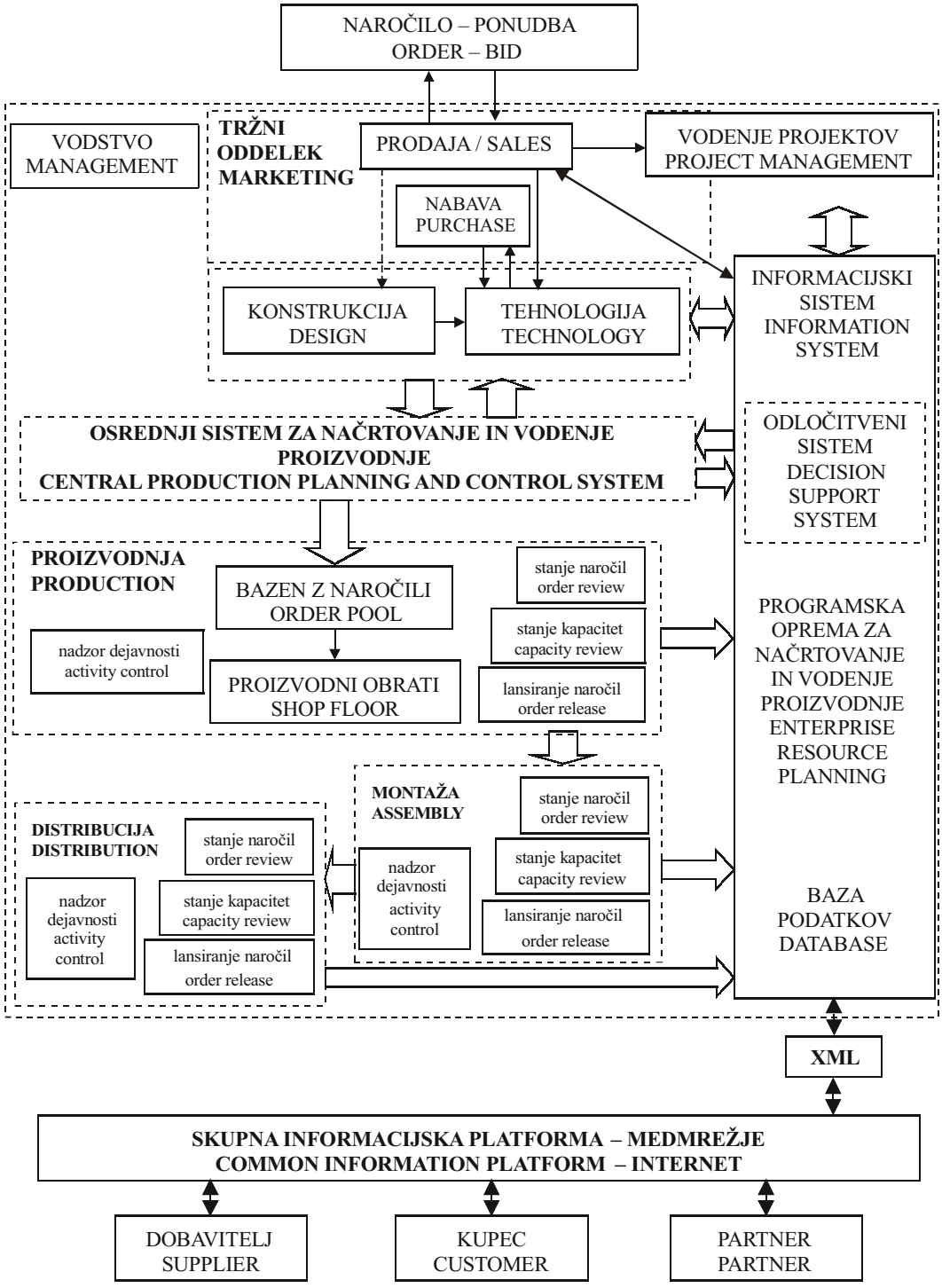
After studying the order-execution process in the company, we wanted to find out how the companies fulfil the above-stated and described presumptions. The grades are a reflection of the situation in particular company's areas, as the researchers and interviewed managers have seen it, or how the company fulfils individual presumptions. Table 1 represents our findings.

We can see that both companies deviate quite a lot from the ideal grade. We can say that there is a big deviation from the proposed theoretical model and its requirements. Strojna Nova got a higher grade since they have a better informatization on their business, but in comparison with Primat its total grade is not higher because of their negative attitude towards project production control. Both companies have some of the same weaknesses, such as bad cooperation between the production and marketing functions, the absence of DSS and the buffer barriers in the production process. We must emphasize that both companies are aware of their weaknesses and that they support the proposed model and its requirements.

The marketing and production planning and control sector do not cooperate well enough, which means that the companies neglect the impact of potential orders on the current situation on the shop floors and they do not use the IOC system. There are many reasons for this: the company accepts each and every order at any cost, the company can determine delivery dates, the company has equally loaded capacities because of too few orders and not many high-priority orders. The companies were not competent when investigating this aspect of successful order-based production planning and control. But neglecting the commonly acknowledged IOC system is a huge deficiency for both companies. Both companies do have satisfactory up-to-date information, which is, however, not controlled by computer, but manually. The informational linkage of a company's areas, which enables a better view of the situation in the company, and provides up-to-date information is settled well in Strojna Nova, while in Primat it is still in its starting phase. Both companies admit that this is a significant factor for successful production planning and control. The decentralization of the company's areas means that each foreman can control the processes in his area and, if necessary, react in the case of disturbances and problems without waiting for an approval of the company's top management. Both companies have a central production planning and control system integrated in the design or technology area. Its tasks differ slightly from the proposed central system in our model, and there are less of them. The companies do not use DSS as they think they do not need it. The first reason is the use of simple priority rules and the second reason are rarely over-

določevanje rokov naročil in izdelavo urnikov proizvodnje ob prihodu vsakega novega naročila. Obe podjetji sta ugotovili, da je vzdrževanje baze podatkov dandanes nujnost. Prav tako je poglavitnega pomena, da je ta baza v računalniški obliki. Kar se tiče računalniške opremljenosti se pri obeh podjetjih kaže napredek iz leta v leto. Nabavljata sodobno računalniško opremo tudi programsko opremo, potrebno za čim bolj učinkovito oblikovanje svojih izdelkov (AutoCAD, Mechanical

loaded capacities. The companies also do not use computer simulations for orders scheduling, and production schedules are created each time a new order arrives. Both companies also acknowledge that keeping a database is essential. The computer equipment in both companies is improving each year. They are acquiring state-of-the-art computer hardware and software, which is needed for the efficient design of their products (AutoCAD, Mechanical Desktop,



Sl. 2. *Predlagani model za načrtovanje in upravljanje proizvodnje po naročilu*
Fig. 2. *A proposed model for order-based production planning and control*

Desktop, ProEngineer). Obe podjetji šepata pri uporabi NUP-a. Neposredne računalniške povezave s svojimi dobavitelji, kooperanti in podružnicami podjetji še nimata. Svoje usluge že ponujata prek svetovnega spleta in tako že komunicirata s svojimi kupci. Projektni način obvladovanja proizvodnje oziroma naročil uporabljajo le v podjetju Primat. Podjetji načeloma ne uporabljata varnostnih zalog oziroma blažilnikov motenj v obliki dodatnih kapacitet, zalog materiala ali nedokončane proizvodnje (predvidevanje uravnoteženega poslovanja, manjša nihanja pri povpraševanju).

Na podlagi naših ugotovitev smo zgradili model za načrtovanje in upravljanje proizvodnje po naročilu, ki je prikazan na sliki 2.

Ta model vsebuje elemente, ki navedene predpostavke podpirajo in ustvarjajo primerno organiziranost podjetja za uspešno izvedbo naročila. V splošnem poteka izvedba naročila takole. Po prejemu naročila steče ponudbeni postopek. V okviru tržnega oddelka deluje projektna služba, ki prevzame nadzor nad izvedbo naročila, in najprej določi vodstvo projekta (vsako naročilo namreč štejemo kot projekt) ter izvajalce. Podjetje ugotovi, za kakšen tip naročila gre, ter kupca seznani s ceno in dobavnim rokom. Dejavnosti, ki jih mora podjetje izvesti za izvedbo naročila, so odvisne od tipa naročila (razvoj, prilagoditev, standardni izdelek, samo montaža). V vsakem primeru mora podjetje izdelati stroškovni predračun, za kar potrebuje ustrezno dokumentacijo (načrti, kosovnica-konstrukcija, delovni in montažni načrt-tehnologija). Dobavni rok določi podjetje z uporabo podatkov iz tehnologije ter OSNUP, ki preveri trenutno stanje v podjetju (proizvodnja, montaža in porazdelitev) in simulira vpliv novega naročila na to stanje. Če se kupec strinja s ponujeno ceno in dobavnim rokom, pride do podpisa pogodbe. Sledi končni razvoj izdelka, če je to potrebno, določitev tehnologije, izdelava končnega urnika ter sama izvedba v proizvodnih in montažnih obratih. Projektna služba nadzira potek izvedbe naročila, ga analizira in v primeru odstopanj od načrta ukrepa. Po dostavi izdelka kupcu (distribucija) sledi še faza garancije oziroma jamstva, ki obsega s kupcem pogodbeno dogovorjen čas, ko mu izvajamo morebitna popravila na predanem objektu.

Kakor je že bilo omenjeno, ima lahko podjetje določen del proizvodnje po naročilu, določen del pa za zalogo. Pri tem je treba upoštevati tudi dejstvo, da imamo različne oblike proizvodnje po naročilu; RPN, PPN, IPN in MPN. Pojavi se tudi primer, ko je nek izdelek razvit po naročilu, nato pa preide proizvodni proces v situacijo, ki je mešanica med izdelavo po naročilu in izdelavo za zalogo. Podjetje mora znati obvladovati tudi take razmere in predlagani model s svojo prilagodljivostjo in zgradbo takšne situacije upošteva.

V današnjem času prihaja do sprememb v organiziranosti podjetij, ki jih prinašajo nove možnosti

ProEngineer). Both companies do not use ERP in a sufficient way. They do not have a direct computer linkage with their suppliers, co-operators and branch offices. Both of them use the internet, and they offer their services to customers over the world wide web and communicate with them in this way. The project way of dealing with orders is present only in Primat. The companies mostly do not use buffer barriers in the form of extra capacities, inventory or WIP (they predict a well-balanced business processes and minor demand oscillations).

Based on these presumptions we built a model for order-based production planning and control, which is represented in Figure 2.

This model contains the elements that support the stated presumptions and form a suitable organization of the company for successful order execution. The order execution has the following course. After the arrival of the order the bidding process takes place. The project office is embedded in the marketing sector and this project office takes control of the order execution and determines the project leadership (each order is treated as a project) and executors. The company must establish which type of order it deals with and then quote the price and delivery date. The activities that a company must perform to execute an order depend on the type of order (design, engineering, standardised product, just assembly). In each case the company must prepare a cost pre-calculation, and for that it needs the appropriate documentation (designs, bill of materials from the design stage, work and assembly plan from the technology stage). The delivery date can be assigned with the help of technology data and the central planning and control system that estimates the current situation in the company (production, assembly and distribution stage) and simulates the impact of a new order on this situation. If the customer agrees with the quoted price and delivery date, the contract is signed. The next phase is the final design (if necessary), technology definition, creation of final schedule and execution in the production and assembly stage. The project office controls this order execution, analyses it, and acts in the case of deviations from the plan. After the product's delivery to the customer (distribution) a guarantee stage follows, which includes a contractual time for eventual repairs on the delivered product.

As already mentioned, a company can have a partly order-based production and partly MTS production. We must also consider the fact that there are different types of order-based production – DTO, ETO, MTO and ATO. Another situation can occur when a product is designed-to-order, but then the production process becomes a mixture of order-based production and MTS production. The company must also be able to manage these circumstances. The proposed model with its adaptability and structure considers such circumstances.

There are many changes in the company's organization today that are the consequence of new

globalizacije, hiter tehnološki razvoj, predvsem na področju informacijskih tehnologij in telekomunikacij, ter do drugih sprememb, s katerimi se v zadnjem času vedno bolj sooča svetovno gospodarstvo – govorimo o t.i. novi ekonomiji. Čas medmrežja in drugih spremljajočih izdelkov informacijskih tehnologij prinaša možnosti drugačnega načina organiziranja poslovanja, ki ni več zaprto v okvire sedanjih podjetij in drugih organizacij, temveč se povezuje s preostalimi podjetji in organizacijami v različne oblike poslovnih mrež, ki postajajo v sodobnem svetu osnovna oblika poslovanja. Z rastjo svetovne konkurence in vse bolj dinamičnega ter hitrega tehnološkega razvoja je skoraj nemogoče biti uspešen, ne da bi se poslovno in razvojno tesneje povezoval s svojimi poslovnimi partnerji. Podjetja s proizvodnjo po naročilu so večinoma mala in srednje velika podjetja, ki se bodo še posebej morala znati prilagoditi novim razmeram, da bodo sploh lahko preživela. Sodobna podjetja se povezujejo s svojimi dobavitelji, kupci in drugimi poslovnimi partnerji ter skušajo oblikovati optimalne poslovne verige dodajanja nove vrednosti. Govorimo o združitvi poslovnih procesov med podjetji z izmenjavo poslovnih informacij v skupnem standardiziranem računalniškem jeziku (npr. XML – eXtensible Markup Language). Predlagan model ima tako strukturo in informacijski sistem, ki to integracijo omogočata. Njegov OSNUP ne pozna le stanja v lastnem podjetju, ampak pozna stanje tudi v drugih podjetjih v mreži (informacije, kapacitete). Če si več podjetij deli kapacitete in imajo ustrezne informacije o njihovem stanju, lahko pride do sodelovanja med podjetji, če ima eno prezasedene lastne kapacitete za izvedbo naročila.

4 SKLEPI

Poglavitni namen prispevka je bil predstaviti nov model za načrtovanje in upravljanje proizvodnje po naročilu. V konceptualnem delu članka so podani poglavitni razlogi za ta nov model, saj sedanji sistemi za načrtovanje in upravljanje proizvodnje niso primerni v tem okolju. Že znane modele, ki so namenjeni za naročniško proizvodnjo, smo dopolnili s še nekaterimi dodatnimi predpostavkami, ki jih mora podjetje upoštevati in uvesti, in so posledica nenehnega prilagajanja tržnim razmeram in neprestanega tehnološkega razvoja. Učinkovita proizvodnja je pomembna za kratkoročno uspešnost podjetja, medtem ko je lastni razvoj izdelkov in tehnologij, povezovanje podjetja z drugimi organizacijami iz takšnih ali drugačnih strateških razlogov ter obvladovanje dejavnikov, ki jih prinaša nova ekonomija, ključnega pomena za dolgotrajni obstoj podjetja in hkrati pogoj za konkurenčno borbo na svetovnem tržišču.

opportunities offered by globalization, rapid technology development, especially in information technologies and telecommunications, and there are some other changes that the world's economy has to face – we are talking about the new economy. The era of the internet and other information technologies bring us the possibilities of different business organizations that are no longer closed into the frameworks of existing companies and other organizations, but they are linked with other companies and organizations in different forms of business networks, which are becoming a fundamental form of business in the modern world. With the growth of global competition and more and more dynamic and quick technological development it is almost impossible to be successful without close cooperation with business partners. The companies with order-based production are mostly small and medium-sized companies; they will have to adapt to the new circumstances, just in order to survive. The modern companies get linked with their suppliers, customers and other business partners and try to form optimum business-value-adding chains. We are speaking about the business process integration between companies with the help of business information exchange in a joined standardised computer language (e.g. eXtensible Markup Language – XML). The proposed model includes such a structure and information system that enables this integration. Its central planning and control system does not only know the situation in its own company, but it is also familiar with the situation in other companies within the network (information, capacities, etc.). If several companies share their capacities and have appropriate information about their current state, a particular company can cooperate with the others if its capacities are overloaded.

4 CONCLUSIONS

The main purpose of this article was to present a new model for order-based production planning and control. In the theoretical part of the article the main reasons for this new model are given, since the existing production planning and control systems in this environment are inappropriate. On the other hand, we have added to the existing models that are applicable to order-based production with some additional presumptions that a company must consider and overcome, and which are the consequence of the continuous adjustment to market requirements and endless technological development. An effective production is essential for the short-term success of a company, while the company's own product and technology development, the linkage with other organizations for the sake of various strategic reasons and the ability to master new-economy factors are of key importance for the long-term existence of the company, and a prerequisite for a competitive struggle on the world market.

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Naslov avtorjev: mag. Iztok Palčič
prof.dr. Andrej Polajnar
dr. Krsto Pandža
Fakulteta za strojništvo
Univerza v Mariboru
Smetanova 17
2000 Maribor
iztok.palcic@uni-mb.si
andrej.polajnar@uni-mb.si
krsto.pandza@uni-mb.si

Authors' Address: Mag. Iztok Palčič
Prof.Dr. Andrej Polajnar
Dr. Krsto Pandža
Faculty of Mechnical Eng.
University of Maribor
Smetanova 17
2000 Maribor, Slovenia
iztok.palcic@uni-mb.si
andrej.polajnar@uni-mb.si
krsto.pandza@uni-mb.si

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