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Entity Ordering Optimization Process Using Virtual Environment

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A combined empirical-mathematical method, which uses classification of materials based on their supply and consumption characteristics is required to calculate the quantities of each material and material replenishment schedules. The volume that is required to store certain material is always greater than the actual real volume that material occupies in space. Materials with simple configuration, if sorted properly, require fewer warehouses, transport or stock volume, than the ones that have complex configuration. An optimization model for a replenishment schedule takes into consideration the material volume factor. If an entity ordering in the given storage volume is taken into consideration, the financial resources related to the manufacturing of a product can be reduced. The problem of entity ordering in the drafting phase of inventory management can be solved by using 3D CAD software which provides and supports a generation of optimal entity ordering, using simulated and real objects, handling, storage and carriage equipment, as well as other influential features. In this way, engineers can generate all possible variants of entity ordering. Every variant must be estimated in relation to the financial context and manufacturing context. If more than one variant satisfies the limitations, the one that has the biggest cost saving influence becomes the new operative replenishment schedule. To check the usefulness of the new approach for the replenishment of schedule optimization process that integrates an entity ordering optimization procedure, an example of a simple assembly is presented.

Proces optimizacije slaganja entiteta korištenjem virtualnog okruženja

Izvornoznanstveni članak

Kombinirana empirijsko-matematička metoda, koja koristi klasifikaciju materijala dobivenu na temelju njihovih dobavnih i potrošnih karakteristika, primjenjuje se za izračunavanje količine materijala i termina dobave materijala. Volumen koji je potreban za skladištenje određenih materijala uvijek je veći od stvarnog volumena materijala koji zauzima u prostoru. Materijali s jednostavnom konfiguracijom, ako su pravilno poredani, zahtijevaju manje skladišta, transporta ili volumen zaliha, nego oni koji su složene konfiguracije. Model optimizacije termina isporuke uzima u obzir faktor volumena materijala. Ako se pristupi slaganju u danom skladišnom volumenu, financijska sredstava vezana za proizvodnju proizvoda mogu biti smanjena. Problem slaganja entiteta u fazi predplaniranja može se riješiti pomoću 3D CAD softwera koji osigurava i podržava generiranje optimalnog slaganja entiteta koristeći simulirane i stvarne objekte, opremu za rukovanje, skladištenje i transport i druge utjecajne funkcije. Na taj način može se generirati sve moguće varijante slaganja entiteta. Svaka varijanta mora biti procijenjena u odnosu na financijski kontekst i kontekst proizvodnje. Ako, slijedom dodavanja (više od jedne varijante), jedna varijanta zadovoljava ograničenja, tada ona ima najveći utjecaj i postaje novi operativni plan popune zaliha. Za provjeru korisnosti novog pristupa termina isporuke optimizacijski proces koji integrira proceduru optimizacije slaganja entiteta prikazani su primjeri jednostavne montaže.

Keywords
Entity ordering
Optimization
Replenishment schedule
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Ključne riječi
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Symbols/Oznake

C_j	- characteristic of price of material - karakteristika cijene materijala
c_j	- price factor - faktor cijene koštanja
C_{kj}	- price of *j*-material, valuta - cijena koštanja *j*-tog materijala
$C_{kj\ max}$	- price of most expensive *j*-material in production, valuta - cijena najskupljeg *j*-tog materijala u proizvodnji
d	- number of working days in week - broj radnih dana u tjednu
D_j	- characteristic of supply availability karakteristika dobavne raspoloživosti
d_j	- availability - raspoloživost
D_s	- annual number of supplies - godišnji broj dobava
F_j	- characteristic of frequency of consumption karakteristika učestalosti potrošnje robe
f_j	- frequency factor of consumption for *j*-material in production - faktor učestalosti *j*-tog materijala u proizvodnji
h	- working hours in one shift - broj radnih sati u jednoj smjeni
k_j	- coefficient of mass related to volume of *j*-material - koeficijent mase u odnosu na volumen *j*-tog materijala
K_{max}	- coefficient of maximal stock for *i*-class material - koeficijent maksimalne zalihe *i*-te klase
k_{min}	- minimal stock coefficient for *i*-material class - koeficijent minimalne zalihe *i*-te klase
N_i	- yearly production quantity for *i*-final product - godišnja količina *i*-te vrste finalnog proizvoda
Q_{di}	- daily quantity of production of *i*-product - dnevna količina proizvodnje *i*-tog proizvoda
Q_{gi}	- yearly quantity of production of *i*-product - godišnja količina proizvodnje *i*-tog proizvoda
$Q_{max\ j}$	- maximal *j*-material quantity - maksimalna zaliha *j*-tog materijala
$Q_{min\ j}$	- minimal *j*-material quantities - minimalna zaliha *j*-tog materijala
Q_{tj}	- weekly material stock - tjedna zaliha materijala
s	- working shifts in one day - broj radnih smjena u jednom danu
S_j	- characteristic of special demands - karakteristika specifičnih zahtjeva
t_{mi}	- time of assembly rhythm for *i*-product - takt montaže *i*-tog proizvoda
t_z	- number of working weeks in year - broj radnih tjedana godišnje
V_j	- volume of *j*-material - volumen *j*-tog materijala
V_{sj}	- volume for warehousing the *j*-material - volumen nužan za uskladištenje *j*-tog materijala
Z_i	- occupation of yearly production by *i*-final product - udio godišnje zauzetosti proizvodnje *i*-tog finalnog proizvoda
Z_j	- characteristic of volume - karakteristika volumena
z_j	- factor of material volume - faktor volumena materijala

1. Introduction

The main characteristics of modern manufacturing enterprises are the dynamic processes. In these condition, changes are constant and decisions have to be made within a short period of time [1]. It is often preferable to make a decision at the right moment rather than seek the optimal decision without any time limit. If the relevant data is available at the right time, decisions that can be reached have more effect on the manufacturing processes and costs that encompass them [2]. In the drafting phase of inventory management, engineers have to take into consideration the entire pool of influential factors and varying these factors they try to anticipate all real, possible situations and problems that follow [3].

An important part of the manufacturing process relates to the assembly process that represents the last phase of every complex final product's manufacturing process, where due to the process significant stocks of parts, reproduction materials and final products are accumulated (material). Among other problems, the technological process must ensure that the stock of single entities are optimal in correlation with the high safety of the assembly. Optimal stock represents the entity's quantity enabling safe assembly of a certain volume of final products in a planned time period. In that case, minimal financial resources are engaged and expressed through the costs of goods, costs of storage and manipulation, as well as through a minimal storage area and quantity of packing material [4]. For this reason, all characteristics of the part's assortment which are incorporated in the final product have to be taken into consideration.

Determination of safety material stocks and material replenishment schedule takes into consideration characteristics such as supply availability, material volume, storage volume, price, frequency of consumption and specific demands toward entities, which are in correlation with operative assembly plans for every single final product, and definition of supply dynamic and consumption of particular entities [5, 6, 7]. Engineers in manufacturing enterprises can manage some of these factors.

Frequency of consumption, as a factor, is a stochastic variable and cannot easily be managed within the manufacturing environment [8]. Only if there is a forecasting model that uses demand distribution for a product which generates demand forecasts, is there the possibility of taking advantage of that data to manage production schedules [9, 10]. Frequency of consumption factor is managed in that way but only indirectly.

Accurate due date fulfillment, represented by supply availability factor, is critical in winning customer orders and maintaining customer retention. It counts on the reliability of various supply chain activities including material supply, production and transportation. Earliness or tardiness, happening in any activity, may affect completion time [11]. This factor is not easily managed within the manufacturing enterprise because it includes various external and internal supply chain participants.

It is very important to recognize the ability of implemented inventory management process and the way it can be engineered to become more cost-effective [12].

This paper presents a practical approach for managing the material volume factor, which may enable engineers to deal practically with issues like entity arrangement and storage volume. It uses CAD software for 3D modeling, CATIA, and connects it with the Excel through a parameter modeling module. Supply and consumption characteristics are set with respect to customer requirements. The focus is on a cost engineering process.

2. Inventory management model

There are empirical, tabulated, graphical and mathematical models for material stocks optimization [13, 14]. It is necessary to have as many parameters as possible, which are different and specific for each production system for a successful optimization process. Optimization for each well-organized production system has its own specifics. These specifics are derived from the fact that each manufacturing activity is based on operational plans from which many characteristics of optimization emerge and use than implemented [15].

A combined empirical-mathematical method, which uses classification of materials based on their supply and consumption characteristics, will be explained in this section.

For each class of material the accounting model of the minimal and maximal quantities on stock is defined. The quantities of each material and material replenishment schedules are defined considering the renewal of material stocks based on operational plans of manufacturing activities in question.

Optimal stock represents the entity's quantity enabling a safe manufacturing process of a certain volume of final products in a planned time period. In that case minimal financial resources are engaged and they are expressed through the costs of goods, costs of storage and manipulation, as well as through a minimal storage area and quantity of packing material [16].

In order to execute adequate manufacturing policy according to stocks, it is necessary to balance the dynamics of procurement to storehouse and manufacturing activities with dynamics of consumption for every single entity [17].

An inventory management model in question comprises the formulation of the final product's structure by establishing the assortment of parts to be incorporated into the product, as well as establishing adequately chosen factors for every single entity. Characteristics of entities as supplying availability, volume, price, frequency of consumption and specific demands are in correlation with operative plans for each final product assembly process, definition of supply dynamic and consumption of particular entities.

2.1. Supply and consumption characteristics

Supply and consumption characteristics are given in Table 1. Evaluation of special demands and supply availability are performed on experience basis. Evaluations of other three characteristics are based on calculation in following sections.

2.1.1. Frequency of consumption factor

According to [15], frequency of consumption factor is:

$$f_{\mathrm{j}} = \sum_{\mathrm{i}=1}^{\mathrm{n}} Z_{\mathrm{i}} \;, \tag{1}$$

Table 1. Supply and consumption characteristics
Tablica 1. Dobavno potrošne karakteristike

Characteristic / Značajka	**Symbol / Simbol**	**Description / Opis**
Supply availability / Dobavna raspoloživost	D_j	The ability level of a supplier to deliver the material in question according to operative schedule. / Razina sposobnosti dobavljača da dostavi traženi materijal sukladno operativnom terminskom planu.
Volume / Volumen	Z_j	The amount of warehouse space that is necessary to sort the material, not considering just its net volume but also the homogeneity of material. / Volumen skladišnog prostora koji je potreban da se složi materijal, vodeći računa ne samo o neto volumenu, nego i o homogenosti materijala.
Price of material / Cijena materijala	C_j	Value of material in monetary units in correlation with the most expensive material production. / Vrijednost materijala u novčanim jedinicama u korelaciji s najskupljim materijalom u proizvodnji.
Frequency of consumption / Učestalost potrošnje	F_j	Takes into consideration various information and assesses the universality of material consumption. / Uzima u obzir različite dostupne informacije, te daje ocjenu univerzalnosti potrošnje materijala.
Special demands / Specijalni zahtjevi	S_j	Incorporates all the material characteristics that are not included in previously described characteristics, but can have an influence on optimal material replenishment schedule. / Objedinjuje sve karakteristike materijala koje nisu uključene u prije opisanim karakteristikama, a mogu imati utjecaj na optimalan terminski plan nadopune materijala.

where:

$$Z_i = \frac{Q_{gi}}{t_z \cdot d \cdot Q_{di}} \tag{2}$$

and

$$Q_{di} = \frac{h \cdot s}{t_{mi}} . \tag{3}$$

2.1.2. Price factor

According to [15], price factor is:

$$c_j = \frac{C_{kj}}{C_{kj\,max}} . \tag{4}$$

2.1.3. Material volume factor

According to [15], material volume factor is:

$$z_j = \frac{V_{sj}}{V_j \cdot k_j} . \tag{5}$$

2.2. Classification of material optimization characteristics

The classes have to be determined in correlation with a specific enterprise situation, Table 2 [15].

Class values, selected according to described procedure in section 2.1. are entered in Table 3. Using the sum of class values the class of material is chosen between A, B and C class.

2.3. Determination of minimal and maximal quantities

Determination of minimal and maximal material quantities is calculated in [18]. Coefficients k_{min} and k_i are practically defined and depend on conditions in manufacturing environment.

2.3.1. Minimal j-material quantities

$$Q_{min\,j} = k_{min} \cdot Q_{tj}. \tag{6}$$

2.3.2. Weekly stock of j-material

$$Q_{tj} = \frac{Q_{gj}}{t_z \cdot f_j} . \tag{7}$$

2.3.3. Annual quantity of j-material

$$Q_{tj} = \Sigma\, N_i \cdot X_{ij}. \tag{8}$$

Table 2. Classes of supply and consumption characteristics and their quantification

Tablica 2. Klase dobavno potrošnih karakteristika i njihova kvantifikacija

Name and class of characteristics / Naziv i stupanj karakteristike	Quantification of characteristics / Kvantifikacija karakteristike	Class value / Vrijednosti klase
1. Supplying / Dobava	Availability d_j / Raspoloživost	
1.1. Very easy / Vrlo laka	1 – at any time / u svakom terminu	1
1.2. Easy / laka	2 – at planned intervals / u planiranim intervalima	2
1.3 Troublesome / Otežana	3 – in usual intervals / u prorijeđenim intervalima	3
1.4. Difficult / teška dobava	4 – in rare intervals / u rijetkim intervalima	5
1.5. Very difficult / Vrlo teška	5 – in very rare intervals / u strogo rijetkim intervalima	7
2. Frequency / Učestalost	*Interval / Područje* f_j	
2.1. Very big / Vrlo velika	0,81 - 1,00	1
2.2. Big / Velika	0,61 - 0,80	2
2.3. Middle / Srednja	0,31 - 0,60	3
2.4. Small / Mala	0,11 - 0,30	4
2.5. Very small / Vrlo mala	0,00 - 0,10	5
3. Price / Cijena	*Interval / Područje* c_j	
3.1. Very expensive / Vrlo skupo	0,51 - 1,00	1
3.2. Expensive / Skupo	0,21 - 0,50	2
3.3. Midium price / Srednje skupo	0,06 - 0,20	3
3.4. Inexpensive / Jeftino	0,00 - 0,06	4
4. Volume / Volumen	*Interval / Područje* z_j	
4.1. Very big / Vrlo velik	> 4	1
4.2. Big / Povećan	2 ÷ 4	2
4.3. Normal / Normalan	< 2	3
5. Special demands / Specijalni zahtjevi	**when / kada $D_j+F_j+C_j+Z_j$ is / je:**	
5.1. Overestimated / Precijenjeno	8 or 13 $C_j > 2$	1
5.2. Normal / normalno	In other cases / U drugim slučajevima	0
5.3. Underestimated / Podcijenjeno	9 or14 $C_j < 2$	-1

Table 3. Classificatory characteristics and possible material class values

Tablica 3. Klasifikacijske karakteristike i moguće vrijednosti klasa materijala

Classificatory with belonging values / Klasifikator s pripadajućim vrijednostima					Class of material with belonging ranging / Klasa materijala s pripadajućim područjem klase		
D_j	F_j	C_j	Z_j	S_j	A	B	C
1 2 3 5 7	1 2 3 4 5	1 2 3 4 -	1 2 3 - -	- 1 0 1	4 ÷ 8 4 5 6 7 8	9 ÷13 9 10 11 12 13	14 ÷ 19 14 15 16 17 18 19

2.3.4. Maximal j-material quantities

$$Q_{\max j} = Q_{\min j} + K_{\max} \cdot Q_{tj}. \tag{9}$$

$$K_{\max} = \frac{1}{f_j} \leq k_i . \tag{10}$$

2.3.5. The annual number of supplies

$$D_j = \frac{Q_{dj}}{q_{\max j}} , \tag{11}$$

$$q_{\max j} = Q_{\max j} - Q_{\min j} = \text{const.} \tag{12}$$

3. Problem statement

The volume that is required to store a certain amount of *j*-material is always greater than the actual real volume that material *j*-occupies in space. The reason is configuration. Configuration of materials can be simple or complex. Materials with simple configuration, if sorted properly, require fewer warehouses, transport or stock volume, than the ones that have complex configuration. If two entities with the same volume V_j have different configuration complexity, it can be presumed the volume that is necessary to store those entities V_{sj} will be different. Often, the price of complex entity is higher than for entity with simple configuration if the material for both entities is the same. So, it is more useful to act in ordering entities with more complex configurations. Warehousing, transport and stock expenses are in direct connection with the storage volume of each entity, so if the storage volume is sized down for the entity, direct influence on the expenses mentioned is reached.

4. Research

Replenishment schedule for an entity has to be optimized. Optimization model for replenishment schedule, given in section 2, takes into consideration the materials volume factor. If an entity ordering in the given storage volume is taken, the financial resources related to the manufacturing of a product can be reduced. Besides, this part of the financial burden has to be transferred to the suppliers.

The problem of entity ordering in the drafting phase of inventory management can be solved by using 3D CAD software.

The widespread use of CAD technology today leads to a situation where conventional methods of planning are no longer sufficient to speed up planning and development process, to reach ambitious budget targets and to manage the increasing complexity of new products [19].

4.1. New approach for replenishment schedule optimization process

A new approach for replenishment schedule optimization process recognizes the importance of an entity's configuration complexity, and suggests an analysis that, as a result, offers the possibility of taking action in entity ordering, Figure 1. If the analysis shows that there is no possibility of taking action, in the case of border area, the optimal model of replenishment schedule from the first phase is adopted. Analysis in this phase of research is done using the heuristic method.

Entity ordering optimization starts with the creation of a virtual environment using 3D CAD software which provides and supports the generation of optimal entity ordering, using simulated and real objects, handling, storage and carriage equipment, and other influential features. In this way, engineers can generate all possible variants of entity ordering. Every variant must be estimated in relation to the financial context and manufacturing context. If only one variant satisfies limitations, defined by manufacturing and financial context, it becomes a new operative replenishment schedule. If more than one variant satisfies the limitations, the one that has the biggest cost saving influence becomes the new operative replenishment schedule. If no variants satisfy the restrictions the optimal model stays the operative replenishment schedule.

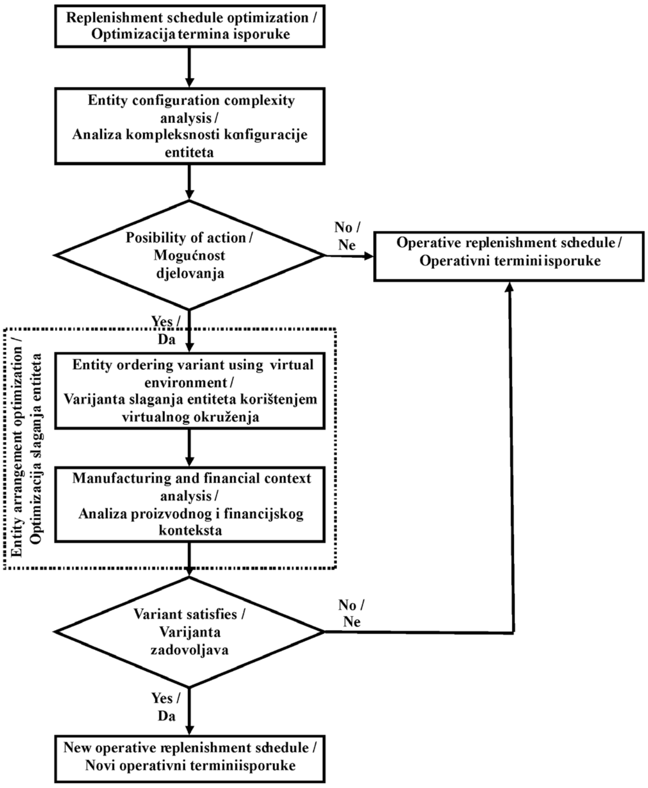


Figure 1. Entity ordering optimization process flow chart

Slika 1. Dijagram toka procesa optimizacije slaganja entiteta

4.2. Practical application of new approach on a real example

To check the usefulness of the new approach for replenishment schedule optimization process that integrates an entity ordering optimization procedure, an example of simple assembly will be presented. Required data includes assembly drawing, detail drawing of three assembly components, operative assembly plan for series of motors, bill of material and technological documentation for assembly process. Documents for presented example are taken from the TORPEDO factory and for practical reasons are not included in this article.

4.2.1. Replenishment schedule optimization

Replenishment schedule optimization for the V-belt pulley, washer and elastic screw will be done based on the given data.

- Type of supply selection is done from Table 2.

  V-belt pulley $D_j = 2$;
  Washer $D_j = 2$;
  Elastic screw $D_j = 2$.

- Frequency of consumption factor is calculated according to (1). Results are listed below. Class value for frequency of consumption factor is selected according to Table 2.

  V-belt pulley $f_j = 0{,}99 \rightarrow F_j = 1$;
  Washer $f_j = 0{,}99 \rightarrow F_j = 1$;
  Elastic screw $f_j = 0{,}99 \rightarrow F_j = 1$.

- The price factor is calculated according to (4). Results are listed below. Prices of materials are given in the structured bill of material. Class value for price factor is selected according to Table 2.

  V-belt pulley $c_j = 1 \rightarrow C_j = 1$;
  Washer $c_j = 0{,}058 \rightarrow C_j = 4$;
  Elastic screw $c_j = 0{,}207 \rightarrow C_j = 3$.

- Material volume factor is calculated according to (5). Results are listed below. Volume of material and volume for storage is calculated using Simpson's rule. Class value for price factor is selected according to Table 2.

  V-belt pulley $z_j = 1 \rightarrow Z_j = 1$;
  Washer $z_j = 0{,}058 \rightarrow Z_j = 3$;
  Elastic screw $z_j = 0{,}207 \rightarrow Z_j = 3$.

- Selection of special demands is calculated and selected according to Table 2.

  V-belt pulley $S_j = 0$;
  Washer $S_j = 0$;
  Elastic screw $S_j = -1$.

- Class of material selection starts with summarizing class values for each factor. Using Table 3 material is classified into one of three classes: A, B or C.

  V-belt pulley Class A;
  Washer Class B;
  Elastic screw Class C.

- Determination of minimal and maximal material quantities is done using the equations from (6) till (12). Result of these calculations represents the optimal supply quantities and the optimal annual number of supplies. Results for all three entities are listed in Table 4.

Table 4. Entities with calculated supply quantities and annual number of supplies

Tablica 4. Prikaz entiteta s izračunatim dobavnim količinama i godišnjim brojem dobava

Entity / Klinasta remenica	Q_{gj}	Q_{tj}	$Q_{\min j}$	$Q_{\max j}$	$q_{\max j}$	D_s
V-belt pulley / Klinasta remenica	23 500	456	456	1 368	912	26
Washer / Podloška	23 500	456	456	2 280	1 824	13
Elastic screw / Elastični vijak	23 500	456	456	2 280	1 824	13

4.2.2. Entity configuration complexity analysis

In order to give optimal manufacturing orders at any given time and to increase flexibility of inventory management model, a computer aided design (CAD) is introduced. Using 3D CAD software allows engineers to respect all possible situations in virtual environment.

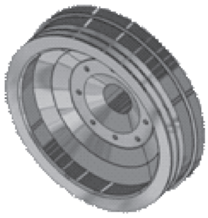
In this phase of the research, a heuristic method is used to analyze entity configuration complexity. There is no need to find the optimal entity configuration solution before the introduction of an entity ordering optimization in replenishment schedule optimization is proven cost effective.

There are few situations, in the border area, when entity ordering optimization isn't cost effective, and even possible:

1. Single piece of entity in the lot, one piece of considered material cannot be ordered.
2. Entities with very simple geometry, with no hollowness.
3. Very small, cheap entities when the ordering is more expensive than savings in warehouse or transport space.
4. Entities which are available in retail stores for a slightly higher price.

Entity configuration complexity analysis shows, Table 5, that for the entity V-belt pulley there is a possibility of taking action in the ordering optimization. For the entity Washer there is no possibility of taking action as well for the entity Elastic screw. Since this research is an attempt to prove that there are manufacturing and financial benefits from ordering optimization, only ordering of entity V-belt pulley will be optimized.

Table 5. Entity configuration complexity analysis
Tablica 5. Analiza kompleksnosti konfiguracije komada

V-belt pulley / Klinasta remenica		• Complex configuration / Kompleksna konfiguracija. • Most expensive entity in the assembly / Najskuplji materijal u montaži. • Number of pieces in the lot is higher than one / Broj komada veći od jedan. • Not available in the retail store / Nije dostupan u maloprodaji.
Washer / Podloška		• Very simple geometry / Vrlo jednostavna geometrija. • Very cheap entity / Vrlo jeftin entitet. • Available in the retail stores / Dostupan u maloprodaji.
Elastic screw / Elastični vijak		• Simple geometry / Jednostavna geometrija. • Moderately expensive / Umjereno skup. • Not available in the retail stores / Nije dostupan u maloprodaji.

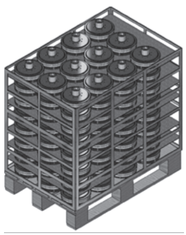
4.2.3. Entity ordering variants using virtual environment

The first step in the building up entity ordering variants is creating a virtual environment, which in this example means creating storage and carriage of the equipment and real entity models. For this example, a standardized euro box pallet, mostly used in manufacturing enterprises, is chosen for the storage and carriage equipment. It represents the first limited factor. V-belt pulley is modelled as well as the cardboard insert that separates the levels of ordered entities. An analysis is shown in Table 6.

For the 1st variant, a calculation was executed in section 4.2.1. Using the relations from (1) to (12) the calculation process for the 2nd variant was carried out after the variant was set up using the virtual environment.

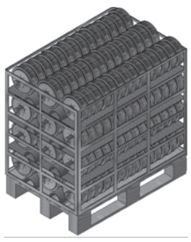
Table 6. Two variants of ordering calculations
Tablica 6. Izračun za dvije varijante slaganja

1st ordering variant / Prva varijanta:



- Available storage volume of pallets / Dostupan skladišni volumen palete: $V_p = 1{,}2 \cdot 0{,}8 \cdot 1{,}0 = 0{,}96\ \mathrm{m}^3$
- Number of entities / Broj entiteta: 96
- Storage volume for a single piece of entity / Skladišni volumen jednog entiteta: $V_{sj} = \frac{0{,}96}{96} = 0{,}01\,\mathrm{m}^3$
- The annual number of supplies / Godišnji broj dobava: $D_j = 26$

2nd ordering variant / Druga varijanta



- Available storage volume of pallets / dostupan skladišni volumen palete: $V_p = 1{,}2 \cdot 0{,}8 \cdot 1{,}0 = 0{,}96\ \mathrm{m}^3$
- Number of entities / Broj entiteta: 168
- Storage volume for a single piece of entity / Skladišni volumen jednog entiteta: $V_{sj} = \frac{0{,}96}{168} = 0{,}0057\,\mathrm{m}^3$
- The annual number of supplies / Godišnji broj dobava: $D_j = 52$

Table 7. Execution of analysis

Tablica 7. Provođenje analize

Limitation / Ograničenja	Ordering variant 1 / Varijanta narudžbe 1	Ordering variant 2 / Varijanta narudžbe 2	Effect / Učinci
1	max 10 pallets / najviše 10 paleta	max 3 pallets / najviše 3 palete	70 % less space required for variant 2 / 70 % manje skladišnog prostora potrebno je za varijantu 2
2	max 10 pallets / najviše 10 paleta	max 3 pallets / najviše 3 palete	70 % less storage and carriage equipment required for variant 2 / 70 % manje opreme za skladišenje i prijevoz potrebno je u varijanti 2
3	245 pieces in pallet / 245 unutarnjih transporta	140	43 % less internal transport is required for variant 2, if we presume that the same carriage equipment is used / 43 % manje unutarnjih transporta potrebno je za varijantu 2
4	14 days / 14 dana	7 days / 7 dana	Average storage period is reduced by 50 % / Prosječno vrijeme skladištenja smanjeno je za 50 %
5	151 872 units / 151 872 novčanih jedinica	37 968 monetary units / 37 968 novčanih jedinica	Financial assets related to material are reduced by 75 % / Financijska sredstva u obliku materijala smanjena su za 75 %

4.2.4. Manufacturing and financial context analysis

This analysis is conducted according to a set of benefits. These benefits are:

1. Less storage space in the warehouse
2. Reduced number of carriage equipment
3. Reduced number of internal transports, (shortened overall transport distance)
4. Shortened storage period
5. Reduced financial resources.

Using documentation mentioned in section 4.2. an analysis is conducted and the results are presented in Table 7.

5. Conclusion

This paper presents a model developed to summarize all steps needed to plan an inventory management system in advance, in order to minimize overall costs related to the logistic parameters in manufacture, using the volume factor to find the optimal replenishment schedule.

Virtual environment is used to aid visualization of ordering variants as well as providing surroundings for development of entity ordering optimization algorithms. The optimization algorithms for automatic ordering of units in virtual storage space are subjects of further research.

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