Recording of inventory and constant monitoring have a huge impact on the cost level of enterprises operating in the metallurgical sector. The article presents methods to optimise the inventory management in terms of a size of orders. This applies to the assumed cost of storage, procurement, expenditure in time unit and unit prices calculated for a range of castings. As an optimisation tool, functions and modules supplied with the MS Excel spreadsheet have been used.

Key words: computer-aided foundry production, logistics, order quantity

Optimatizacija upravljanja zalihami u ljevoanicama u pogledu ekonomičnog naručivanja količina. Snimanje zaliha i stalno praćenje ulaznih materijala imaju ogroman utjecaj na razinu cijene kod poduzeća koja posluju u metalurškom sektoru. U članku su prikazane metode za optimizaciju upravljanja zalihami u smislu veličine narudžbe. To podrazumijeva i procjenu troška skladištenja, nabave, potrošnju u jedinicni vremena i jedinične cijene izračunate za različite odjeljke. Kao alat za optimizaciju korištene su proračunske tablice MS Excel sa funkcijama za različite module.

Ključne riječi: računalno potpomognuta proizvodnja u ljevoanicama, logistika, količina naručivanja

INTRODUCTION

The main objective of logistics in metallurgical plants is skillful warehouse management, remembering that the well-run warehouse and efficient stock control enable smooth running of production and trouble-free circulation of goods. In [1,2] it was noted that proper operation of the warehouse has a significant effect on costs generated by the company. The correct interpretation of the warehouse data is one of the key factors that decide about the financial results of the company. Inaccurate analysis of total inventory can lead us to a false conclusion that we have high inventory levels, characterised by small deviations, while in reality more detailed analysis carried out for individual items will unmistakably show low levels with large deviations, or even the zero status of goods.

DESCRIPTION OF PROBLEM

Using a spreadsheet, one can effectively monitors the inventory, also in the case when different raw materials (products) are stored in the warehouse. This is possible by keeping a database in the spreadsheet and updating it at the end of settlement day by introducing the current values of both revenues and expenditures. In this simple way, at any time, we can have ready detailed information about the specific inventory items and the system of logistics. The basic rule for running any warehouse: first, determine the current status of each article separately, and second, introduce changes, if any. To get the final status add the value of the income to the initial status, or – in the case of expenditure - subtract its value from the status. Any change in the status of raw materials in the warehouse should be dated, and then the final status at the end of the selected reporting period (one day) will make the initial status at the beginning of the next reporting period (day) [3,4].

METHOD OF RESEARCH

The first step is to create a spreadsheet to control the raw material stock necessary to produce castings, where the raw material is designated by an identifier K3-456-Z and the spreadsheet is called STATUS_K3-456-Z. The first line of this spreadsheet should be completed by inserting appropriate data in the fields named: IDENTIFIER, DATE, STATUS, INCOME, EXPENDITURE AND REMINDER. Then, in block of cells H2: J6 of the sheet, for the raw material K3-456-Z enter the following data: PRICE/PIECE; e.g. 8 PLN, DELIVERY DATE, e.g. 3 days, DELIVERY READINESS, which is the probability of delivery estimated from orders placed during previous periods of cooperation with the supplier, and which can amount to e.g. 95 %, STORAGE COSTS, which include, among others, the rent paid, preparation of storage sites and other means of storage, etc., and which can amount...
to e.g. 18 %, ORDER OR CONTRACT COSTS, which are related with the contract itself (e.g. telephone charges, delivery costs, etc.) and can amount to e.g. 45 PLN. First, it is necessary to specify the values that will be optimised at the subsequent stages of the study, i.e. MINIMUM RESERVE of raw material K3-456-Z in stock, e.g. 1 000 pieces, ORDER QUANTITY, e.g. 3 000 pieces. Enter in the next line the data linked with the relevant fields: IDENTIFIER of raw material, STARTING DATE of registration of the raw material income and expenditure (e.g. the date 2008-03-01), marking first the column of cells B and formatting it with category DATE to yy-mm-dd. To cell C2, which defines the stock available in warehouse – introduce a formula compatible with equation (1), which means that when the INITIAL STATUS of raw material K3-456-Z is 2 500 pieces, the formula should run as follows: = 2 500+D2-E2, and to cell E2 – insert the value of the first expenditure in pieces (e.g. 50). Then to cell F2 enter the formula =IF(C2<$I$8;"PLEASE ORDER!";""), so as to get under the heading REMINDER the message PLEASE ORDER! displayed. Using function = IF (...) this will happen when the current inventory status in the current record (the value in cell C2) is lower than that defined in cell I8. At the next stage, copy to cell A3 the contents of cell A2 (IDENTIFIER of raw material) and to cell B3 enter another date. In cell C3 enter formula computing the stock currently available in the warehouse: INITIAL STATUS + INCOME - EXPENDITURE = (C2+D3-E3), and in cell E3 enter current Expenditure, e.g. 60 pieces. Copy also the formula in cell F2 to cell F3. In this way, a database on the warehouse management of raw material K3-456-Z has been made. It has two data records (the second and the third row of spreadsheet STATUS_K3-456-Z). To enter other data records on the storage management of raw material K3-456-Z, a tool very useful in the creation of databases, called FORM, can be applied. To do this, select and mark block of cells A2:F3 and choose command FORM in the DATA menu. Appropriate names to the data columns, copy to columns A and B the values of dates and expenditures, respectively, from the spreadsheet STATUS_K3-456-Z (Figure 2).

To calculate total expenditure in a workday of the warehouse, i.e. the so-called cumulative daily expenditure, enter to cell C2 the formula = B2, which copies the value of the first expenditure on the first workday of the warehouse, while to cell C3 enter the formula = IF (A3=A2;C2+B3;B3), which, depending on the change of the date (by comparing the contents of cell A3 with cell A2), either calculates the total value of expenditures (by summing up the contents of cells B3 and C2) or copies the value of expenditure from column B (i.e. the contents of cell B3). In column D selected data from column C are obtained, and (strictly speaking) the cumulative daily expenditure falling to each day of the warehouse operation (CUMULATIVE DAILY EXPENDITURE), calculated by entering in cell D2 the formula = IF(A2=A3;"";C2) which, depending on the change of the subsequent reporting date (comparing the contents of cells A2 and A3), will either return an empty string (if the date has not been changed, that is, A2=A3) or the contents of cell C2 (cumulative expenditure - if the date has been changed). Copy this FORMULA to cell D3, and then copy block of cells C3:D3 to other cells in columns C and D (i.e. to block of cells D4:C195). At the next stage determine the structure of CUMULATIVE EXPENDITURE. The obtained value should be rounded to the nearest integer, using e.g. function = ROUND (...). The next step involves the determination of daily expenditure of raw material K3-456-Z. For this purpose, in a new spreadsheet called RD_K3-456-Z format column A with category Date, and then, after giving appropriate names to the data columns, copy to columns A and B the values of dates and expenditures, respectively, from the spreadsheet STATUS_K3-456-Z (Figure 2).

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Figure 3 Calculation of selected characteristics for cumulative daily expenditures

Figure 4 Estimated value of the minimum status moved to spreadsheet STATUS_K3-456-Z
The last stage in the inventory management optimising is calculating OPTIMUM BATCH SIZE OF ORDERED GOODS. To this end, copy to the newly created spreadsheet W_Z_K3-456-Z from spreadsheet STATUS_K3-456-Z the following data: PRICE/PCS., STORAGE COSTS, ORDER COSTS and from spreadsheet RR_K3-456-Z-ANNUAL EXPENDITURE. Calculation of the economic batch size of the raw material (product) Q (i.e. the economic order quantity) is done with the formula [5]:

$$Q = \sqrt{\frac{2 \cdot \text{Annual demand} \cdot \text{Order costs}}{\text{Price/ piece} \cdot \text{storage costs} \%}}$$

To calculate this quantity use formula ROUND (SQRT ((2*B4*B3)/(B1*B2));0), which makes the obtained value rounded to an integer. In cell F2, this amount can be rounded to the number of tens. So the optimum order quantity (in terms of cost minimising) will be 2 000 pieces. Copy this value to cell I9 in spreadsheet STATUS_K3 I9-456-Z. To optimise the warehouse operating costs there is no need to order 3 000 pieces, but only 2 000 pieces of the raw material K3-456-Z. To collect data for a graphic representation of the cost development, insert in block of cells A8:G8 appropriate row headers and define in the first column in cells A9:A27 examples of the coefficient values (e.g. from 0,2 at every 0,1 up to 20), for which the cost components have been calculated together with overheads. To calculate ORDER QUANTITY (in cell B9) for given multiplier (equal to 0,2), multiply it by, rounded to the nearest hundred, ROUNDED ORDER QUANTITY, i.e. by = A9*$F$2. The NUMBER OF NECESSARY SUPPLIES is calculated in cell C9 by rounding the quotient of ANNUAL EXPENDITURE / ORDER QUANTITY, i.e. = ROUND ($B$4/B9;0). The value of ORDER COSTS was obtained multiplying the previously calculated NUMBER OF ORDERS by COST OF INDIVIDUAL ORDER, i.e. = C9*$B$3, while AVERAGE WAREHOUSE INVENTORY was calculated dividing BATCH SIZE by two, i.e. = B9/2. Overall STORAGE COSTS were obtained in cell F9 multiplying AVERAGE WAREHOUSE INVENTORY by PRICE/PIECE and STORAGE COSTS indicated as an interest, i.e. = E9*$S$1*$S$2/OVERALL STORAGE COSTS were obtained in cell G9 summing up ORDER COSTS and STORAGE COSTS, i.e. = D9+F9. The formulae from block of cells B9:G9 were copied to block of cells B10:G29 thus obtaining data to a chart COST STRUCTURE, from which the value of an optimum ordered batch size was read out. Thus obtained data are useful in plotting a chart of the cost structure, which accounts for OVERHEAD COSTS series (G9-G29), STORAGE COSTS series (G9-G29) and ORDER COSTS series (D9:D29). This chart was plotted in a new spreadsheet called STRUCTURE_COST. The intersection of lines STORAGE COSTS and ORDER COSTS gives on the x-axis (which is the ORDERED PRODUCT (RAW MATERIAL) BATCH SIZE) the optimum ordered batch size. For this point, the line of OVERHEAD COSTS gets closest to the abscissa.

**CONCLUSIONS**

In calculating the optimum status of order, it is necessary to consider not only the average value of expenditures from the warehouse during the reporting period, but also their distribution and structure. In this discussion should also take into account the assumption (in most cases true) that the values collected during the reporting period will be valid in the future forecast, too. This assumption is the basis for forecasting in general [5,6]. Based on the three and a half month (from March 31 to June 15) observations of the warehouse operation, that the minimum stock to guarantee the lowest warehouse operating costs of approximately 2740 PLN (including also other parameters, i.e. PRICE/PIECE, DELIVERY DATE, DELIVERY READINESS, STORAGE COSTS, ORDER COSTS) should be kept at a level of about 318 pieces of the raw material K3-456-Z, while the minimum batch size of this raw material delivered to the warehouse should be kept at a level of about 2 000 units.

**REFERENCES**


*Note:* The responsible translator for English language is K. Kowalska-Bany, Katowice, Poland.