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The Use of Some Forecasting Methods and SWOT Analysis in the Selected Processes of Foundry

J. Szymszal *, B. Gajdzik
Institute of Production Engineering, Silesian University of Technology,
ul. Krasińskiego 8, 40-019 Katowice, Poland
* Corresponding author. E-mail address: jan.szymszal@polsl.pl

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Abstract

Forecasting and analysis SWOT are helping tools in the business activity, because under conditions of dynamic changes in both closer and more distant surroundings, reliable, forward-looking information and trends analysis are playing a decisive role. At present, the ability to use available data in forecasting and other analyzes according with changes in business environment are the key managerial skills required, since both forecasting and SWOT analysis are a integral part of the management process, and the appropriate level of forecasting knowledge is increasingly appreciated. Examples of practical use of some forecasting methods in optimization of the procurement, production and distribution processes in foundries are given. The possibilities of using conventional quantitative forecasting methods based on econometric and adaptive models applying the creep trend and harmonic weights are presented. The econometric models were additionally supplemented with the presentation of error estimation methodology, quality assessment and statistical verification of the forecast. The possibility of using qualitative forecasts based on SWOT analysis was also mentioned.

Keywords: Computer-aided casting production, Forecasting, SWOT analysis, Statistical and econometric methods

1. Introduction

Practice shows that in the area of business management, rational predictions are most commonly used when future inference is a logical process starting with the collection of facts belonging to the past, going next through their proper interpretation, and ending in the formulation of conclusions. In this type of inference it is also necessary to make use of the learning rules and certain research methods. These predictions of the future include forecasting, which – speaking in most general terms – is a rational science-based tool enabling us to anticipate future events [1-3]. More specifically, it can be stated that the forecast is a statement that refers to a specific future, is verifiable empirically, formulated with the help of scientific achievements, and is acceptable but not decisive [3-5]. It is important to emphasize the fact that, due to the complexity of economic phenomena which are dynamic in a turbulent environment and the lack of full scope for experimentation, proper use of the rich heritage of science does not always guarantee complete predictability of the developed forecasts, but greatly facilitates the task of obtaining such forecasts [6-7].

Forecasting is a very valuable tool in the business activity, because under conditions of dynamic changes in both closer and more distant surroundings, reliable, forward-looking information is playing a decisive role. Statistical and econometric methods are an integral part of the management process, and the appropriate level of forecasting knowledge is increasingly appreciated [8-11]. Accurate forecasting reduces the uncertainty and contributes to a measurable increase in the accuracy of the decisions that are made, thereby reducing or even eliminating losses in business. Quantitative methods, such as the one included in the stand-by forecast, are complementary in the decision-making process by qualitative methods, including SWOT analysis. SWOT analysis (alternatively SWOT matrix) is an acronym for *strengths*, *weaknesses*, *opportunities*, and *threats* and is a structured planning method in a company. The list of four elements of the analysis determines the situation of the company and changes in its environment. During discussion with experts in the field of foundry, a list of useful factors for analysis was compiled (list is presented in this paper). Using quantitative and qualitative methods in companies to anticipate change and build business strategies is preferable to limiting only quantitative or quality. Examples of selected qualitative and quantitative methods are presented in the paper. The scope of analysis is shown in Figure 1.

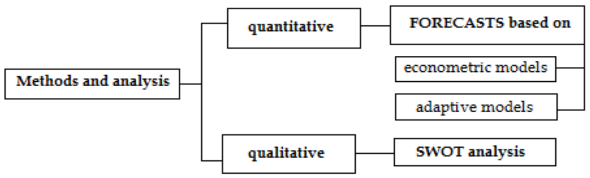

Fig. 1. Methods and analysis used in the paper

2. About prognostic system

In modern foundries, as in other production plants, the prognostic system is usually operating as a subsystem of a larger system, namely the information system, which is a spatially distinguished and temporally structured collection of information, information channels, technical means of processing and sending information together with their senders and recipients [2]. The basic tasks carried out within the framework of this system include building of forecasts related to the important factors in the closer and more distant surroundings of the foundry and variables describing its functioning.

Among the most important elements of the foundry system one can mention the existing forecasting database, the methods used for statistical processing and analysis of such data, and also the forecasting methods, the infrastructure related to computer software and the subsystem for forecast monitoring. In the practice of functioning of production plants, when collecting the statistical material used to build forecasts, it is necessary to define the manner of describing and measuring the phenomena analyzed, as well as the type of statistical observations, that is, to state clearly which of the available statistical data will be used: cross-sectional data, time series data, or cross sectional – time series data [2,7].

As demonstrated by industrial practice, among the major forecasts generated by the forecasting system under foundry conditions are forecasts of technological factors, forecasts of demand for raw/auxiliary materials (dependent demand), forecasts of production and sales (independent demand), and financial forecasts. Properly organized and operating forecast subsystem should enable the effective use of all basic and auxiliary functions of forecasts. The basic functions of forecasts include:

- ✓ Activation - stimulating actions that foster the implementation of a prediction which announces positive events, and actions preventing its implementation, when the anticipated events have a negative rating (e.g. forecast downturn in the company or increase in the manufacture of non-quality products).
- ✓ Preparation - initiating actions that create background for other actions taken by the decision maker, who will be able to act rationally when he has confidence in the forecast made.
- ✓ Information – making the predicted changes more familiar and reducing the level of anxiety, since – as practical experience teaches us - the release of certain forecasts can lead to controlled responses to changes and even to their full acceptance.

The auxiliary functions of forecasts include:

- ✓ Argumentation - the forecast can provide arguments that facilitate decision making.
- ✓ Advice - the forecast can prepare relevant information underlying the phenomena related with the subject matter of the decision-making process.
- ✓ Mediation - the forecast is often helpful in determination of transaction elements.

Forecasting is a process that consists of several basic steps. The first step is formulation of the forecasting problem, the next step involves the definition of the existing forecasting criteria, and the choice of the method and the rule of forecasting; the procedure ends in the construction of the forecast itself with the assessment of its accuracy.

Practice shows that the demand for forecasts lies both with the company's management and its individual organizational units. In this scheme, the role of the management is primarily that of developing general guidelines for the company's operation, including supply, production and distribution forecasts, e.g. general economic conditions, prices of raw and auxiliary materials, sales volume and introduction of new technologies or new products on the market. Currently, the process of planning material needs and labour demand is based primarily on the results of forecasts. Similarly, the definition of the production volume and structure in an enterprise requires the determination of the expected demand for its products, which in turn allows for the implementation of appropriate production plans.

It has been found that marketing decisions can deliver the best results if their choice is based on reliable predictions, and forecasts used to build the company's marketing strategy provide a reliable assessment of the company's market opportunities and the choice of its target markets. Forecasts related to the demand for company's products, consumer preferences and tastes, general economic conditions, or intentions of competition may form the basis for the development of sales plans and directions, promotional activities and advertising campaigns.

On the other hand, the most important consequences of inaccurate forecasting decisions can be [7]:

- ✓ in forecasting the volume of production - overestimating can lead to excessive stockpiling of products, while underestimating – to unsatisfied demand;
- ✓ in forecasting the level of employment - overestimating can lead to excessive cost of high wages, training and benefits,

while underestimating – to organizational difficulties that are often manifested in improper customer service;

- ✓ in forecasting stock levels - overestimating can lead to unreasonably increased cost of the storage of goods, while underestimating – to the lack of sales continuity;
- ✓ in forecasting the finances - overestimating can lead to the increased level of unused or "dead" capital, while underestimating – to the lack of financial liquidity;
- ✓ in forecasting price levels - overestimating can lead to a decline in competitiveness, while underestimating – to the lack of full use of existing opportunities for market growth.

3. Selected methods of forecasting used in the foundry

Own research presents solutions to specific forecasting problems in foundries.

3.1. Quantitative forecasts based on econometric models

Econometric modelling involves the construction of a model that explains the mechanism of changes in the predicted phenomena occurring under the influence of explanatory variables [4]. It should be added that forecasts based on a single-equation linear econometric model are among the most commonly used in the daily forecasting practice. The basic task will be to build an econometric model for the time series involving a temporary demand for the selected assortment of castings (Fig. 2).

In the case of a model with many explanatory variables, the problem most important and at the same time most difficult to solve in the construction of the econometric model is the selection of appropriate variables which will contribute significantly to the explanation of the studied phenomena. Literature of the subject suggests to choose variables that simultaneously meet the conditions of strong correlation with the variable that they explain, show the lack of correlation or the existence of weak correlation with each other, and are characterized by high variability and resistance to the influence of external factors. The functional form of the econometric forecasting model can be linear, nonlinear but by appropriate transformations reduced to a linear form (the, so-called, linearized function), and nonlinear that cannot be transformed into a linear form. The main task was to build an econometric model for time series of demand volumes for selected assortment of cast iron for the power industry produced by the selected foundry (cell block A1:D27 – Fig. 2). When analyzing one explanatory variable, it is helpful to make a scatter chart (Fig. 2). Based on the nature of the relationship between the time period of the analysis and the volume of demand, it has been found that a linear econometric model may be the suitable one. At the next stage, the model parameters were estimated and verified (cell block A34:B39 – Fig. 2). The classical least squares method is used to estimate the parameters of linear models a(b1),b(bo) [4,6].

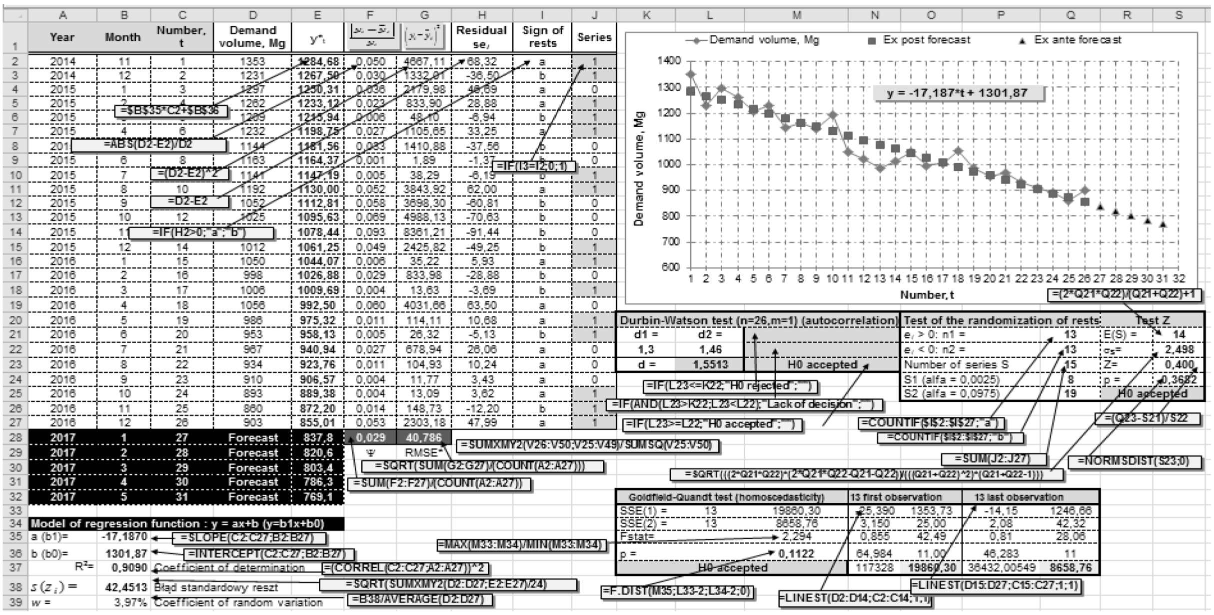

Fig. 2. Forecasting using a single-equation econometric model with statistical verification

Then the model was examined for its fit to the empirical data: standard deviation of the residual component of the s(zi) model, coefficient of random variation *w*, coefficient of determination *R*2. Based on the constructed linear regression function - in this case y = -17,187 + 1301,87 (Fig. 2) a linear econometric forecast model *ex-post* was constructed (cell block E2: E27 on Fig. 2) and the forecast of demand for five consecutive months was appointed (cell block E28: E32 on Fig. 2).

In order to estimate the level of admissibility of the forecasting method used and to select the best method, an estimation of the errors of the, so-called, apparent or expired (*ex post*) forecasts is made [2,12]. Two types of errors were defined:

- square root calculated from the root mean square error of the apparent forecasts (also known as *RMSE** error). The value of this error indicates the average deviation of the forecast from the actual values comprised in the forecast verification interval (cell G28, *RMSE**=40,776);
- mean relative error of the apparent forecasts (also known as Ψ error). The value of this error indicates the absolute error portion per unit of actual value of the explanatory variable (cell F28, *Ψ*=2,9%).

For the verification of statistical model was used the evaluation of random deviations of residues (cell block H1:H27), including: autocorrelation (cell block K20:N23; D-B test); randomness (cell block I1:J27; O20:S26) and homoscedasticity (G-Q test, cell block K32:Q37). The compliance of residual distribution with normal distribution was checked by using the Shapiro-Wilk test. In each case, the estimated forecast model was compliant with the requirements of verification rules.The built and positively verified econometric model can be a very valuable tool in the company for constructing forecasts and identifying and evaluating the company's further operational strategies. In the case of the developed forecast model (Fig. 2), when compared with the real values (real demand for the forecasted months), significantly underestimated values of the projected demand were asserted, which is about 44 tons per month. Thus, despite the fact that the model has met all statistical conditions, the ex-ante forecasts' values were too different from the actual values as for foundry conditions and the volume of production. Such model cannot be adopted to develop a rational forecast of demand. For the production planning department it is recommended to consider a selection of another method of forecasting. If positive verification of the econometric model proves to be impossible, adaptive models, autoregressive models or forecasting methods that take into account seasonal fluctuations can be used [6,9,10].

3.2. Quantitative forecasts based on adaptive models

A very interesting adaptive model, which, as the experiments show, practically gives a very good fit, especially in the case of time series characterized by high random fluctuations, is based on the creep trend using harmonic weights. Fig. 3 shows the method for constructing a forecast based on the model in question. It was initially assumed that the empirical observation segments would have k = 4 elements. The individual partial values of each segment were determined based on the estimated linear regression model. (cell block F2:AE26; Fig. 3). The weights i.e. the coefficients taking into account the aging of the information (cell block AF2:AI28), were calculated from the following formula:

$$C_{t+1}^{n} = \frac{1}{n-1} \cdot \sum_{i=1}^{t} \frac{1}{n-1} \qquad (1)$$

where: n – the number of time series elements (l <t <n), *Ex-ante* forecasts y_T* for the next five months (cell block E29:E33) were calculated from the following formula:

$$y_T^* = y_n + (T-n) \cdot (\sum_{t=2}^{n} w_t \cdot C_t) \quad dla \quad T = n+1, \ldots, \tau \qquad (2)$$

where: y_T* - the forecast value (n <T <τ), τ - the last moment or time period for which the forecast is made.

Similar to the linear model (Figure 2), an RSME error was estimated, which was the half size and is 21.47. The error *Ψ* was only 1.6%. A comparison of predictions of the ex-ante with the actual values in the present model adaptation showed that the average deviation of the residue from the actual values varied about 4 tons, which was almost 10 times lower than in the linear model-based forecast. The analyzed foundry used only linear econometric models before predicting the demand for cast iron products in the next few months. These models, as it was demonstrated in this study, were underestimated, which resulted in errors in the production planning process. As the projected demand for cast iron products was considerably underestimated, the plant maintained too low inventory level at entry and exit of the production system. Such a situation could jeopardize the continuity of production and loss of customers. Due to this, the forecasting model presented in Figure 3 was proposed the researched company. Thanks to its use, a significant improvement in the logistic functioning of the warehouse management was observed and the production plans were made more realistic.

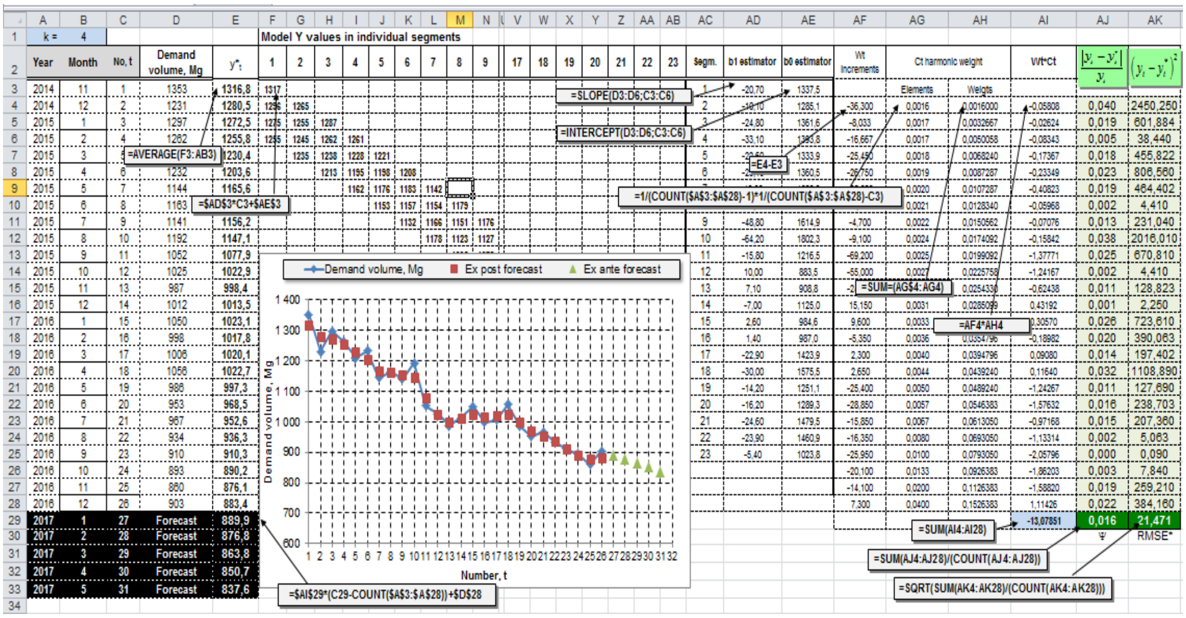

Fig. 3. Creep trend method - harmonic balance forecasting

3.3. Qualitative forecasts based on SWOT analysis

Within the scope of own research it has been proposed to add to the quantitative forecasting methods their qualitative counterparts. The following qualitative methods are used most often today: scenario methods; brainstorming methods; methods based on the SWOT analysis.

There is an extensive literature on the first two methods, while the SWOT-based forecasting requires more detailed discussion. Methods based on the SWOT analysis have recently become very popular in developed countries in the construction of forecasts, especially as regards the determination of the initial condition of the investigated enterprise in terms of the quality of its management.

The term SWOT analysis is a composition of the first four letters of the English names of the criteria (factors) that are taken into account in the evaluation: strengths, weaknesses, opportunities, threats.

The given system can be modified depending on the nature of the plant in question and preferences of the person making this analysis. Unfortunately, as demonstrated by practical experience, the results obtained by this method are quite difficult in the objective approach as they often depend on the subjective perception of the evaluation criteria used in the process of concretizing their individual parameters. It is precisely this character of the evaluation that constitutes a further arbitrary and subjective assessment of the state of the system, and additionally it is done most often consciously, with the exclusion of specific quantitative data. From this fact comes an important conclusion that in some systems and under certain circumstances the described composition of the evaluation elements may prove inadequate in meeting the basic requirements of a reliable forecast.

In the investigated foundry, the potential internal sources of the strengths of the currently functioning production and trade system are as follows:

- the ability to use the efficient and modern means of production as well as own in-plant technologies;
- the increased flexibility of production;
- highly efficient in-plant management system;
- the possibility of gaining a positive attitude of the company's customers;
- appropriate sources of funding the company's activities and maintaining a competitive level of costs (production, services, products, etc.);
- interesting promotional campaigns conducted for own products and services;
- adequate level of competition in the foundry market and properly selected position on the market;
- the ability to properly use the competition currently existing on the market in selected areas of foundry production;
- increasing skills in introducing innovation and modern solutions to the produced range of castings;

The potential sources of weaknesses in the investigated foundry include:

- lack of a clear development strategy,
- lack of properly developed distribution network,
- lack of the ability to properly use the opportunities to make extra profits,
- lack of the adequate human resources, especially as regards the base personnel,
- compared with similar foundry plants, too low economic viability index expressed as a profit - to - income ratio,
- lack of the ability to fully use the own potential and existing opportunities to operate on the market of foundry products,
- difficulties in management, especially at the operational level,
- poor assortment of castings;

- low skills in the area of sales logistics, especially as regards the development and application of modern optimization methods;
- compared to other foundries, higher total cost per production unit;
- lack of reliable data from the past on the supply volume, which translates into the quality of the forecasting process;
- lack of the possibility to achieve the assumed level of financing for proposed changes in the strategic development of the Company.

In the investigated foundry, the set of positive external opportunities includes:

- high level of competitiveness compared to other companies with similar profile of activity in the market of foundry products,
- flexible adaptability to existing market needs in terms of both quantity and quality;
- the possibility to significantly expand the sales market, the circle of customers and/or selected elements of the market,
- real opportunities to eliminate trade barriers present in other competitive outlets.

The most important external threats operating in the Foundry's environment include:

- significant and dynamic changes in customer preferences and/or needs,
- slowdown in demand growth in the sales market of foundry products for selected assortments of castings,
- the existence of high competition on the foundry market offering much lower production costs,
- the emergence of significant legal barriers leading to tightening of existing legislation,
- noticeable increase in sales of castings being substitutes for castings produced by the investigated foundry,
- very unfavourable changes (especially in the last two years) in foreign exchange rates,
- significant increase in the bargaining power of own suppliers and/or customers.

Of the list of testers used in the SWOT analysis for the investigated foundry, the list was established based on expert knowledge. A list of positive and negative factors on Polish foundry market is presented in tab. 1. The developed list of factors affecting the market can be used to perform the TOWS/SWOT analysis. (Approaches from "outside to inside" / from “inside to outside”). The performed analysis should be based on the predicted changes in the demand for iron castings (results of the analysis according to the developed model shown in Fig. 3). In an aggressive strategy, a larger volume of production than in a defensive strategy can be planned (S/W and O>T). In the case of defensive strategy, the demand for castings should be carefully predicted due to unfavourable situation in the cast iron market and unfavourable internal conditions at the plant (S<W, O<T). Relating to the competitive strategy, the market is conducive to increasing the volume of production, because of the advantage of opportunities over threats (O>T but S<W) and vice versa while using conservative one because O<T and S>W.

Table 1.
A list of factors characterizing Polish foundry market [8,9,13]

Factor	Argumentation
Casting production	Casting production in Poland is at over 1 million tons per annum (The annual progression was then maintained between 1% and 2%)
Demand for castings for the automotive industry	Rising trend in long time. More than 50% of the casting orders the automotive industry.
Export	60% the annual production of castings in Poland is destined for export (62% in 2015)
Export of castings to EU countries	Nearly 90% of Polish castings are exported to EU countries
Assortment produced castings	In Poland in recent years widened assortment produced castings - from simple castings for construction, mainly sewage, to complicated automotive molding
Trends in the volume of production	A few percent increase in production in the last two decades
Work productivity	Growth from 26 tons per worker in 2000 to about 40 tons in 2016, 4 ths. tons / foundry (compared to European countries: Germany, Italy, France and Spain, this is about 2.5 times lower efficiency)
Demand for castings in global market	Reduction in global production castings of one million tons in next five years
Labour cost	Lower than in Western European countries but higher than in Asian countries (China)
The structure of Polish foundry market	Over 90% of the population in Poland are representatives of the small and medium-sized enterprises sector. (There are about 400 foundries in Poland)
The structure of production in Polish foundries	Gray cast iron has the largest share in the structure of casted materials (46% in Poland and 44% in the world). The characteristic feature of Polish foundry is more than double the share of aluminum alloys in the structure of products compared to world production (32% and 15%, respectively). Much less ductile and malleable cost iron (16% compared to 27% globally and 29% in Europe).

4. Summary and conclusions

The basic rule in the process of building and using forecasts in the production facilities, which include foundry plants, is to make the forecasts generated by the existing forecasting system simple, easy and user-friendly. It is therefore important that the use of this system is not too complicated for the managers of the company, both in terms of the forecasting methods used and the related technical and technological procedures. The developed forecasts should be consistent with the current needs and expectations, understandable, and easy in interpretation and application. At the same time, the observability and measurability of phenomena should not be forgotten during the specification of forecasting models. For example, when discussing the problem of demand, it is recommended to take into consideration the effective demand, which is observable and can be measured with, for example, the expenditure on given commodities rather than the unobservable actual demand. Additionally, factors shaping the predicted phenomena can be of both quantitative, i.e. reflected by measurable parameters, and qualitative nature, and in the latter case they are described with the non-measurable (qualitative) attributes. If they showed in own examinations, even it is possible to appoint very complex quantitative forecasts using the popular sheet Excel. The qualitative and quantitative analysis was prepared for the specific plant in order to improve the functioning of the production department and warehouse management (at the level of functional strategies). At the level of the plant strategy (great strategy) the TOWS / SWOT analysis allowed to bind the top management level with the operational divisions of the plant.

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