SIMULATION-BASED PRODUCTION PLANNING BASED ON LOGISTIC MONITORING AND RISK MANAGEMENT ASPECTS

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For companies which are part of complex supply chains structures, risk management is getting increasingly important. This development is the result of actual trends that can be observed, especially in the automotive industry.
Companies reduce their work in progress to cut down the cost level of stock; certainly the delivery performance is expected to be excellent. However, the reduction of work in progress frequently results in missing parts or raw material. Moreover, the logistic environment is continuously getting more turbulent by continuously fluctuating demands and in some cases - like steel for example - increased delivery times for raw materials. Combined with the mentioned reduction of work in progress, achieving the agreed logistic performance is not ensured without a significant additional effort.
An approach, developed by IPH, is the use of discrete-event simulation tools for the combination of production planning and control methods with logistic monitoring tools. Based on the periodic analyses of the logistic supply chain performance and the simulation of different alternative scenarios, the relevant planning parameters are identified and adopted to the planning processes.
For this feedback loop, logistic risk management aspects need to be considered as well. By identifying potential risks and developing counter measures, the logistic performance is increased tremendously and consequently the performance of the complete supply chain is improved.
In this paper, the specific challenges of forging companies that are part of an automotive supply chain are described and lined out. The forging industry is subject to the implementation of new forging technologies for being able to battle the competition from low cost countries. Those new technologies are not only beneficial; they bear significant risks for the companies as well. For some new technologies, the tool life cannot be forecasted accurately, hence the lot sizes are only estimated roughly and not calculated with a well proofed algorithm.

1. PRODUCTION PLANNING AND CONTROL IN THE CONTEXT OF CUMULATIVE QUANTITY

Cumulative quantity is a method to record and describe cumulated actual and target data over defined time periods. The method is usually applied for material movements of sourcing products or in-house products as well as assemblies or completed, finished products.

In the context of the Collaborative Research Centre 489 (Control and Planning of Flexible Supply Chains for the Manufacturing of Precision Forged High Performance Components) methods are developed for an adaptive production planning and control system. Forging companies are frequently integrated in automotive supply chains. The importance of using risk management methods – as a part of the logistic monitoring – has continuously increased for forging companies. Identifying potential risks and using the opportunity to react in time helps to reduce negative impacts to the company performance significantly.

The main field of application of the cumulative quantity method is found in companies with serial production of standard product with high diversity. The production is often structured in a flow principle [Wiendahl, 1997; Heinemeyer, 1988]. It is appropriate to the high volume production of forging companies and becomes more important in the context of supply chain management. It is well adapted to the coordination of the production program planning in supply chains and contributes importantly for the containment of the bullwhip-effect [Lödding, 2005].

Within the scope of cumulative quantity, methods were developed for program planning, quantity planning and scheduling. The calculation models and methods for the forecast of the customer and the supplier behaviour have been developed and integrated in an instrument for production planning. Furthermore planning methods have been developed based on the cumulative quantity method which can be parameterised depending on the situation of the order spectrum in the predefined planning period. The developed methods use dynamic instead of static planning parameters. For an efficient calibration of the parameters, the planning methods have been linked to a monitoring instrument. This instrument enables the measurement of turbulences as well as the analyses of logistic performance and logistic costs. Furthermore, a control tool for stock levels has been developed as a support to the production planning and control processes. In the following section, the elaborated methods are described in more detail. A specific and methodical adaptation for forging companies is shown in this context. Besides the program planning the logistic monitoring is exemplarily described in the following section.

Program planning

The production programs are continuously “rolling” over a constant period of time. Due to the planning complexity, the generation of the production programs occurs in regular intervals. Periods between four or six weeks are typical. In most instances, basic agreements are negotiated between forging companies and their customers. On basis of those agreements delivery schedules are ordered. These orders can take place weekly for example and include upcoming and committed demands as well as an updated forecast of future demands. The forecasts in these orders are the basis of the program planning.

In a first step, the planning horizon is supposed to be defined by the production planner of a company. The advance planning process is expected to determine production orders well in advance and release them in time.

Afterwards the forecast of the customers demand is arranged according to the different products. To represent the demand curve, the forecast of the planning time horizon for every single customer is cumulated. A fundamental advantage of this method is the early consideration of expected events which do influence the supply chain and moreover the possibility to consider this information in the sales planning of forging companies.

The result of a survey, accomplished by IPH, demonstrated, that the forecasted quantity differs from the committed order quantity for different reasons. The indicator “forecast performance” was defined to evaluate these circumstances. This indicator is used for production planning processes. The forecast performance of every customer is expected to be calculated. This results in a value between 0 and 100% whereas 100% characterizes a “perfect forecast”. The difference between the perfect and the real forecast performance is represented by a vector for the adaptation of the customer demand curve (for example: the difference of 12% equals a forecast performance of 88%). Having a “forecast performance” below 100% requires the establishment of a safety stock to compensate forecast uncertainties. Afterwards the demand curves adapted by the forecast uncertainties are deferred by a customer-specific transport vector. Different transport times for every customer result in different customer specific transport vectors.

Logistic monitoring

Cumulative quantity diagrams are also used for measuring and visualizing the logistic performance [Reinsch, 2003]. As a result of the monitoring the logistic specifications of the process chain are provided. The targets for the process chain which apply for the individual process elements are: high utilisation, short lead times, short throughput times, minimum stocks level and a high delivery performance. By means of cumulative quantity diagrams, the actual values of the logistic targets as well as the deviations of the actual values and the target values are determined. A fundamental advantage of the cumulative quantity is the simplified inventory level control. By analysing the difference between consecutive actual values of the cumulative quantity, the actual stock levels in all process elements are supposed to be determined at any given time. The overall stock level along the complete process chain corresponds to the sum of the individual stock levels. Furthermore the order throughput time can be calculated by means of cumulative quantity. It equals the sum of all throughput times related to the actual resources. By account of a chopped process chain, the mean performance of every single process chain element agrees with the mean performance of all process elements in combination. Comparisons between target values and actual values are made if the target values of the cumulative quantity are determined. Thereby overdeliveries and underdeliveries of the different production stages and process elements are determined. By comparing the target and the actual values at the finished product stock the delivery reliability is evaluated [Ouali, 2004a].

The logistic induced costs are assigned by adopting the activity-based costing model to measure the logistic efficiency. Based on the research work of Kerner [Kerner, 2002], a cost model is configured which links the emerging costs of the forging sub-processes to the individual forging process elements [Ouali, 2004b].

Simulation Based Production Planning and Control

The lined out considerations and calculation approaches were consolidated to a method for the planning and control as well as the monitoring of forging processes. Then the method has been implemented in object-oriented software modules for planning and monitoring. A modular built discrete-event simulation model was developed for the validation of the method. The model is composed of three modules: supplier, manufacturer and customer. The modules are linked by an MS-Access data base and integrated to a simulation based system for the monitoring and the planning as well as control of supply chains [Wiendahl, 2005].

Because of long reaction times in combination with the bullwhip-effect it is required for the forging industry to act actively and not only to react to market changes. For this purpose an approach is developed, which helps to identify the logistic risks in the forging processes and derives corrective measures for the risk control. This approach – the operative risk management – is implemented as an add-on to the monitoring tool. The interface with the production planning and control is the feedback data of the manufacturing simulation. This is the input of the monitoring module, which converts them into logistic key figures, such as the mean throughput time and mean work-in-progress. According to the resulting key figures, the system user can finally adapt the planning parameters in the ERP system [Wiendahl, 2005].

Operative risk management

The term "risk" has different meanings in a lot of disciplines. In everyday life the term risk is reduced to the possibility or the increased feasibility of the admittance of a negative rated incident [Dahmen, 2002]. In general the term risk is defined as the statistical spread about an expected issue. Accordingly, positive issues (chances) are considered as well as negative issues (dangers). The main challenge of a risk management is the methodical identification and embankment of risks for a successful realisation of the business objectives. Thereby chances and risks need to be systematically identified and rated regarding their incidence rate and their potential influence on the given business objectives. The intention is to prevent or reduce negative impacts and to increase chances. Risk management has a strategic and an operative dimension. Strategic risk management represents the basis of the whole risk management [Romeike, 2002]. In form of a policy towards risks, the objectives of the risk management are configured. At this juncture the positioning in the area of a conflict between chances and risks is the main aspect. The intention is to solely develop methods for the operative risk management. Therefore strategic risk management is not yet researched in appropriate detail. Operative risk management contains risk-identification, risk-analysis and rating as well as risk-control and monitoring.

Risk-Identification

Risk-identification is the key for a successful realisation of a comprehensive risk management. At this stage potential logistic risks for forging companies are identified. Process oriented risk-identification is realized by applying different analysis methods for failure detection (FMEA, FTA). The supply chain of forging companies can be classified in three business processes: sourcing, manufacturing and distribution. Accordingly the forging relevant risks are assigned to these three categories. Well-established actual approaches of risk management do mainly classify risks in two categories, namely external risks and business risks. External risks do primarily result from fiscal influences as, environmental impacts and social or political risks [Diederichs, 2004]. Risks resulting from the production processes, *Simulati*

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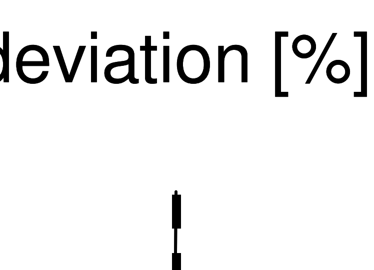
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RV	risk value
IR	risk incidence rate
V	relative economic dimension of the risk

Risk control and monitoring

The aim of the risk control and monitoring step is to prepare arrangements for influencing the risk situation of a company. This happens either by avoiding potential risks, consequently to reduce the risk incidence rate or to reduce the financial risk. Generally the option exists to accept specified risks without operational discharge of arrangements. If the risk occurs the resulting costs are consciously anticipated and accepted. The seized arrangements in the context of the risk control and inspection corresponds with the defined objectives of the strategic risk management. The identified potential risks of the risk analysis are inscribed in a so called risk portfolio. The risk portfolio is characterised by 3 category groups which correspond to 3 different risk classes. Class A risks have high risk values, class B risks have medium risk values and class C risks have low risk values. The limit values between the classes are defined by the risk strategy of the company. Generally, the objective of the risk control is to avoid class A risks, to reduce class B risks and to accept class C risks. Established methods of the quality management (e.g. cause and effect diagrams) are used to identify the risk causes for the risk control. Thereafter risk control scenarios are established. The compiled control scenarios are checked up on their efficiency by the described simulation tool before seizing required arrangements.

2. CONCLUSION

Recently logistic risk management becomes increasingly more important. Particularly for forging companies which are mainly integrated in supply chains of the automotive supplier industry, the requirement to manage potential risk has obviously intensified. This is the bases for several different developments. First of all, forging companies try to continuously reduce their capital lockup by reducing the stock levels without reducing their delivery reliability. The reducing of the stock levels contains the risk of shortage in the final stock and the raw materials warehouse. Second, forging companies have to face a turbulent logistic environment caused by fluctuating customer demands and long delivery times of steel suppliers. The dilemma of an efficient reaction to unreliable and fluctuating customer demands with the focus of reducing the stocks requires a methodical approach for the risk management. This is especially important for forging companies with high set-up times and large batch sizes. On this account, a production planning and control system for forging companies has been developed. This system is able to identify technological (forging) and logistic relevant risks at an early stage in the process chain of high precision performing and to evaluate the consequences of these risks belonging to the achievement of the logistic aims. For these purposes methods for the forecast of the risk incidence rate and their organisational and monetary consequences were developed. Based on this, a risk portfolio was implemented which classifies risks in three different risk classes. Thereafter risk control scenarios were established and validated by an in-house programmed simulation tool.

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