4

Design of Logistic System – Applications

4.1 Design of the Logistic Strategy

This study based on transformational leadership, which underlines the value of managerial behaviour supporting subordinates capabilities and motivation to develop them, increase their self-worth, work towards the benefit of a group, and build base for learning which helps a person to evolve and transform toward new level of capabilities.

Burns (1978) differentiated with transaction and transformational leadership, transnational leaders lead through social exchange, like politicians lead by exchanging one thing for another; jobs for votes, etc. Transformational leaders are those who stimulate and inspire followers to both achieve extraordinary outcomes and develop their own leadership capacity.

Bass (1985) defined four main "*I*"s as cornerstones of transformational leadership: idealized influence, inspirational motivation, intellectual stimulation and individual consideration [1]. The theoretical frame is based on transformational leadership, Bass' Directions of outputs [3].

A holistic but simple model of a human being (profile) from resource allocations to behaviour and finally to outcome directions and outcomes has been built basing on psychic, social, functional, organizational and structural factors [12] and put together according to the Sand cone model (Takala et al MD'2005, Takala IJMTM'2002, Ferdows et al 1990) and decision maker's outcomes in transformational leadership [11,13]. A reactor is stable on a very limited area, and adaptively monitor and react to the change in the environment in a systematic and effective way [11, 13].

The mathematical calculations are based on information collection by Analytical Hierarchy Process where qualitative objects are converted to quantitative values [9].

4.1.1 Methodology

Research Strategy and Methods

1. With the theoretical frame of reference we measure empirically by deduction profiles for transformational leadership by using Analytic Hierarchy (AHP) questionnaires. Questionnaires were distributed to 2 cases institution, one in china where 10 managers were interviewed, the other in Slovakia where 5 managers were interviewed. The Chinese case institution is a Public health administrative organization, which in charge of public health propaganda and coordination of the city. Questionnaire was distributed to 10 main principal within the organization.

2. Statistical tests will be made to find out the logic in the leadership profiles to increase the accuracy, statistically analytical models will be built and tested to measure leadership skills by leadership indexes from resource utilization to leadership behaviour and finally to outcome directions and outcomes.

3. Finally models are built to measure the effectiveness of leadership within different areas of outcomes. We try to find out the correlation between these outcomes and leadership indexes in a forecasting way.

Definition and Formula

1) Prospector

Oriented for future and extra effort, The people in the prospector group are looking further future and are willing to make some sacrifices at present to reach the goal set in the future.

1-(1-(EE^1/3) * (1-EF) * (1-S) * Std^(1/3) EE>0.43, EF, A≤0.57

2) Analyzer

Oriented between prospector and defender, Analyzers are balanced between these two groups mentioned earlier.

1-(1-(S^1/3) * 1-(Std^1/3) SA>0.43, EE, EF≤0.57

3) Defender

Oriented for effective use of existing resources at present, Defenders are conversely making good results currently and putting less effort to the future.

1-(1-(EF^(1/3))) * (1-EE) * (1-S) * (Std^(1/3)) EF>0.43, EE, SA≤0.57

4) Reactor

All the rest of the leaders' categories. Earlier literature defines Reactors as unstable and inconsistent with their leadership style by having mixed characteristics of all the other categories. On the contrary, we claim according to the analyzed new research data that "Reactors" can be characterized as highly adaptive, effective and systematic. Reactors are strongly self directed and confident to make quick decisions. Due to lack of resources Reactors have learned to rely on their skills and abilities to succeed as a leader. In this paper, according to the definition, based on the value of EE, EF and SA, interview results of two managers from Chinese case institution can be classified as reactor, one lies between analyzer and prospector, the other lies between defender and prospector. We will use the simply average to calculate reactor:

1/2(Analyzer+Prospector) OR 1/2(Defender+Prospector)

Others

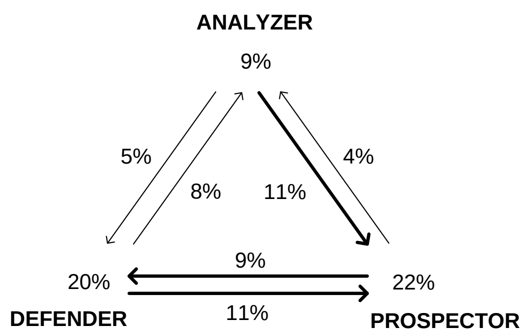


Fig. 56. *Change in outcome direction of different leadership group.*

('EF') = Effectiveness; how to meet or even exceed the objectives on results and performance.

('S') = Satisfaction; to the leader.

('EE') = Extra effort; to create entrepreneurship.

('Std') = std deviation in E, S and EE.

4.1.2 Results

Tab. 8. *Different index of Chinese case company.*

	RI	LI	OI	TL	ICR	STD
Interviewee 1	0.214	0.270	0.981	0.057	0.084	0.145
Interviewee 2	0.316	0.046	0.165	0.002	0.172	0.342
Interviewee 3	0.250	0.545	0.973	0.132	0.116	0.306
Interviewee 4	0.302	0.385	0.575	0.067	0.114	0.077
Interviewee 5	0.618	0.242	0.939	0.140	0.066	0.330
Interviewee 6	0.475	0.151	0.990	0.071	0.126	0.077
Interviewee 7	0.143	0.194	0.978	0.027	0.064	0.191
Interviewee 8	0.215	0.138	0.971	0.029	0.150	0.194
Interviewee 9	0.415	0.260	0.155	0.017	0.136	0.412
Interviewee10	0.427	0.473	0.120	0.024	0.464	0.291

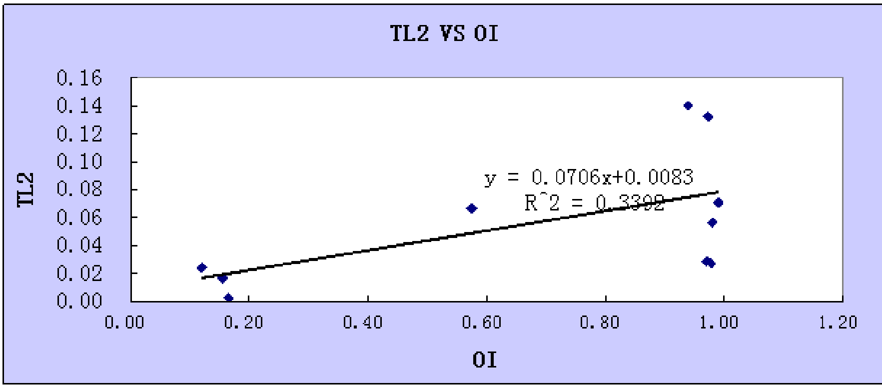


Fig. 57. *Total leadership index VS Outcome index of Chinese case company.*

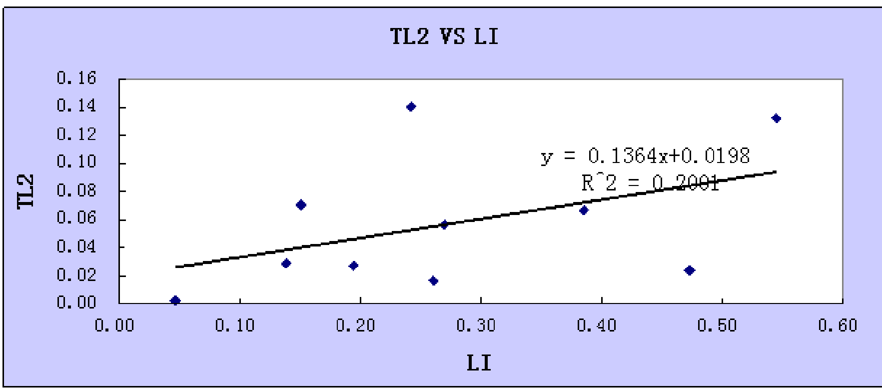


Fig. 58. *Total leadership index VS leadership index of Chinese case company.*

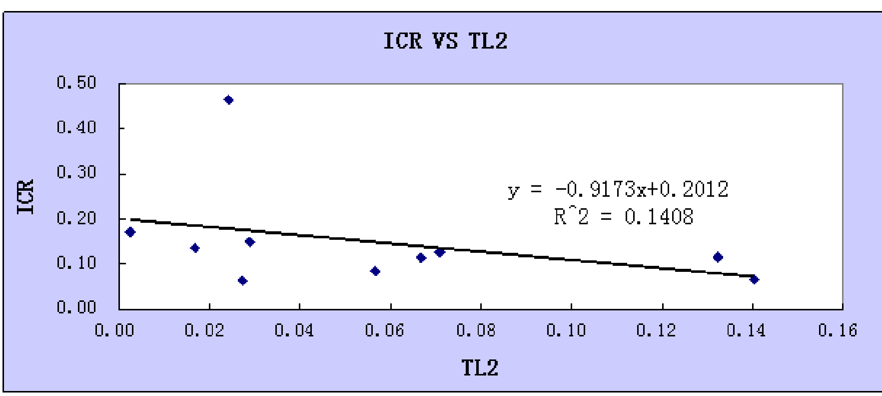


Fig. 59. *ICR VS Total leadership index of Chinese case company.*

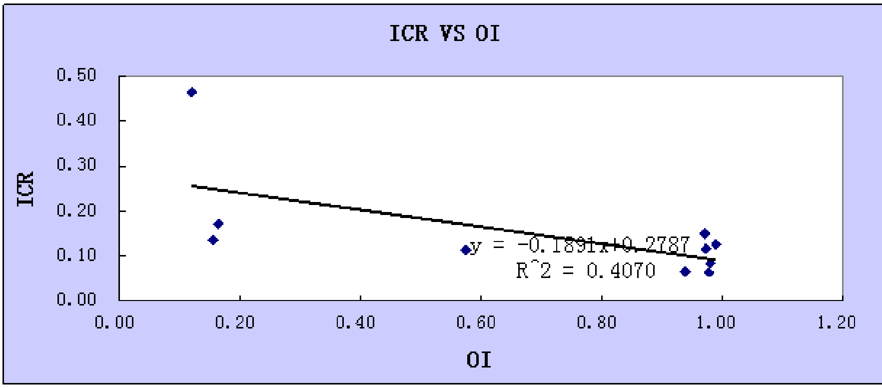


Fig. 60. *ICR VS OI of Chinese case company.*

Tab. 9. *Different index of Slovakia case company.*

	RI	LI	OI	TL	STD
Interviewee1	0.103	0.292	0.931	0.028	0.363
Interviewee2	0.090	0.239	0.957	0.021	0.265
Interviewee3	0.277	0.347	0.979	0.094	0.144
Interviewee4	0.331	0.133	0.982	0.043	0.180
Interviewee5	0.106	0.143	0.978	0.015	0.251

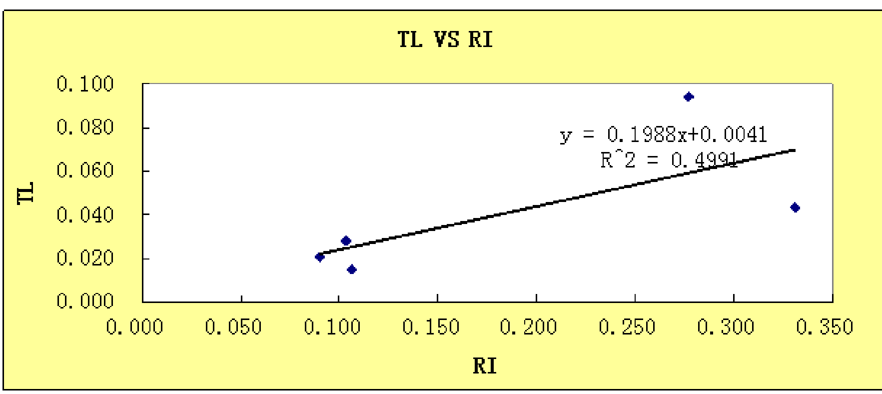


Fig. 61. *Total leadership index VS resource index of Slovakia case company.*

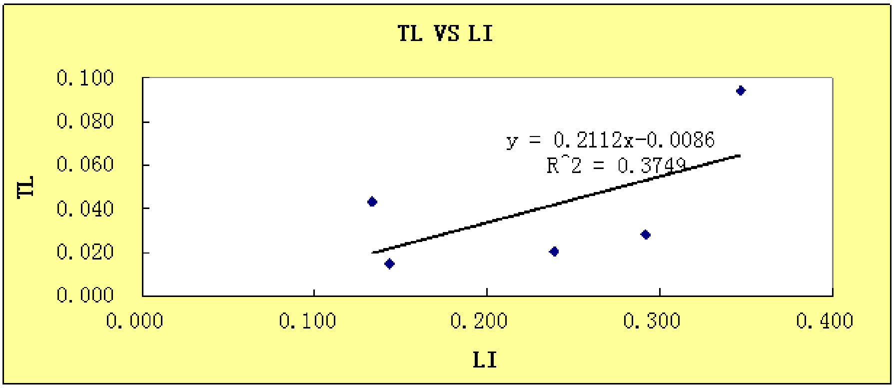


Fig. 62. *Total leadership index VS leadership index of Slovakia case company.*

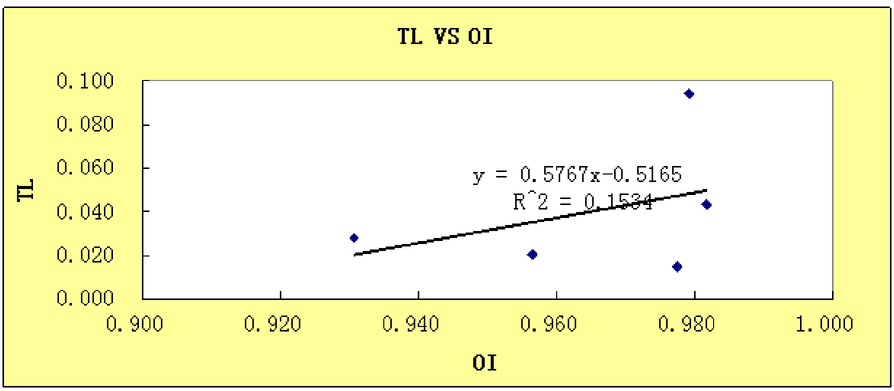


Fig. 63. *Total leadership index VS Outcome index of Slovakia case company.*

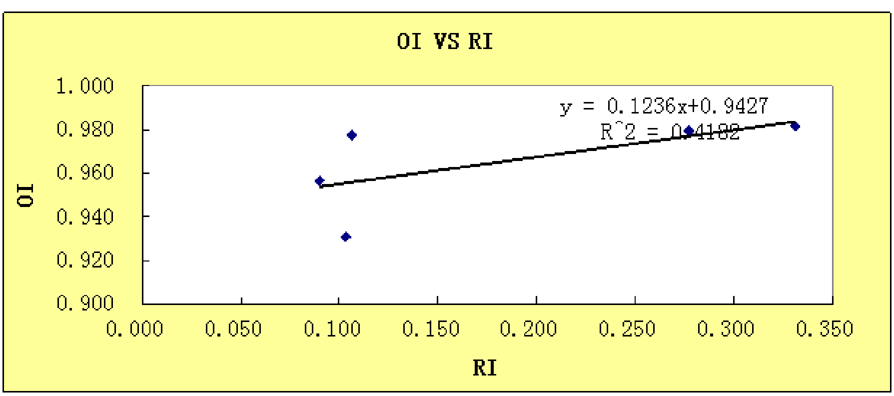


Fig. 64. *Outcome index VS resource index of Slovakia case company.*

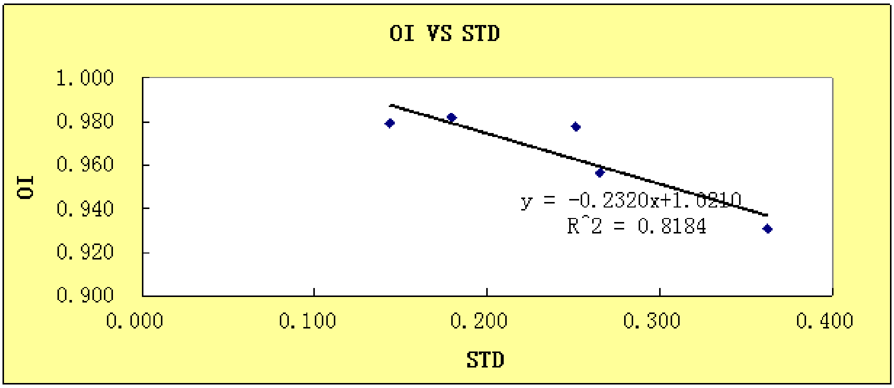


Fig. 65. *Outcome index VS Std of Slovakia case company.*

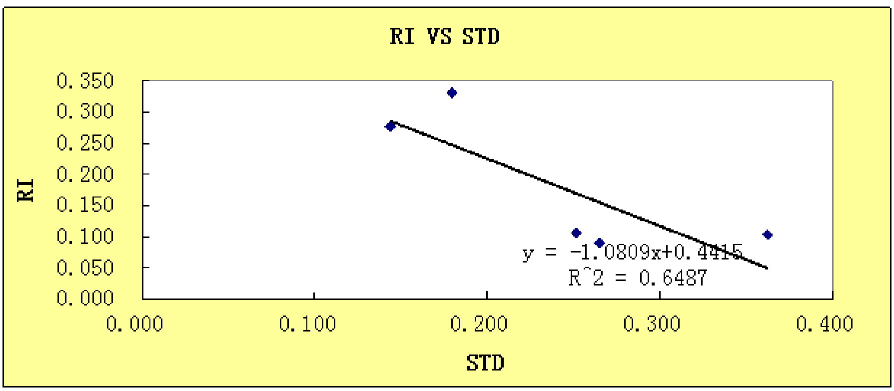


Fig. 66. *Resource index VS Std Slovakia case company.*

4.1.3 Findings and Discussions

For Case Institution from China

1. Compared with other index, Outcome index plays the most significant effect on total leadership index, the relationship between outcome index and total leadership index is positive, which implies that the director of outcome plays the most important role in deciding the total leadership performance of this institution.

2. Leadership index also has some effect on total leadership index, but not as significant as outcome index. The effect of resource index on total leadership index is very limited

3. Inconsistent ratio has negative effect on total leadership index, which shows that a poor understanding toward transformational leadership will affect the performance of total leadership. Inconsistent ratio has negative effect on outcome direction index, which shows that a poor understanding toward transformational leadership will affect the direction of transformation leadership.

4. All the regression results are not significant enough.

For Case Institution from Slovakia

a) Analysis of SEZ Krompachy company

Company Profile: SEZ Krompachy a. s. is a company with more than 60 years of tradition in producing low and high voltage electrical appliances. It was established in 1948. In 1992, it was transformed to a private shareholding company.

SEZ Krompachy a. s. has its seat in the town of Krompachy in the eastern part of Slovakia, about 400 km eastwards from the capital city Bratislava, with 70 km to the Hungarian border, 100 km to the Polish border, 160 km to the Ukrainian border and 240 km to the border with the Czech republic.

Principal company processes include development, production, assembly and sales of electro-technical products and systems, engineering products, in particular tools and moulds and plastic mouldings.

State-of-the art development trends are applied in production activities to produce technically and qualitatively leading products.

The enterprise has its own development department and cooperates closely with the Technical University in Košice, ensuring continuous innovation and development of new products. The products are developed and designed in compliance with international IEC standards and tested and compared in our own test room as well as in independent national and international laboratories and testing and certification authorities, indicating high technical standard and user safety of our products [15].

In 1994, the company was awarded the *ISO 9002 Quality Certificate an ISO 9001/2000 Certificate in 2002*.

Its quality management system was verified and the certificate was granted by SGS Yersley (UK). The company developed a programme of increasing qualifications of workers within the whole range of technology structure, starting from manual workers up to top managers.

The production programme includes:

(a) Circuit breakers, current protectors, modular appliances (LV - low voltage).

(b) Cam switches (LV).

(c) Household insulation materials (LV).

(d) Switchboards and racks (LV).

(e) High and low voltage (HV and LV) circuit breakers.

(f) High voltage disconnectors.

(g) Tools, moulds and models for plastics moulding (EP – engineering production).

(h) Plastic mouldings (P – Plastics).

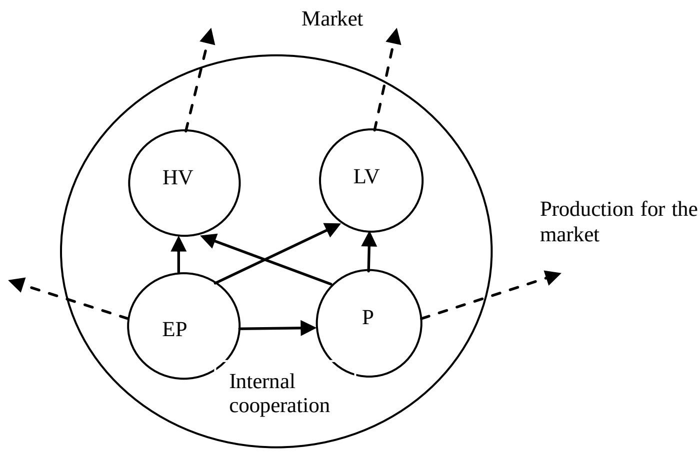


Fig. 67. *Product flows in SEZ Krompachy, a.s.*

The production is divided into four parts – low voltage appliances LV, high voltage devices HV, engineering production represented by the tool shop (EP) and plastics production to produce mouldings on injection presses. The LV and HV programme focuses on external markets; EP fulfils tasks needed for inter-company cooperation, LV and HV programme and plastics production; production of plastic mouldings (P) is intended for needs of the LV and HV programme, too.

Market and Clients: Products made by SEZ Krompachy have a strong position especially in the Central European Countries, Czech Republic, Ukraine, Poland, Hungary, Bulgaria and Russia, but over the years they are getting established on markets of the Western and Southern Europe, Southern America and Asia.

The tools and moulds are used by many renowned companies, such as GEC, VA Tech Rezlodle – UK, Schupa, Siemens Kramp – Germany, Whirlpool Poprad etc.

In the last 5 years, production volumes have been increasing on a year-to-year basis since 2004 until 2008 (in SKK mil.)

2004	2005	2006	2007	2008
450	470	500	514	540

SEZ Krompachy a.s. has been generating profit all the time during its existence. In the last two years 2007 and 2008, the company invested significant resources into technical innovations in particular.

b) Conclusion of the Analysis

1. RI, LI and OI have positive relationship with TL. Resource index plays the most significant role on total leadership index. While regression relationship of outcome index on total leadership index is not significant, which shows that outcome index has limited effect on total leadership index. The importance of leadership index on total leadership index lies between resource index and outcome index.

2. Empirical findings show that there is interactive relationship between OI and RI, this is a very important finding. It shows that resource index has positive effect on outcome index. This interactive relationship between outcome index and resource index may affect the calculation of total leadership index as well. It is a direction for further studies.

3. The regression relationship between OI and ICR, RI and ICR are both significant negative. It implies that a poor understanding toward outcome direction and resource will affect the efficiency of transformational leadership. These finding also confirm the above interactive relationship between outcome index and resource index.

4. There is no reactor group in Slovakia case.

4.1.4 Conclusion and Future Studies

Discussion and studies on Reactor are brand new and limited, more detail and deeper researches on the definition, calculation and application of Reactor group in transformational leadership is essential and meaningful. As the concept of Reactor group is based on the first three strategies, namely prospector, analyzer and defender, any change on other strategies will have effect on reactor group as well. Calculation of leadership index under reactor group is not unit, it depends on the understanding toward its definition from leadership group. Some assumption may be made before calculation.

4.2 Design of Manufacturing Logistics System

Each company is original from the point of production processes. Application of standard enterprise information system (SAP, proAlpha, etc.) need difficult adaptation especially for conditions of small or medium enterprises (SMEs) and the price of that system is relatively high. Therefore, the proposed model of capacity planning is much more suitable for the conditions, requires and demands of SMEs [17, 18, 19]. Specifics of production processes of RS Ltd. are combinations of discrete and continuous processes and the fact that this small company is connected to a supply chain (KANBAN) with its mother company, which defines the level of some chosen products in the expedition warehouse by the end of a month [23].

For the above mentioned reason it had to be designed the new original production logistic system. This system starts with order evidence, it includes the model of capacity planning, which respects KANBAN and model for production scheduling and operation evidence after the finishing of manufacturing [20, 22]. Both models are created on the heuristic approach i.e. there were analysed rules and limitations, which were applied to algorithms of the models. By this approach applied in the model there were included all activities, knowhow, experience, knowledge of the experts and people, who works in the company for a long time [19, 23]. Design of the logistic system of RS Ltd. can be also applied in any SME, in the area of machinery industry connected to supply chain system with another company.

4.2.1 System Analysis for the RS Ltd

The enterprise RS Ltd. is producer of stator and rotors for industrial ventilation and air conditioning system and is conformed to the German mother company. The basic production process starts at cutting of dynamo plates and their welding or riveting (PP1), its casting to aluminium alloys (PP2), finishing (PP3) and surface treatment (PP4), see figure 1.

Production process management starts with order evidence and the process of planning in the enterprise of RS Ltd. starts at the purchasing and sale manager, who collects continuously incoming orders. The term of delivering of all filed orders is 20th day in a month to a planner (if the day is weekend, then this file is delivered obviously sooner). The file with orders contents is in the status as they were delivered without any editing. The file content date of receiving, date of production (due date), article number and name, quantity, and customer (standard customer is mother company). The term, when the plans should be ready for supervisors of production division and to general manager is 25th day.

The file of recorded orders (FRO) is continuously actualised by adding new incoming orders, while planner can open the file anytime but on mentioned date he will receive the file through e-mail. By this step the actualisation of this file is finished and it is ready for planner to create new production plans.

The plan is created separately for these divisions:

- for cutting (CNC machines).
- for casting.
- for finishing (CNC machines), however this is not detailed plan given to a supervisor but it is a list of products and due dates and delivery dates.

The first set of information input is in-process production itself, which was planned in previous periods “N-1” for present period “N” (e.g. cut dynamo plates are not already casted in to aluminium body, casted are not finished and finished are not surfaced etc.)

The second set of information input is store levels of finished products, so called “KANBAN”, where the certain levels are need to be kept (levels represent quantity) by the end of a month. The decree, from the mother company which defined the certain levels of finished products, is actualised regularly, sometimes also when there is unexpected increase of orders of standard (often ordered) products. KANBAN is a kind of flexible reserve between the planning and fulfilling store levels, when the planning is not strictly fixed on term but for managing of store levels. It is also a kind of buffer in a peak ordering while incoming of many orders of many products to one due date. Ordered assortment is firstly fulfilled according the KANBAN levels in a store and then the missing items are planned first as a priority.

Some of the semi-products (e.g. riveted stators and welded rotors) are not produced in this enterprise but they have to be ordered. This idea is used as a flexible item in capacity planning model. These purchased semi-products are also a reserve for smoothing of material flow especially between cutting and casting (Fig. 68). The second task of purchased semi-products is a capacity balance of production process. The capacity calculation is done first with all incoming unproduced orders. Then it shows the “bottle neck” (usually it is welding and riveting) of the process by its calculation which also shows the ratio of possible and impossible produced orders and thus it is possible to enlarge capacity of welding and riveting by purchasing of these semi-products.

Purchased semi-products represent standard products, which are parts of best selling products. They are even with better quality and in many cases cheaper in comparing with self-produced semi-products.

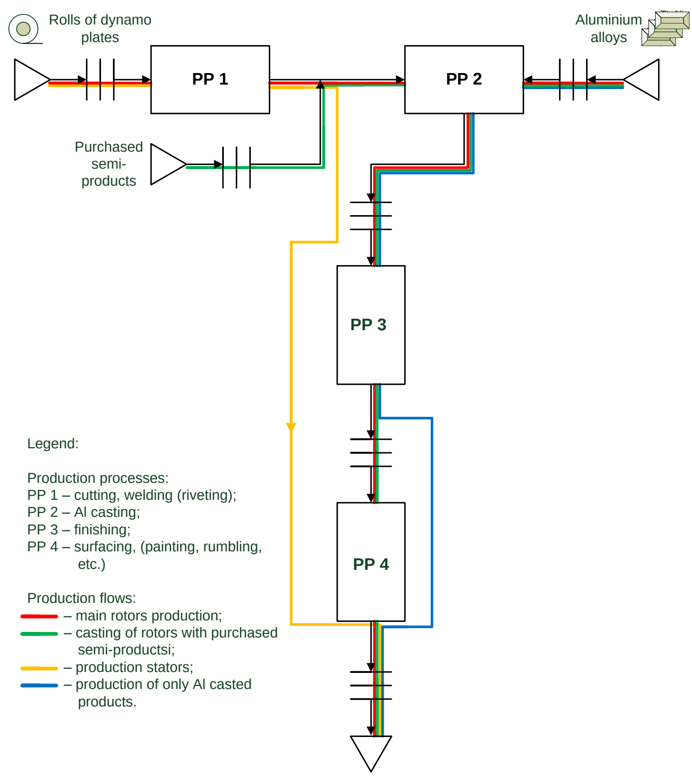


Fig. 68. *Basic production processes and flows of RS Ltd. enterprise.*

Capacity planning: Source of input information is the file of all orders. Each order has the certain quantity of ordered assortment and due dates. Present capacity planning consists of planning of all orders backwards from due date to first operation. There are calculated latest times of beginning of production and capacity need of each machine by this way, supposed that all income orders are put into production. Next, there is calculated in-process production and purchasing of semi-products, which can relieve capacity need at PP 1. In each production company, including RS Ltd., the capacity calculation have to include unexpected influences (lost times) i.e. breakdowns, increased time of setting etc., which is 10 – 15% of all times. That is why the machines are planned at about between 85 – 90% of their capacity, so this created a kind of time reserve.

The calculation of capacity needs is done each month - month forward. There is always done the balance of produced assortment by taking products from KANBAN levels first, it shows: how many products can be taken from the warehouse, how many need to be produced, how many need to be bought, etc. Two situations can be occurred after the KANBAN application:

- capacity needs (CP) are higher than capacity possibilities (CP), (CN > CP):
    - One possibility is to buy semi-products. It can happen that even everything is bought there are still not enough sufficient capacity possibilities e.g. casting has to be provided inside the enterprise, it cannot be replaced. In this case there it is need to contact customer by phone and discuss with him about priority of ordered products, which are urgent for him, that means the sequence by which the products will be produced or to discuss about partial shipment, the part will be produced on time, the rest later or to discuss about backup date. All customers (however the mother company has majority of all orders) are considered as equivalent.
- capacity needs are lower than capacity possibilities (CN < CP):
    - All levels of KANBAN are filled at first. While filling the standard assortment (very often demanded) there are created over-KANBAN

levels. When this is done and the capacity needs are still low, the machines maintenance is planned and also the all-company holiday can be determined.

The standard bottle neck in RS Ltd. is welding at PP 1. Welding is slower as the next process – casting. The actual principle is that the whole batch of material is welded first and then the whole batch is moved to casting. While welding of brakes all the following production, the purchased semi-products are used. Thus the purchasing is a kind of regulative item.

This bottle neck should not be bottle neck, because it is relatively cheap and simple equipment. In the proposal it is proposed to enlarge the capacity of this place by buying other welding machine and adding the servicing person or automating this place [21].

4.2.2 Proposal of New Conception of Production Logistics

The new proposal has to fulfil some specific targets:

- completion of orders in required quantity and quality in priority to mother company.
- flexibility and stability, minimization of operative changes.
- increasing of technological and logistic discipline, keeping of a production plan and dates of delivery.
- increasing of regularity (smoothness) – production tact.
- consecutiveness order changing and minimizing of stores (buffers).
- minimizing of production costs.

The proposal of the production logistic system (SYVYLO) is described in the (Fig. 69). The production logistics means managing, ensuring and providing of material flows in the RS Ltd. company, which are provided through these basic activities:

1. annual planning of trade and production.
2. order logistics:
    - processing of workload (from incoming orders) into planning periods.
    - technological, material and economic order appraisal, material balance.
    - capacity planning.
    - cumulations and creation of internal work orders.
3. preparation of production scheduling for machines and equipments.
4. shift managing of operative production plans.
5. operative evidence of production.

SYVYLO is only the "core" of the production logistic system and does not include:

- annual planning of trade and production.
- warehousing management and material ordering, reality and material order assurance will be confirmed by a supplier.
- preparation and recording of new technological descriptions for new products or changing in technological descriptions will be added into proposals manually through prepared interfaces.

- operative evidence will not be automated (e.g. by bar codes) but will be entered through the terminals of information systems located in production area by production supervisors and also into KANBAN cards.

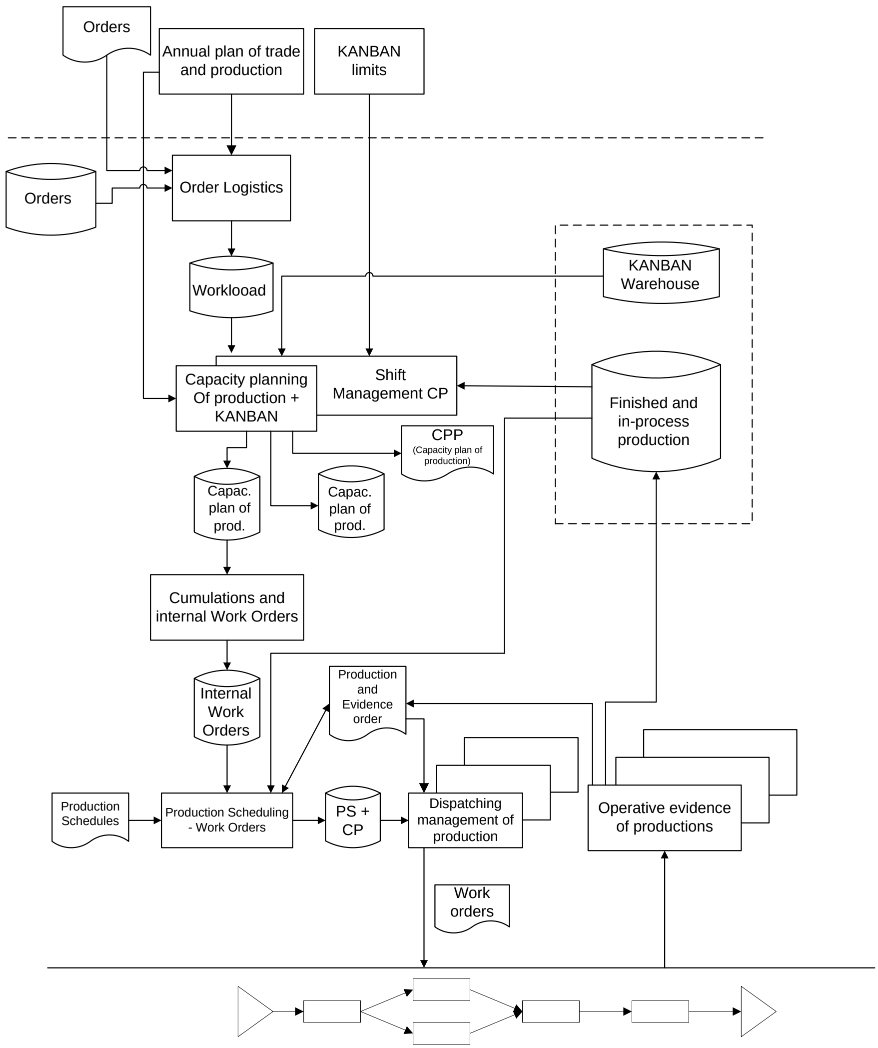


Fig. 69. *The structure of production logistics system (SYVYLO) in RS Ltd.*

4.2.3 Proposal of Capacity Planning Model

The capacity planning comes out from known workload – orders to certain planning period. Its aim is to choose orders from the aggregated orders (file of incoming orders) and to put them into a production plan, into a certain planning period by keeping the following:

- to fulfil required ordered quantities and due-dates for customers.
- to give in balance capacity demands to machines, equipments, workplaces with their capacity possibilities.
- to keep the prescribed store level limits of products in KANBAN warehouse.
- to purchase material, semi-products or sub-deliveries based on capacity plan of production.
- to have the capacity plan as a basis for creation production scheduling, in this there is no need to take care about capacity.

Parameters and criteria for capacity planning:

1. The capacity plan is created for all company and it is divided to:
    - U1 – cutting, welding, riveting.
    - U2 – casting and production of aluminium (Al) alloys.
    - U3 – surfacing, finishing and other finalising.
2. Planning period will be at minimum 8 weeks. Planning point is between 10:00am – 12:00pm on Thursday.

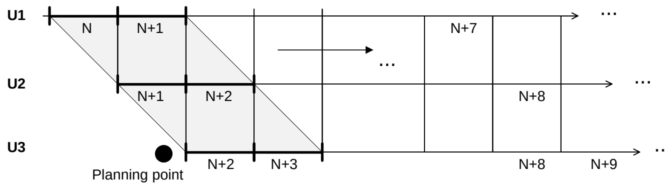


Fig. 70. *Planning periods of defined divisions (U_1 - U_3).*

3. There is used the principle of sliding planning, which is performed each Thursday at noon (12.00 o'clock).

4. There is a different obligation in weeks (1st week is definite, 2nd week is preliminary – set at approx. 80%, 3rd week – 8th week is forecasted). The exact authorisation of doing changes have to be defined, e.g. changes for 1st week – only general director can provide changes, for 2nd week – only delegated production supervisors or planner can provide changes, other weeks planner and other entitled persons can provide changes.

5. Planning by PULL system – it means from the end to beginning.

6. The products will have priorities "B" – ordinary, "S" – urgent, "SS" – super urgent.

7. Closed system of capacity planning (phase production) besides the products with priority "S" and "SS" (defined by general director) will be kept, i.e. what is produced at U1 in week N will be processed at U2 in week N+1 and at U3 in week N+2. It results to defined production time, which for "B" products is three weeks, for "S" products two weeks and for "SS" products is one week or orders are completed from KANBAN.

8. The capacity plan will be created at 90% of maximum capacity (10% is left for unexpected, unaware changes and interactions).

9. Initial variant of plan is created in the way that:

- Inputting “S” and “SS” orders into weeks according to DD_I to division U3.

- New “B” orders are assorted by: LRT – Longest Remaining Time, i.e. maximum time to their production is:

$$\sum_J MN_I * t_{I,J} = \max,$$

respectively according to DD_I to division U3.

Orders are inserted to certain weeks from the end of U3 through U2 up to U1.

- The capacity calculation is provided and there are calculated CN_J (capacity needs) in certain periods of weeks N+1 - N+8, but planning dead times, compulsory maintenance and in-process production have to be taken into calculation.

10. Calculation of bottle-neck.

11. Solution of bottle-neck through KANBAN stock levels, and point 10 is again repeated.

12. Calculation of sub-deliveries of welded and riveted parts and point 10 is again repeated.

13. The capacity smoothing is possible to reach:

- By using KAIZEN.
- By moving forward.

By dividing one big order to 2, 3 smaller batches (internal work orders) and moving two, three batches a period back.

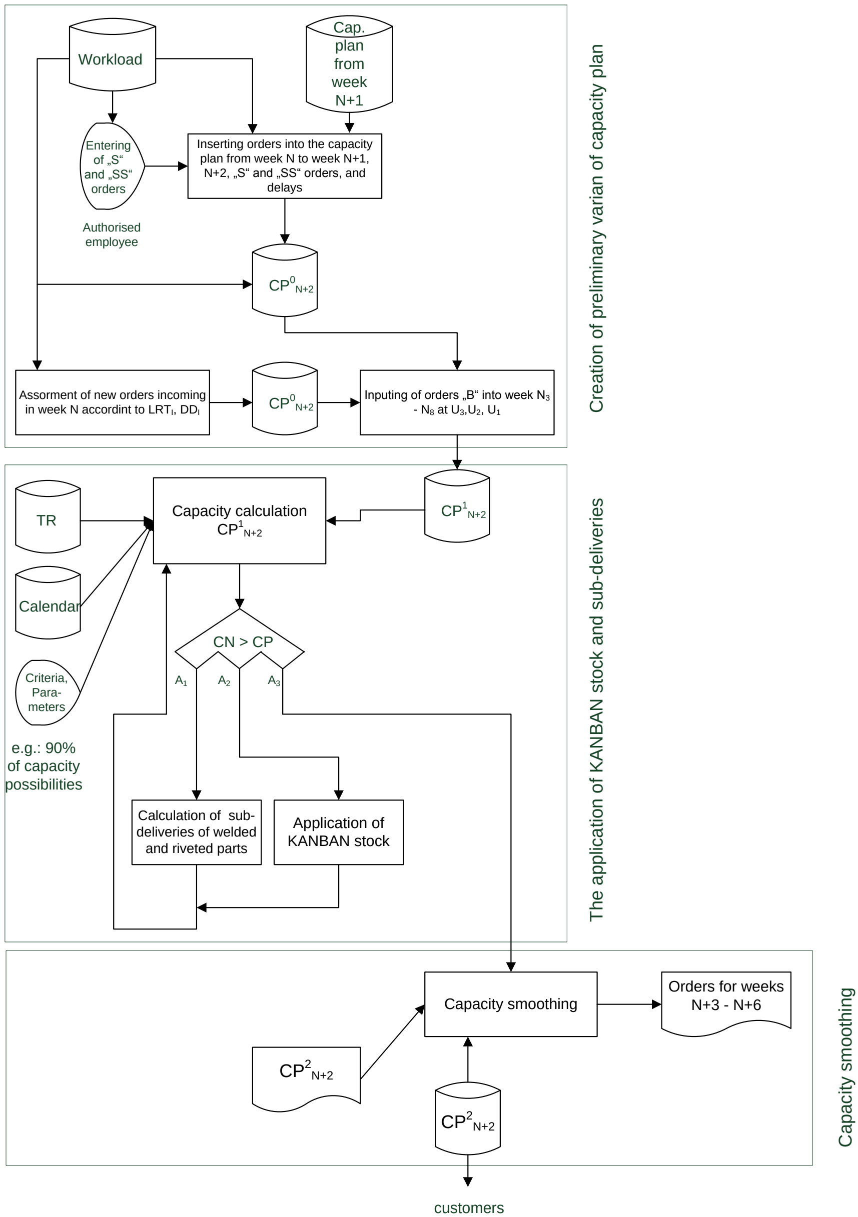


Fig. 71. *Algorithm of the capacity planning model.*

4.2.4 Conclusion

The real system for the company RS Ltd. is not only the model for capacity planning itself. It was also created the model cumulation of orders and production scheduling with the evidence of work in progress and finished products for the each machine. The system, in this state, is already similar to the professional information systems for production management, with the difference, that there are integrated all the features and tools they really need and will use them as it is required from their production practice. Description of such a system would have far exceeded scope of this article and further description of this model is omitted.

The proposed model of capacity planning itself is a key activity of the whole system, because in this model it is created a file of possible workload that is possible to process, in the certain week with the given capacity potential of machines. This file is important for the operation of the further model of cumulation of orders and production schedules preparation and faults in that file would cause malfunction of the system.

4.3 Design of Model for Creation of Basic Foil Manufacturing Plan in Chemosvit Fólie a.s.

The department of manufacturing of basic foils is the first step in the whole manufacturing process. For better illustration of the position of the manufacturing of basic foils follows (Fig. 72).

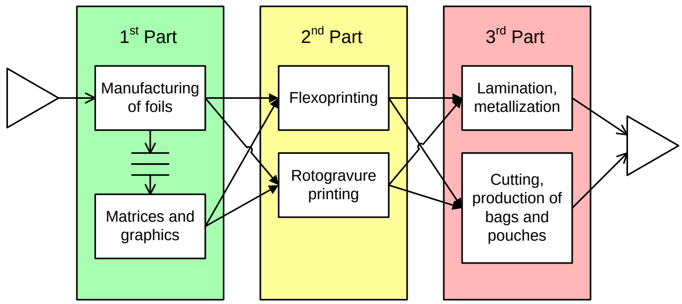


Fig. 72. *Three-tact manufacturing process.[32]*

The company, from the point of capacity planning is divided into three parts. The 1st tact includes basic foils manufacturing and purchasing, in the 2nd there is the printing and in the 3rd tact there are laminating, cutting, slitting and shipping (Fig. 72). [29, 30]

The assortment of manufactured products in the company Chemosvit fólie a.s. represents basic polyethylene - PE and polypropylene - PP foils, flexo and rotogravure foil printing, lamination and manufacture of bags and pockets. The company has its own graphic studio and preparation of printing forms for flexo-printing and rotogravure printing.

The assortment of products can be divided into two basic groups:

- Product type of monofoils.
- Product type of laminates (further classified into large range of the assortment). [26, 27, 32].

The basic division of foils:

- *Blown* (3 layers foils).
- *Casted* (2 - 5 layers foils).

The basic division of the assortment:

- Barrier foils - polymer (impermeable of certain types of gases): 3 – layers, 5 – layers.
- Polypropylene (so called - the bread foils, suitable for food use): combination of homopolymer and copolymer, pure homopolymer (homo), pure copolymer (copo), twist foil. [28, 32].

Technology of basic foils manufacturing.

Manufacturing of basic foils is currently provided on four extruders i.e. blown foils and cast foil technology, i.e. casted foils. The overview of different maximal widths, the number of worms (layers) in the manifold nozzle and manifold nozzle sizes are listed in Tab. 10.

Tab. 10. *The overview of width (winding), the number of worms in the nozzle and nozzle dimensions of the technology.*

	Technologies			
	Macchi	**Varex 1**	**Varex 2**	**Alpine**
Max. width	2200	2600	2600	2000
Number of worms	5	3	3	3
Manifold nozzle size	500	500	500	400

The mixture of granules is prepared by an operator according to the recipe in the technology tab. The granules are melted in the worms (max. number of layers of a foil = number of worms), homogenized and transported to the extrusion tool (manifold nozzle), where the melt is co-extruded and blown through the nozzle slit to circular cross-section in the form of foil sleeve. Then the process follows this procedure:

1. blowing and stabilization of a bubble – adjustment of the thickness, width by the calibration basket.

2. cooling IBC (internal bubble cooling) and also EBC (external bubble cooling).

3. flattening (by a flattening device).

4. pulling and foil reservation.

5. winding (cutting of a hose to desired foil size).

6. coiling up a roll as a final product, which goes either on sale directly or as a semi-product for further cooperating departments (flexo-printing, lamination, confection and cutting). [31].

4.3.1 Definition of Model Creation Principles

Determination of Main and Alternative Technologies.

Every product has determined main (most efficient) and alternate technology, where it can be also produced, but with lower efficiency. Example of technology determination is given in the Tab. 11.

Tab. 11. *The example of technology determination.*

The assortment – chemical composition	Macchi	Varex 1	Varex 2	Alpine
H2	H2			
H1S	H1S			
H701 RS	H701RS			
	- main technology		- alternate technology	

The Assortment Changeover.

Changeover is a state, where it is necessary to change one type of material (chemical composition) to another, while it is created a downtime and a waste is produced. A waste is represented by a cleaning of a machine between the manufacturing of two products of different chemical composition. The changeover involves also the exchange of the nozzle. Changeovers respectively changes of assortments are done under the certain rules to these technologies and are explicitly expressed by e.g. the changeover matrix (Tab. 12).

The criteria for the efficient operation of technology are: a minimum number of changeovers, the minimum number of nozzles exchanges.

The Colours of the Assortment Changeover.

Similar like in the previous case, here are also rules which are explicitly expressed, e.g. network diagrams at extruder Varex 1. (Fig. 75).

The Cumulation of Orders and its Rules.

The cumulation follows these listed rules:

1. The same quality i.e. the same assortment (chemical composition), type.
2. The same thickness.
3. Different widths, if they can be fit into the coiler.

There are necessary to be kept the following parameters for the required width of an order:

- Blown ratio – equation (1) for standard foils: 1,7 – 3.
- Consideration of a half circle circuit: 1,58 (π/2).

It means that it is possible to produce a min. and max. width from the nozzle 500 mm (taking into account the tolerance):

- Minimal width: 500 x 1,7 x 1,58 = 1343 mm.
- Maximal width: 500 x 3 x 1,58 = 2370 mm.

Thickness is independently controllable variable and has nothing to do with blowing ratio.

$$Blown\ ratio \in \frac{\dfrac{width\ of\ \ foil\ \ for\ an\ order \times number\ of\ \ coils}{nozzle}}{\dfrac{\pi}{2}}$$

Blown ratio influences the properties of foils, a foil structure is oriented through that nozzle, i.e. for a given speed and temperature there are oriented polyethylene, chains are oriented and a foil acquires its properties.

4.3.2 Proposal of the Operational Planning Model

The conception is based on the analysis, which confirmed the suitability of the present way of capacity planning and production scheduling for particular extruders (technologies). The current way is sophisticated, there were created procedures during a long-term application, which create the appropriate variants of manufacture planning of foils. It is therefore appropriate to apply the heuristic approach that is based on defined and explicit described rules and procedures used at the actual creation of plans by a logistician, to put these rules into the sequence and to draw them into the algorithms (models) for the plans creation. The principle of Synchro-MRP was applied as another strategic principle (Fig. 73), and thus it reduces overall manufacturing time of an order execution and increases flexibility. [25], [33]

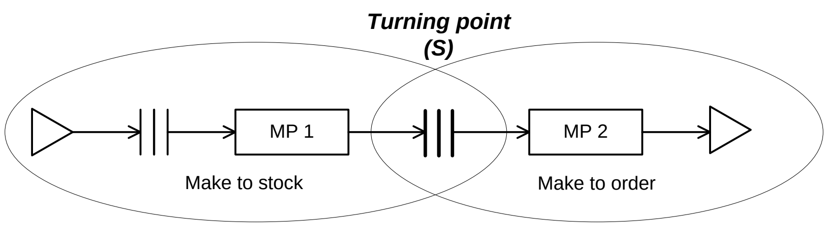
The levels of foil stocks (in the “turning point” S) were defined based on the analysis of the frequency and volume of contracts over the past two years. “S” means the buffer store of the basic foils at two-week supply of the standard foils.

Then there was applied rule that orders for the manufacturing of foils for the certain planning week *N+1*will come out of the consumption in the buffer store

"S" in the week *N*. These may be modified by the prescriptive orders entered by a production manager. The Synchro-MRP is based on the idea that the manufacturing process is divided into 2 parts in terms of planning: [25]

1. MP I - the first part of the manufacturing process, make to stock "S", it is mainly the production of standard foils, which is similar to many products, i.e. planning is provided in the part MP I – by PUSH system, it is planned statistically or with a certain time delay, for example, one time unit (e.g. a week).

2. MP II – it is the manufacturing to order i.e., it is flexible to customers, it is planned by PULL system – make to order – i.e. manufacture of printing.



MP 1 – the first part of manufacturing process – manufacturing of the standard foils
MP 2 – the second part of manufacturing process - rotogravure printing and flexoprinting

Fig. 73. *The proposal of production management scheme of basic foils in company Chemosvit fólie a.s. with the principle Synchro – MRP.*

Model of capacity planning and scheduling is created by the following activities (Fig. 74):

(a) The model for calculating of stock levels of standard foils.

(b) The calculation of virtual order content ($M_{I,\ N+1}$) – the manufacturing volume of products for week *N+1* (according to consumption from the stock "S" in week *N*).

(c) The capacity planning.

(d) The cumulating and the sequence planning.

4.3.3 The Model for Calculating of Stock Levels

The calculation of the proportion of particular foils to the manufacturing volume was quantified by using the Pareto analysis. It points out that the total production of 20% of its products in the company provides 80% of the profits. The idea of the method was used to determine the optimal portfolio of the current products composition, but with a buffer–for a risk in the future.

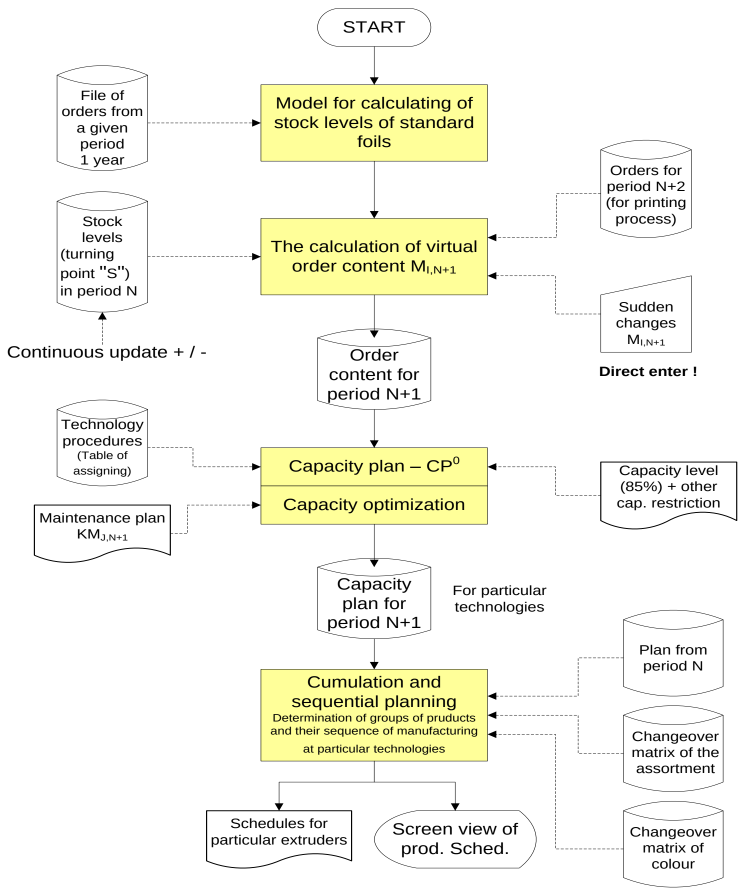


Fig. 74. *The basic algorithm of the concept of capacity planning and production scheduling solution.*

Based on the Pareto analysis of the current data file of the foils manufacturing and a small but regular repeating products it was designed to produce the standard foils and it resulted that 14,22% of all foils with the different thicknesses are involved in nearly 62,8% of total manufactured output. The remaining foils are considered as the special foils that are about 37,2% of the total manufactured foils during the given period in the company Chemosvit fólie a.s. Any other foils that were not produced in a given period or new products shall be considered as the special foils.

Two-week stock levels were calculated from the given data file according to equation:

$$Two - week\ stock\ level = \frac{Total\ volume\ of\ manufactured\ orders\ during\ given\ period}{number\ of\ weeks\ during\ given\ period} \cdot 2$$

4.3.4 The Calculation of Virtual Order Content

To add stock levels (and therefore the orders for the manufacturing of foils) for the week *N+1* can be defined according to:

1. The basis of the consumption of foils in the week *N* (if the state is below of the two-week supply), but is produced in whole economically effective batches.

2. The prescriptive enter due to expected consumption e.g. because of a sudden change in the consumption in the downstream manufacturing sections of printing.

Special foils, because they are not produced to the stock, are manufactured on the basis of the material balance of incoming orders for printing. Need foils for week *N+2* is manufactured in week N+1.

4.3.5 The Capacity Planning Model Proposal

Then the model of capacity planning continues after calculation of the order content for the individual extruders. Assignment of the order content for each technology (extruders type Macchi, Varex 2, Varex 1, Alpine) is done according to the main technology. Thus, it is created the zero level (unbalanced) capacity plan CP^0. After this step, it can be proceed the capacitive balancing – the capacity optimization.

The principle is as follows:

1. Machines are sorted to sequence Macchi, Varex 2, Varex 1, Alpine, this order is a priority for capacity optimization (ranking from the highest quality technology to less quality).

2. It begins with the first machine *J*, where the capacity is exhausted.

3. Then it is found an available technology (machine) *K* with the highest priority.

4. It is found an order with the main technology in machine *J* and alternate in the machine *K*.

5. This order is moved from the technology *J* to *K* and then there are re-calculated the capacity requirements at the technology *J* and *K*.

6. If such an order is not found, it is continued with next available technology *K+1* and the procedure is repeated from the point 4.

7. Finally it is found another machine *J*, where the capacity is exhausted.

The process is repeated until all machines are balanced. If this is not possible, the orders, which cannot be produced for capacity reasons, remain as unmanufacturable in a week *N+1* and they are entered in the file of unmanufacturable contracts.

4.3.6 The Production Scheduling Model

The production scheduling aims to arrange orders to the optimal sequence. Sequential planning is divided into two activities:

- Cumulation orders to groups.
- Sequential planning.

Cumulation

Developing algorithms for cumulation was based on the conditions that production is made to stock. It includes the following procedure:

1. Entering of so called side-runs (side-run is a part of unused width of a foil) into the system (by a logistician of production section).
2. Grouping of orders according to the quality (chemical compos.), then to the thickness.
3. The calculation of the minimum and maximum width of side-runs to each planned order based on the blown circumference.
4. Assigning of side-runs to manufactured orders:
    - Assigning of manually entered side-run into the calculated tolerance of side-run to each manufactured order.
    - Assigning of side-run as an order, if the calculated tolerance range of side-run meets some dimensions of orders from the technology and the creation of so called double-order.

- Assigning of side-run to defined storing assortment.

Sequential Planning

Criteria for sequential planning:

1. Minimizing of changeovers of chemical composition of the sconsecutive orders.
2. Exact date (time) within a week is not set, the production must be executed within one week (manufacturing is made to stock with weekly advance).

Each extruder can be considered as separate element at sequential planning because the rules are different for each extruder. Thus, each technology has different criteria. As an example there is the sequential planning for extruder Varex 1:

The situation on the technology Varex 1 is the most difficult because it produces a large range of products. It can produce almost complete range of assortment produced at all machines.

Production at this technology already includes coloured assortment of white, black and white and white-black-white. These colours are in particular layers e.g. white-black-white is made up of layers of white - black - white. Possible changeovers are shown in the (Fig. 75).

Another problem arises at the “peat – agro” assortment - AG320 and AGW320 alike at Lamiten 105 and W105, 111 and W111 or W205 and 205 etc. where it is added so-called master-batch to white colour. If there are at least two such cases in the cumulating is the procedure in the way that there are changeovers from clear to white, then the W105 and 105, what ultimately means the changeover clear - white - white - clear etc. The changeover from one type of a white assortment to a clear of another type would cause a high production of waste, because there is a different polymer composition.

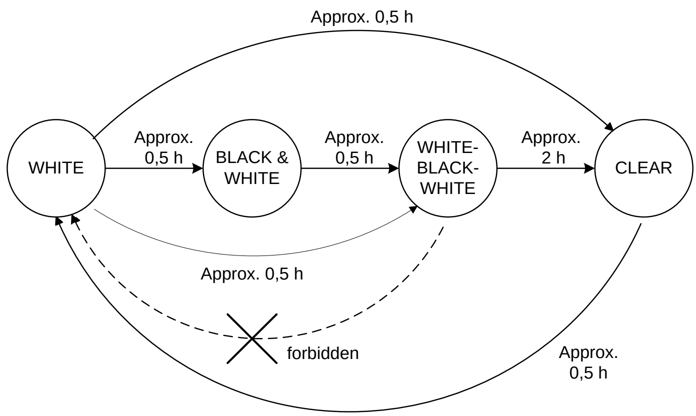


Fig. 75. *Network diagrams of colour changeovers.*

Changeover matrix of chemical composition is referred to the assortment of groups, which have a higher priority than changeover of colours (e.g. Lamiten with Lamiten is preferred against to clear with clear…) Tab. 12.

Tab. 12. *Changeover matrix of chemical composition of assortment at Varex 1.*

	HP, HPE, T09	Lami-ten.	Peat AG	X10	701	702	Milk-MLB	MLB 282S	Others
HP, HPE, T09	X			X					
Lamiten.		X		X					
Peat AG			X	X					
X10*	X	X	X	X	X	X	X	X	X
701				X	X				
702				X		X			
Milk - MLB				X			X		
MLB 282S				X				X	
Others				X					X

4.3.7 Conclusion

The proposed system is built as an autonomous information system, which will itself monitor inventory levels, set the level in stocks with directive inputs of extreme or urgent orders. Its autonomy is more advantageous as a link with the capacity planning of printing because of the effectiveness of the work.

The benefits of this planning model are:

(a) Increasing of objectivity at inclusion of orders to the plan.

(b) Increasing of variability because a person normally created only one option of the plan but this model can serve as a simulator and in a moment it can prepare several variations of the capacity plan and production schedules.

(c) Efficiency performance of orders fulfilment was improved, because in the case of obtaining orders with higher priority, the system can be restarted from any time, i.e. changes are not made at random, but they respect all the rules.

(d) The model allows establishing an advantageous variant of plan in order of optimizing because optimization criteria are directly incorporated in the model of its work.

4.4 Analytic Application of Forecasting of Orders for Printing Rollers in Chemosvit Fólie a.s.

The printing of flexible films for food and non food products uses the system based on the printing rollers, where is engraved graphic (pattern) which is printed on a film. Each colour (also specific colours) is printed by a separate roller. For common full-colour graphics, i.e. one order, approximately 6 - 7 printing rollers are needed. The number of rollers is limited because of storing capacity and costs of rollers. In case of new incoming order there are two possibilities how to cover an order by the sufficient rollers: to use totally new rollers (as a carrier of future graphics) or to use old (already used) rollers, where the old graphic will be cancelled and a new one will be created. The problem is appeared when a graphic on a stored roller is discarded for orders, which can be reordered again. It means, that the main task of the forecasting system is to mark orders connected to rollers, for which it is necessary to keep already engraved rollers, because occurrence of orders in near future (nearest months) is highly probable. The repeated preparation of graphics for certain rollers is very expensive and it takes relatively long time. That is why there is a need to predict time of probable occurrence of each recorded order in this company.

Nowadays, there are in records more than 3500 different orders and the great majority have the signs of uncertainty or irregularity and that is why each order needs to be examined by a separate approach. To eliminate a fatal error it is necessary to find out the solution, which is possible to use in such unstable dynamic processes. This article brings two possibilities of solution: a method suitable for mentioned cases and two methodologies of multi-method combinations.

4.4.1 Basic Function of CFS (Complex Forecasting System)

In the following chapter the performance and deeper study of the complex forecasting system is described. Primary information which is available, consist of the dates, when orders were received and this is the main basis of the historical data. This data need to be transformed into the periods of an order occurrence. Then, there are certain graph lines created for each recorded order and the periods of an order occurrence can be assignment to the typical models of historical data (see below). The transformation of the graph lines is described in Fig. 76. The time line at the top represents an order occurrence in last 24 months (from 1/24 to 24/24), i.e. during two-year performance. A thick line means that an order was active in this time, the number represents produced quantity, but this number is not important for transformation. There is a calculation of inactive periods between two active consecutive periods and the result is increased by 1, for better statistic interpretation later. For example between the periods 11/24 and 12/24 the result is "0" and this can cause a mathematical difficulty. This procedure creates the graph lines of each order. The axis 'X' represents *the number of occurrences – frequency of occurrences* and axis 'Y' is *the number of inactive periods – interval of occurrence* between two active consecutive periods, increased by 1. In principle, this transformation calculates that each following active period is after the calculated period (Fig. 76).

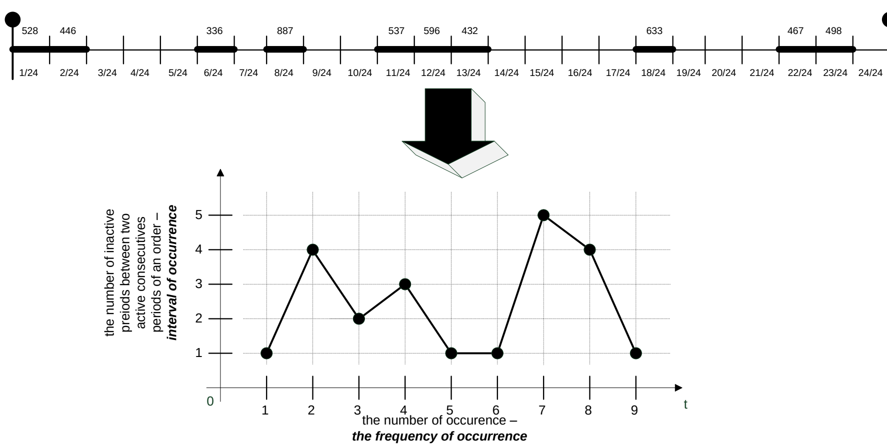


Fig. 76. *Transformation of periods of an order occurrence into the graph line (Kačmáry, Malindžák, 2010).*

After the transformation of order occurrence to graph lines, the next process of classification of the graph lines is provided. The block of classification is important for the strategy of forecasting, which method or technique should be used to create good forecasting results. There are seven basic and associated types of graph line models of historical data [34, 35, 36]:

1. "**K**" model – constant model.
2. "**T**" model – trend model.
3. "**S"** model – seasonal model.
4. "**C**" model – cyclic model.

To trend models can be associated also two sub-models:

5. "**TC**" model – trend **-** cyclic model.
6. "**TS**" model – trend **-** seasonal model.

Model time series, which do not suit with the above models:

7. "**E**" model – empiric model.

It is possible to assort any graph lines to the above mentioned models only when the frequency of occurrence is higher or equal to 6, besides model "K" and "T", where the minimum of 3 occurrences are enough. Because, three occurrences give two points to get a line and it evaluates by "K" or "T" model. At least one of the occurrences has to be within the last six months, otherwise the forecasting is skipped in this case of the application because it is considered that an order is totally inactive.

There were used only standard and generally known forecasting methods in all models besides model Nr. 7 – empiric model. This is a model, where it is not possible to determine any patterns of value occurrence so it is not possible to allocate these lines into above determined models. Thus, forecast calculation becomes very difficult with an uncertain result. The way of forecast calculation can lead through methods or methodologies suitable for stochastic, dynamic changeable processes, chaotic scatters or volatility time series. New approaches (both methods and both methodologies) described in this paper were used and were applied in CFS.

4.4.2 System Application

The application and implemented of new methods and methodologies in the proposed CFS is shown in the block algorithm (Fig. 77). For each roller set connected to recorded order is prepared forecast individually. The CFS uses standard statistical method according to models in which the time series are sorted. In case that no standard model is used, the calculation is done by the proposed methods and methodologies implemented in the last block of the algorithm – empiric model.

The example of the CFS system output with the certain order, its history and the order occurrence prediction with recommendation is in the following (Fig. 78).

The fist example had almost the sings of constant line, so the calculation was provided according to rules of the model “K”. Because the predicted time of the order occurrence was almost 2 month, the result was to keep the engraved rollers on stock for the soon occurrence of the order.

The second example has signs of stochastic behaviour of the time series, so the calculation was provided according the rules of the model “E”. There were used new approaches and it resulted to the predicted time of the order occurrence up to third month, which was also recommended by the CFS to keep the rollers on stock.

Calculation in the third and the fourth example was provided according to rules of the model “T”. Predicted time of the order occurrence of the fourth order was over the determined limit, the CFS gave recommendation to reject rollers for the order – it means, that this set of rollers can be used for another orders.

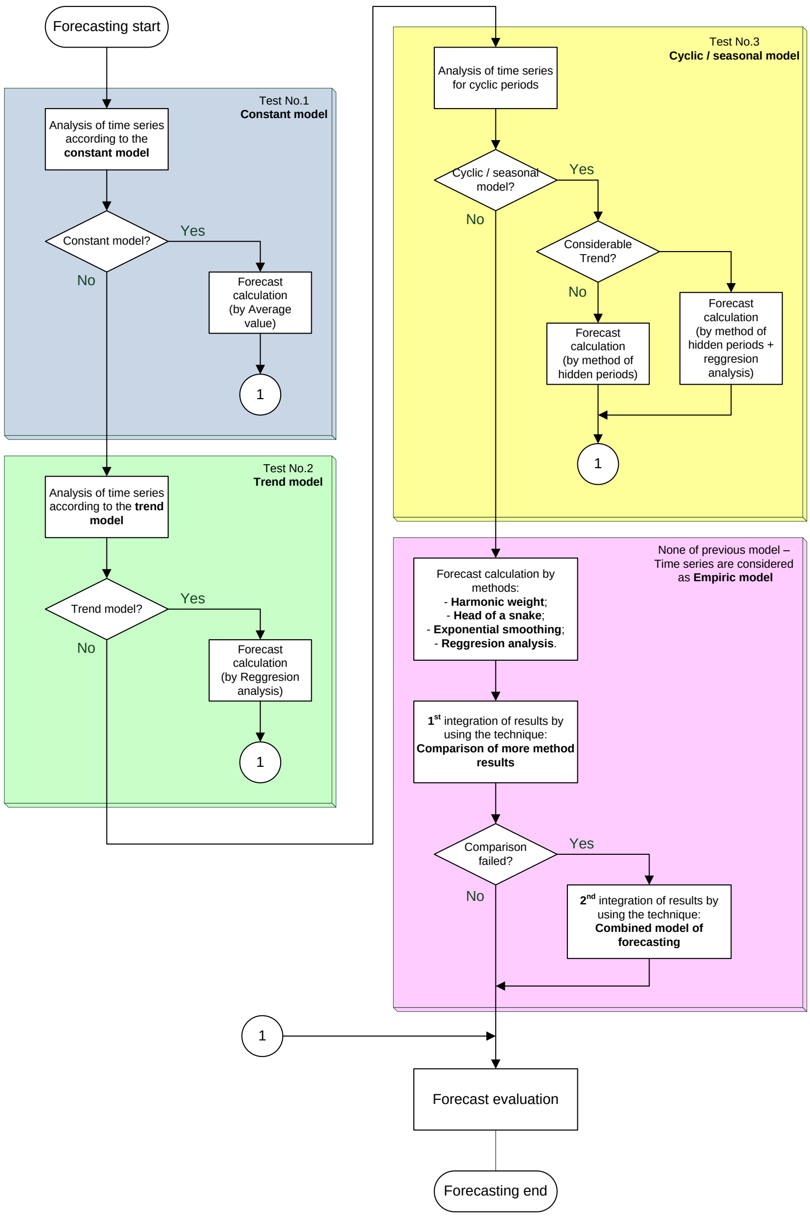


Fig. 77. The algorithm of the Complex forecasting system progression.

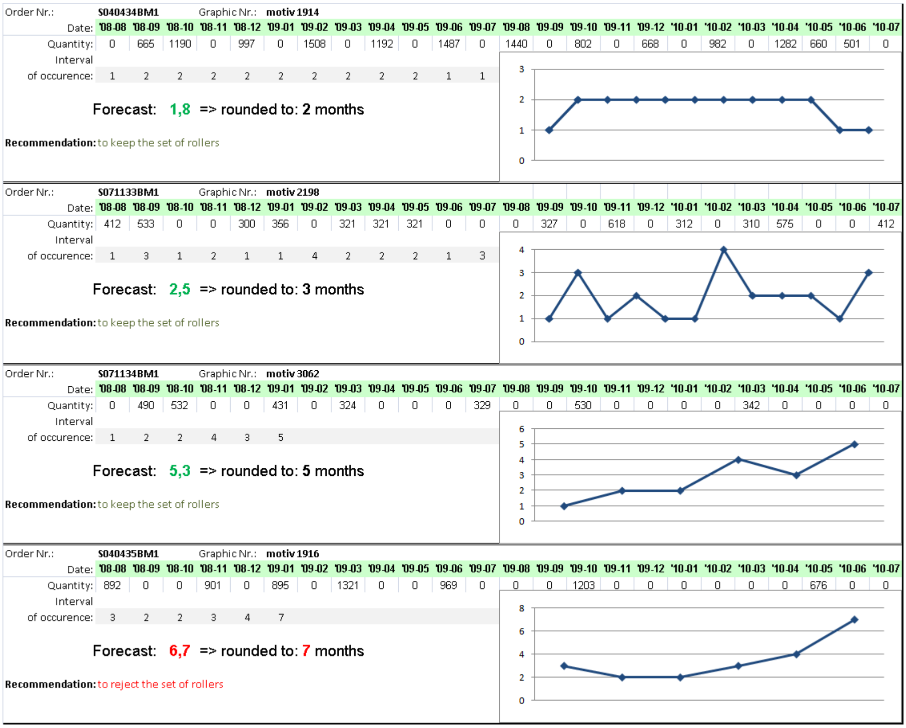


Fig.78. *The example of the application of the Complex forecasting system.*

4.4.3 Conclusion

There are some important reasons for prediction of incoming orders in analysed company. One of the most important reasons was the optimisation of store of archived printing rollers in a company's warehouse. The second important reason was to decide immediately which of the sets of rollers graphics can be cancelled and prepared for active uncovered orders. These facts were the foundation of the project for design and implementation of the proposed complex forecasting system. It also began to be a part of ERP system of the company.

In the company there are more than 3500 records of orders in evidence, which were ordered and were produced in history. Average number of rollers in one set for one order is approx. 6,7 pcs. Assuming, that the company wants to keep on stock all sets of rollers for each recorded order, approximately 24000 rollers with ready graphics are required. Then a huge storing space would be required because of relatively large dimensions of one printing roller. It is almost impossible to have on stock such a large number of printing rollers. That is why the company is forced to optimise this storing space and to keep on stock only these rollers, which are supposed to be often and frequently used. This is evaluated by the complex forecasting system. The system has to evaluate continuously the present situation, because the company has in disposal only approximately 7000 rollers. The CFS was created for the company, which calculates the forecast and recommends which rollers need to be kept on stock and which is possible to rework for another uncovered active order.

This Complex forecasting system is a part of multicriteria decision process concerning cancelling or keeping roller graphics for certain orders, because there are numbers of other factors, which can influence this decision process. The whole system is implemented into an ERP system of the company and it is a tool for a worker of operation planning at the division of rollers preparation.

In Figure 6 there are examples of the results of forecast calculations by the CFS using four real records of orders from the total number more than 3500 records. Each order from these 3500 records is analysed and forecasted continuously every week before the capacity planning of the manufacturing process to count required capacity for the division of rollers preparation. These four examples from 3500 records were chosen to demonstrate the outputs of the CFS, the first order represents calculation according to “K” model, second order according to “E” model, third and fourth order according to “T” model. The fourth order example also demonstrates the recommendation of rejection of printing rollers for this order, and these rollers can be used for another active order.

There are used many circumferences of rollers in the company, it varies from 550 mm up to 1000 mm. The circumference of 600 mm is most often used and in total comparison it is about 15%. Following, there are the results of optimisation process using the CFS in all orders using 600 mm rollers. Some facts are summarised in the Tab. 13:

Tab. 13. *Input information.*

Total number of orders using rollers of 600 mm circumference:	**530**
The number of orders, where the frequency of occurrence is higher or equal to 5:	94
Number of cancelation and remaking graphics for the sets of rollers connected to above mentioned orders:	633
Average number of rollers per order:	6,7

Calculation:

633 x 6,7 ≈ 4241 engraving per two years.

The complex forecasting system could save approximately 4241 engravings. If the present capacity of engraving facility is 80 pieces per day, it means there can be saved 53 days of useless engraving during two years, which would definitely help to increase flexibility and money savings. To increase flexibility at their planning system is one of the main goals of the company during the years of economic crisis.

4.5 Simulation Model of Big Metallurgical Company

The content of this paper is focused oriented on data obtaining for the modelling and simulation of the production, transport and stores processes in the metallurgy, which represents system approach of LS starting from the raw material resources through mining and metallurgy processes to the customers (automobile companies, cold roll mill factories, civil engineering industry, e.g.).

This large system can be considered as a LS or logistics nets. For the research purposes this type of the system can be analyzed applying simulation models. In many cases the simulation (when parameter systems are stochastic) is only one possible solution. The goal of this paper is to describing the methodology of the simulation model design and optimization of parameters LS applying simulation models. LS consists from elements which have very complicated structure.

In the LS model this complicated units are represented as one element with its inputs and outputs. For information obtaining about each elements is necessary their depth analyses.

> *"This large system – originating its material flow from raw materials and moving towards end – customers we can understand as a logistics system or supply demand network" [47].*

To obtain the data for the simulation model design and experimentation, it was necessary to analyze all processes in the chain as well as all divisions participating in the LS. The present research study describes case studies and models to analyze processes of mining, materials processing, metallurgical, transport, warehousing, maintenance, e.g. The result of case studies are data for the simulation model design, and input data file for the simulation model experimentation [48].

4.5.1 The Methodology for Large LS Simulation Model Design

The system can be analyzed and explored [49]:

(a) on a real object.

(b) on a physical model.

(c) on a mathematical model.

(d) on a simulation model.

The simulation is analysis and synthesis method, where the designed LS is replaced by its simulation model. On this simulation model are carried out experiments with the aim to achieve parameters that are later applied back on the examined and designed LS [50, 51].

The simulation of a large LS is one of the latest and most expensive alternatives for the LS optimization. From the point of complexity, stochastic characters of operations the simulation is unique approach for the LS synthesis. *"Specific problem areas in steel production planning and scheduling include inventory management, slab, plate and cast design and melting shop, hot strip mill and finishing-line scheduling. Optimizing of each problem area independently can result in savings for a steel manufacturer. However, even greater gains can be achieved by simultaneously optimizing all of these interrelated areas."* [52].

Simulation models are functional models which simulate the functions, activities and processes of the real LS. In our case we are not modelling the real factory parts but its functions and processes, e.g. ore exploitation, storing, transport from underground, transportation of raw materials etc. The creation of a simulation model requires a specific analysis described during the simulation model creation [53].

In our case a large LS consists of discrete (transport of slabs, manipulation with coils, slabs) and continuous processes (iron and steel production, continue casting) [48]. For these types of the LS it is better to apply simulation systems which are able to model discrete and continuous processes, e.g. EXTEND.

4.5.2 Steps of Simulation Model Synthesis

1. The problem definition is e.g. wrong function fulfilment; low performance of a shipping system, long waiting time at the crossings, violation of delivery dates, and overload of intermediate operation stores, etc. The problem definition is e.g. to find the optimal length of the green light at the crossing, the right place of allocation and the layout of the manufacturing system, the design of the optimal capacity of intermediate operation buffers, etc.

2. If the object (a company, crossing, conveyance system) exists, we have to define the system on this object, which we would like to optimize e.g.: a topology, element parameters, transmittance, and capacity utilization and to define the variables: time, position, and capacity. If a real system doesn't exist, we have to conclude it from its project and design. The meaning of the simulation model assumes the existence of projected system in a real or project form [50].

3. The definition of variables for the simulated model and capture of data, which described particular LS (operational time, transport time, waiting time, transmittance, capacity, etc). Provision of data for simulation model appears from results of analyses of each works in metallurgy factory.

4. The transformation of the defined LS into a bulk service system respectively or other formalized models which are in the form useful for modelling by a particular simulation tool (a simulation language or system).

5. The selection of a simulation tool – a system for the model creation. It can be – the universal language, e.g. Pascal, C++, however a creation of the simulation model is more complicated, or it could be one of block-oriented simulation languages e.g. GPSS, SIMAN, or one of iconic languages SIMFACTORY, EXTEND, which are necessary for the model creation. In

these special simulation languages the model creation is significantly easier. There is the only disadvantage of the simulation model synthesis, the designer must be skilled in at least in one of the simulation languages or some other tools.

6. The creation of the general simulation model – is a concept of the simulation model and it defines which element of a real system will be modelled by which elements or tool of the simulation language, e.g. arrival of cars to the crossing will be modelled by generating random numbers in GPSS represented by the GENERATE block, in SIMANE by the CREATE block; the machine operation will be modelled in GPSS by orders:

   - SEIZE A
   - ADVANCE $T1$, $T2$
   - RELEASE A

   (A-name of machine, $T1$-processing time, $T2$-processing time dispersion). Such modelling will be carried out by different blocks in SIMFACTORY, and different blocks in SIMAN, EXTEND, etc. Steps 5 and 6 are the most creative. They are the core of the synthesis and require concise and creative way of thinking, knowledge of the object programming philosophy.

7. The creation of models of the elementary processes and the definition of parameters, functions and blocks:

   The parts of the model consist from elementary components – inputs, queue, machines, buffers, dividing, gathering, quality control, etc. Other parts of the model are:

   - the generation of random numbers (modelling of inputs, orders).

- the process synchronization.
- the time control in a simulation model (TIMER).
- the gathering of the simulation results.
- the output definitions of variables and their charts.

8. Transcribing of the model to simulation model using the language command – the creation of a simulation model (according to language type).

9. The verification of a simulation model:

   - From a logistic point of view – if processes in the real system are performed in the same way as in the model, if model truly reproduces the behaviour and functions of the real system.

   - From the formal point of view – if the syntax of the used language is ensured. While the logistical correctness must be controlled by particular controlling steps (e.g. model flows control, their directions and capacity), the formal point of view is controlled by a selected language compiler – simulation system.

10. The simulation time is the time that passes during model experiments. The essential question is how long it is required to simulate a real system so that results (executed statistically) can be approved as valid for a designed LS. Due to the complexity of LS relations, very often there is no possibility to define a simulation time. But the more precise results we want to achieve, the longer simulation time is required. There is one simple rule: the simulation is performed till $|x_i - x_{i+n}| \leq p$. This means, that the difference of variable *xi* values during *i* experiments and $i + n$ experiments is less than or equal to the defined precision – *p*. If the required precision is achieved during experiments, the simulation can be finalized.

11. The evaluation and result calculation. From the results which offer the standard of simulation systems we can calculate some cumulative variables, e.g. total cost, calculation of multicriteria optimization.

12. Experiment iteration with another variant. One of the big advantages the synthesis by the simulation model is a possibility to simulate many variants.

13. Variant evaluation and selection of optimal solution. By some multicriterial evaluation of variants the optimal solution of the system is calculated. Simulation model makes possible to change input parameters as variation of parallel working equipments, variation of processing time. Variations of results are subject of multicriteria classifications. Target is to select optimal solution at clearly defined data.

14. Application of a solution to a real system.

4.5.3 The Transformation of the Real Logistic System to Formalized Model

For the simulation model design of the LS we have to transform the real manufacturing, transport and storing processes to a formalized model as described above in the steps sequence of the simulation model synthesis [48].

This case study presents formalized model (from the Slovak industry) of the LS from the mine Siderit Nižná Slaná, s.r.o. (Fig. 79, 80), processing division Nižná Slaná: production of Fe pellets Nižná Slaná, transport to metallurgical company, reloading of raw materials and storing inputs, material stores, Fe production in three blast furnaces, Fe transport to steel works, continue casting works of the slabs, repairing hall and storing in the cold store, modelling of charging into the push furnaces, rolling on the wide hot rolling mill and creation the tin coils, cutting workshop. Outputs of these processes are branches to three directions:

- customers.
- cutting division.
- cold roll mill division.

Within the frame of the Mine Siderit Nižná Slaná research we concentrated on the balance model design of the production process and on the multicriteria optimization of applying reengineering methods.

For the purpose of production process analysis has to be created the next models within the frame of a metallurgical company it was mainly:

- the raw material discharging model.
- the layout of raw material optimization in the input raw materials stores.
- the blast furnaces charging model.
- the planning and scheduling models for individual aggregates.
- the models for indirect measurements.
- the products sequence optimization models for individual aggregates.
- the capacity models for the definition of the bottle neck of the metallurgical process.

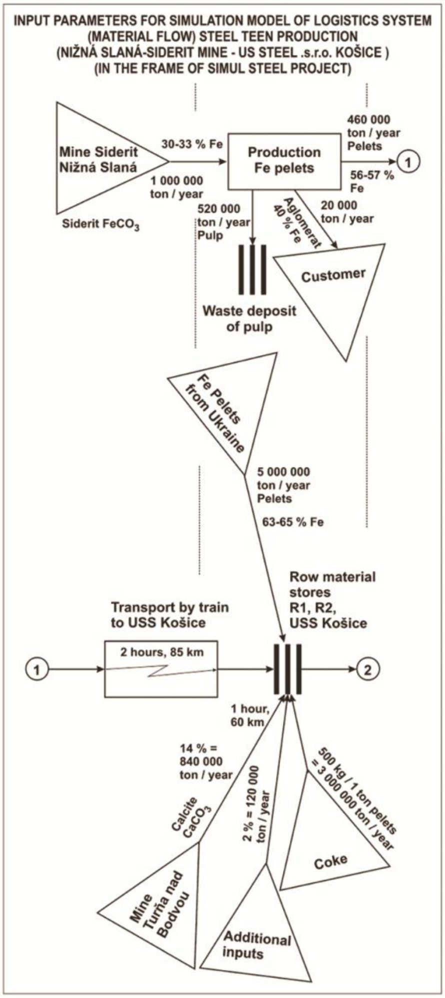


Fig. 79. *Formalized model LS, input parameters for simulation model of LS, part1 [48].*

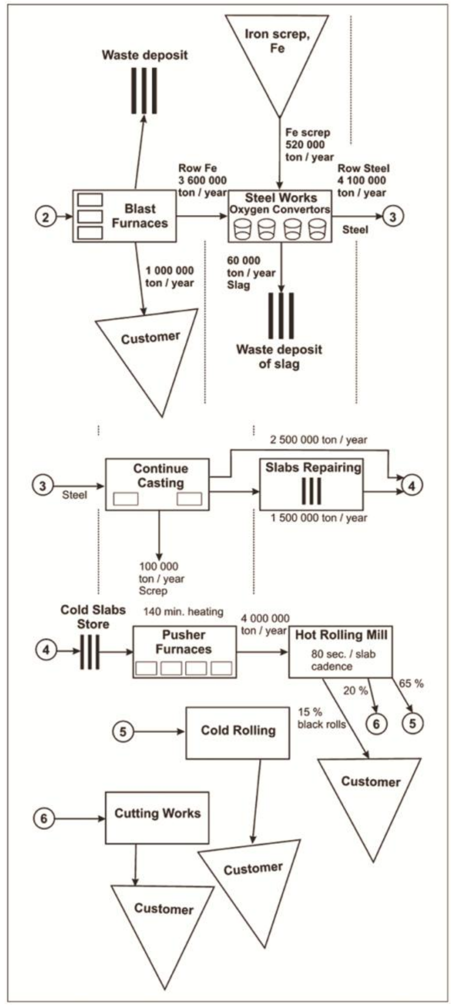


Fig. 80. *Formalized model LS, input parameters for simulation model of LS, part2 [48].*

Figure 79 and 80 displays a chart diagram of the formalized model LS in mine and metallurgy manufacturing processes described above.

The results of the analysis and case studies are data files for the design of a simulation model and experimental data for the simulation model of the LS.

Results of the analysis are the summary and aggregate data described in the chart diagram of the logistics system on Fig. 79 and 80. The logistics system is described on the principle input - output (black box) for each elements of the complex modelled chain from raw material resources though individual technological, manufacturing, transport and storing processes to consumers.

Data which contain formalized model are obtained from case studies [48, 50-56].

4.5.4 Conclusion

The present paper describes the methodology of the creation of the simulation model which is in many cases only one way of analysing and designing the large scale LS. This methodology has been applied under the condition of the mining and metallurgy manufacturing [48, 59, 61-70]. The paper describes a formalized model and data which are necessary for the simulation model design and to perform the experiments with this model.

Described methodology was applied in many factories for example VSŽ – USS Košice, the Mine Nižná Slaná, the Mine Lubeník, Steelworks Podbrezová, the Mine Nováky, and the Mine Veľký Krtíš.

4.6 Quality Evaluation of Logistic Systems

The origin of the term of quality dates back to the ancient times and philosophical sciences. For the first time it was used by Plato, who believed that judgments based on measurable (quantitative) criteria cannot fully describe phenomena and items. The real world is an imperfect representation of really existing perfect ideas. Quality of individual items means therefore the reached degree of perfection [76].

In the following centuries many authors dealt with the issue of quality, described and characterised it. E. Kindlarski gathered over a hundred definitions of quality [77]. One of them was formulated by Donkelaar:

> *"Product (service) quality is good only when with minimum costs of use it provides maximum contribution to the health and happiness of all persons who have participated in its design, production, distribution, use, protection and recycling and distinguishes itself with minimum consumption of energy and resources as well as acceptable impact on the environment and the society" [78].*

This definition expresses fully and unambiguously the essence of quality and indicates all elements that should be taken into account in designing and quality assessment of products and services. It also refers to ecological aspects and the impact of products and services on the society, which is quite important today. The history of logistics is also that long.

Quality and logistics should be closely related to each other. It is enough to compare definitions of both these terms, in which satisfying customer's needs and the level, that is the quality of provided services, are very important. On the other hand, reference books rarely and only fragmentarily refer to the issue of quality in logistics. They lack a comprehensive, complex approach encompassing all aspects of this issue.

4.6.1 Quality Assurance Methods and Systems

Quality assurance is the primary objective of quality management because not only quality alone but in fact quality assurance inspires trust in the supplier. Quality assurance implementation requires development of a quality assurance system including such components as: proper organisational structure, processes, procedures and assets [80].

Reference books in the field of quality as well as practice of production companies demonstrate that there are many various solutions and concepts of quality assurance. In a synthetic aspect, we may properly classify these solutions and present the following description perspectives [81]:

- evolutionary, presenting stages of development of the concept of quality assurance.
- proprietary, presenting achievements of selected and popular originators of quality assurance.
- regional, representing differentiated approach to quality assurance depending on local conditions of a given country or commonwealth.

These aspects overlay and are closely related to each other. However, we cannot determine accurate time frames of individual stages of quality assurance development because they started differently and their course was in each case different, depending on the country, region, branch of economy and even the company.

A. Hamrol and W. Mantura distinguish the following most typical stages and concepts of quality management development [81]:

1. Production control: It is included in the organisational structure of the company, in production units in the production or technical department. Control functions in this case refer to a work post. The subject of the control

may be the product, but also a part, unit, assembly, etc. which is obtained in the course of a production process and assessed in terms of technical quality. Therefore product orientation and acceptance function dominate. It is a control that has properties of restrictive remedial inspection. The main purpose of its results is to determine whether to accept or reject a product and remunerate or punish an employee.

2. Quality control: This type of control is based on the assumption that quality may not be forced by control, it must be developed. A more developed organisational structure occurs, closely related with quality. It mainly concerns laboratories, test and analysis units, staff units and other. Quality is taken into account not only in the technical aspect. This approach usually includes certain elements of preventive activity as well. Responsibility for quality is divided between production and management units and method of self-control is in use. Quality control in this case has features of acceptance and prevention control and uses methods of statistical quality control.

3. Quality guidance Regulating is most important, including the functions of control and correction. Elements of planning and quality stimulation are also present. Quality guidance uses a cybernetic model with feedback, therefore it is process-oriented. It is complex, so it goes beyond the quality service which has a very important place in the organisational structure of the company. Quality guidance employs self-control and systems of faultless work. Additionally, methods of statistical control of technical process are often in use.

4. Quality Management: The abovementioned concepts and stages included only certain management functions, while this concept takes into account a complete set of these functions. Growth of importance of quality management was particularly distinctive in Great Britain where BS 5750 standard

was introduced in 1979. It determined requirements for quality assurance systems. In 1987 the International Organisation for Standardisation published a series of standards referred to as ISO 9000, which specify terminology related with quality management, describe different models of quality assurance, determine functional conditions for this models as well as guidelines for quality management and elements of quality assurance systems.

The third edition of ISO 9000 was introduced in 2000. It includes four standards:

- ISO 9000:2005 (PN-EN ISO 9000:2006) Quality management systems – Fundamentals and vocabulary.
- ISO 9001:2000 (PN-EN ISO 9001:2001) Quality management systems. Requirements.
- ISO 9004:2000 (PN-EN ISO 9004:2001) Quality management systems. Guidelines.
- ISO 19011:2002 (PN-EN 19011:2003) Guidelines for auditing management systems.

The next edition of ISO 9001 standard was introduced in 2008 and since 2009 it has been in use in Poland as PN-EN ISO 9001:2009. Minor changes introduced in this edition mainly concern more specific and accurate formulation of certain terms and provisions [82].

Changes were also introduced in 2009 to ISO 9004 standard, which is Polish PN-EN ISO 9004:2010. Above all, the name was changed. The current name is: *"Quality management oriented on permanent success of an organisation. Quality management approach"* [83].

Complete, accurate and detailed implementation of the said standards in a company as well as meeting all the related requirements do not mean that the company has a comprehensive and complex management strategy. The concept that is currently referred to as the best one, including all issues related with quality management implementing all management functions and involving all employees of the company, is “Total Quality Management” (TQM).

According to S. Tkaczyk: “Total Quality Management is a people-oriented management system purpose of which it is constant increase in satisfaction of customers gained at really constantly decreasing costs. The TQM is a complex system approach (not a selected field or programme) and an integral part of the high-level strategy; this system functions horizontally, crosswise to functional sections and departments, involving all employees of the entire company; it goes in both directions beyond the company in order to incorporate the supply and distribution chains. The TQM emphasises teaching and adaptation to the process of constant changes as the key to the success of the organisation” [84].

The integrated management system is an interesting idea. More and more often in theory and practice of company management are taken actions oriented at integration of individual autonomous management subsystems. One general management system may encompass [85]:

- quality according to ISO 9001.
- environment according to ISO 14001.
- occupational safety and health according to PN-N-18001 (BS 8800).
- finances.
- logistics.

However, most often integration encompasses only quality, environment and occupational safety management systems and sometimes quality systems implemented in individual branches of industry. Logistics is treated as a separate field of management.

4.6.2 The Concept of the Logistic Process Quality Assurance System

Logistic process may be implemented with use of all of the methods and quality management systems described above. However, they do not guarantee reaching the goal of high level of customer service because they do not include all aspects of logistic process management. Furthermore, research carried out in Polish companies indicated that many quality management tools are used only to a small extent (Tab. 14).

Tab. 14. *Quality management system improvement tools being implemented (results of research of 2006 and 2007, comparison of segments depending on the number of employees and origin of the capital; percentage of indications).*

Implemented management system improvement tools	**Number of employees**						**Capital**			
	up to 50		**51 - 250**		**over 250**		**foreign**		**Polish**	
	2006 N=64	**2007 N=63**	**2006 N=112**	**2007 N=147**	**2006 N=83**	**2007 N=90**	**2006 N=73**	**2007 N=66**	**2006 N=186**	**2007 N=234**
Environmental management system	15.63	20.63	42.86	38.78	56.63	61.11	52.05	74.24	36.02	65.38
Occupational safety and health management system	20.31	3.17	24.11	14.29	55.42	28.89	43.84	31.82	29.03	11.97
Total Productive Maintenance/5S	10.94	14.29	17.86	19.73	27.71	36.67	24.66	33.33	17.20	20.94
Self-assessment/ assessment according to quality awards criteria	12.50	17.46	12.50	10.90	20.48	21.11	15.07	7.58	15.05	17.09
Lean Management	9.38	15.87	15.18	8.84	26.51	25.56	24.66	34.85	14.52	9.83
Balanced scorecard	23.44	7.94	16.07	9.52	19.28	23.33	17.81	21.21	19.35	11.11
Six Sigma	6.25	3.17	9.82	7.48	14.46	14.44	13.70	19.70	9.14	5.56

Source: Prepared on the basis of: [86].

Individual quality management methods and tools are mostly used by large companies with foreign capital. It was confirmed in independent research in companies in the automotive and aviation industry. The figure 1 shows the model, the use of which guarantees a large extent the goal. On this basis we may say that the most complex logistic process quality management system that may also be introduced in other companies has been developed and used at United Technologies Corporation.

Companies belonging to the UTC implement the system of Achieving Competitive Excellence. It is a system of continuous improvement in all fields and aspects of company functioning, in particular in terms of operational activity management and in production logistics. It enables achieving company goals through mobilisation of employees in their everyday activities [87].

The system consists of ten "tools". These are popular work and management organising methods and techniques, in particular based on Lean Management but within the framework of ACE used in a comprehensive and consistent manner. The tools are integrated, effective and may evolve depending on specific application. They encompass methods of communication and measures for monitoring of activity.

The first one is 5S + 1 method. Its objective is to simplify, improve and create safe work conditions. It reduces wasted time, visually arranges the workplace, creates friendly and safe work environment.

Use of 5S method consists in removal of useless items from the workplace, putting useful items in their specific place and keeping production department and the entire plant impeccably clean. As these activities are performed systematically and work methods are constantly improved, a firm system guaranteeing order and tidiness is created. It is not only tidying, though, it is a process of thorough changes in the company culture, based on management visualisation, standardisation of processes and teamwork. The sixth “S” is Safety, which means safe work in a safe environment.

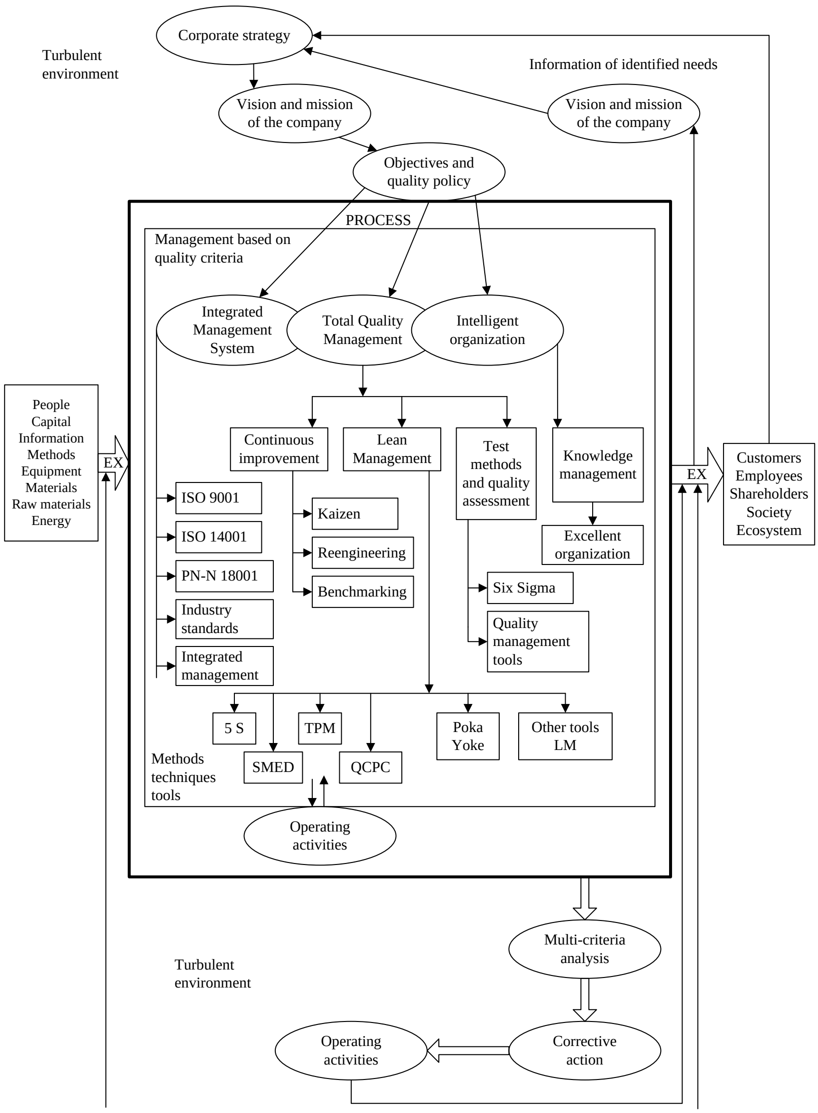


Fig. 81. *The model of the quality assurance system.*

The second tool is Single Minute Exchange of Die (SMED), it is team reduction of machine tooling exchange time. Activities are focused on reduction of down time between production of the last part of one series and starting production of the first part of another series. The positive effect is increase in machines and equipment capacity, increased work efficiency, standardisation of work methods and optimisation of series sizes.

The third tool, Total Productive Maintenance is a concept aimed at increasing productivity and efficiency of processes related with workflow maintenance through increasing creative involvement of employees participating in such processes.

The major issue related with the fourth tool of model methods is grouping similar parts in so-called families in order to standardise methods of production. This promotes elimination of activities that do not provide added value, avoiding losses and shortening of the production cycle.

The most important problem to be solved with use of the fifth tool: Quality Clinic Process Chart – QCPC, is organisation of a database system, which enables constant improvement of the process and solving quality-related problems. Each employee may present comments on their work post, describing everything that hinders reaching the required production quality in an appropriate questionnaire. Employees' remarks also refer to occupational safety and health threats.

Gathering information every day facilitates taking immediate corrective actions. Additionally, all reported issues are categorised according to their importance and suggested solution at the weekly meetings of the QCPC team. If there is a problem that cannot be solved by the team, it is passed on to the “Quality Clinic”.

The sixth tool is the RCCA method (Root Cause Corrective Action), consisted in developing standard decisions referring to specific original causes. This tool is used in order to prevent reappearance of problems.

The basic issue in the regression analysis of the market, which is the seventh tool, is to identify external and internal customers and provide feedback that will make each employee understand their needs. Data from the market and the customers, concerning quality of products must reach every work post, every employee. This will facilitate improvement of quality of products and services.

The eighth tool, error prevention (Poka Yoke) is strengthening the process against errors, which consists in active controlling of potential sources of inconsistency, so that it would be possible to identify an error before it becomes inconsistency. When the error is found, production is stopped or a proper action is taken to prevent occurrence of inconsistency as a result of such error. While monitoring potential sources of errors in each phase of the process, we may found and correct inconsistencies at their very source, which means that this tool may prevent errors through elimination of their causes.

Process validation is the ninth tool and it enables process management, understanding, controlling and monitoring deviations. Validation or certification of the process is used for stabilising it and maintaining at the statistically controlled level. Certification of processes is based on statistical methods and includes measurable and non-measurable characteristics. The result of using this tool is repeatable production of high quality items.

The tenth tool is process management which consists in permanent and consistent implementation of preventive methods in process improvement. It enables determining the optimum process and identifying its weak points. It eliminates activities that do not bring added value to the process.

Beside the described tools, Kaizen system is in use. It consists in making slight improvements in a continuous series with use of the existing tools or systems, through the employees of proper company departments for the benefit of which improving actions are taken. Such activities mostly do not require involving significant financial assets or external experts. In Kaizen, standardising and a system that supports maintaining the level of changes are essential. It is also related with the principle which says that no further actions may be taken if the level of previous change is not maintained.

We may use either all the above mentioned tools, the chosen ones or even only certain parts of these tools. However, positive effects will not last if they are not supported by the organisational structure facilitating changes in the company operations and by professionally trained personnel.

Achieving Competitive Excellence system is based on three basic components:

- quality management principles developed by Yuzuru Ito – ITO University carries out weekly training sessions within this scope for all employees, in particular directors and managers.
- a system which helps the organisation identify and solve problems, improve processes and supports strategic thinking.
- professionalism, dutifulness and involvement of all employees and the entire organisation.

Training company employees is essential. All employed persons have the possibility to participate in a free training and improve their qualifications, mainly within the framework of the scholar programme in which course fees as well as the costs of materials and textbooks are covered.

ACE system is not a one-off action - within its framework teams of employees systematically reach four successive levels:

- qualifications.
- bronze.
- silver.
- gold.

It is the primary motive for constant improvement and consistent use of ACE tools. It is hard to define and measure the results of implementation of the system. However, if we take a look at individual companies of the UTC concern, we may notice that they beat their competition, gaining contracts, for instance to supply aircraft engines. In the times of the today's crisis, companies not only collapse, but also develop while UTC buys other ones in the aviation industry.

All companies within the concern carry out an annual survey among all their employees. Answers are helpful in improving the company activity and reflect results of the implemented system. The survey carried out at WSK "PZL – Rzeszów" presented good economic condition of the company and over 80% of the respondents said that the good points of that company are care of quality and following occupational safety and health rules, whereas around 80% of them referred to the company as a good workplace.

4.6.3 Conclusion

Achieving Competitive Excellence system may be implemented and used not only at the UTC but also in other companies. However, it always requires adjusting the system principles to the specific character of individual companies as well as monitoring and analysing results obtained in implementation of the modified system.

Implementation of the ACE system is not easy. Costs of preparation of individual system components, training of employees and making necessary organisational changes must be incurred.

Good preparation and consistency are vital in implementation, and in particular in employing the developed solutions in everyday business. Therefore change in mentality of all employees including the management is very important, so that the introduced and implemented actions would be the work culture on each post.

The most significant threat related with implementation and functioning of the system is lack of consistent actions of the management and employees of the company. Low qualifications of the personnel may also be a threat, therefore particular attention must be paid to training and professional education as well as all company staff. Problems may also occur if other, competitive companies employ the same or similar solutions. But ACE system is flexible enough to enable introduction of other, new components, which makes it possible to beat the competition.

Still most important chances lie in improvement of the company structure and organisation, reduction of costs. But above all, implementation of the ACE system and its everyday functioning may contribute to improvement in management and functioning of the company, also in the area of logistics, which is followed by improvement of its condition and market position.

4.7 Application of Logistic Principles in Metallurgical Production

Logistics is the branch of management, where the objects of management are flows and chains with the target of their overall optimisation [24]. Logistics has a cross sectional character [88, 93]. The specific characteristics of the logistics of metallurgical production follow mainly from the object of management i.e. metallurgical production processes. The production processes of metallurgical production have several specific characteristics, which have to be accepted while managing them.

MPP is a chain of continuous and discrete technological, transport, manipulation and storing operations, which have to be transformed into a discrete form first when modelling these processes.

Then, there is a long production cycle and also great inertia especially for thermal processes, long delivery cycles of supplied material (even several months) and typical tree structure of the production process [24]. From these the strategy of Feed Forward management resulted. [24]

Metallurgical companies are huge companies making very high investments (even billions of Euro) resulting in long recoupment period of investments and high lifetime [18]. Metallurgical products are at the beginning of the production chain. These products are materials like metals, semi-products (plates, pipes, wires) which is the reason why products with different than planned quality do not need to be scrapped (as it is e.g. in machine or electrical industry) and it can be still used for a lower quality purpose. The output of these production processes is only one product or a narrow assortment of products.

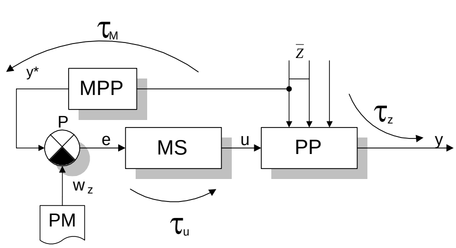
Above mentioned and other characteristics of MPP – classify these production processes into so called homogeneous production processes. [24] The costs for its automation, informatization, and logistics applications are relatively low compared with the costs for building the technology and equipments. All of these approaches bring at least 5% of cost savings. In absolute value these savings are high. That is the reason, why metallurgical companies are leaders in these applications which means also leadership in logistics as well as production logistics. [24, 88, 91]

4.7.1 The Specific Characteristics of MPP Logistics

The specifics characteristics from the point of logistic are:

(a) *Great inertia* - This is influenced by a long production cycle, thermal processes (blast furnace, push furnace) and big amount of moving material flows.

For this types of processes as the basic logistics model is the feed-forward principle of management is applied, which is based on the program – operative plan of production (PM) and monitoring of inputs $\bar{z}$ to the production processes. On the basis of the vector $\bar{z}$ and the model of production process (MPP), the forecast of outputs y* are simulated (Figure 1). PM is usually created on heuristic principles. [18]



P – comparison process – element
PM – planning model – program
MS – management system
MPP – model of production process
PP – production process
z – inputs, break down
y – outputs
y* – simulated outputs
e – deviations
u – decision making
w_z – the goals of production
τ_M – simulation time of the outputs y*
τ_Z – transmission the break down to outputs of PP
τ_U – decision making time

Fig. 82. *The structure of feed-forward management – philosophy FFM (Feed forward model).*

(b) *Big investment* and long life cycles mean long economic return. It is necessary to continuously adjust and keep the parameters of the products from the point of facility and aggregates utilization. This fact has to be taken to MPP.

(c) *Narrow product assortment* - Narrow product assortment (metal sheets, cement, wires etc.) enables application in the production process of special purpose aggregates, facilities, and machines with high level of automation. A disadvantage here is low level of flexibility in changing the production. These characteristics have to be taken into account in the planning models (PM).

(d) Combined continuous-discrete process - Metallurgical processes consist of continuous and discrete technology processes. If we want to create MPP, it the first step is transforming these processes into discrete types and then to apply a system for modelling the discrete system, because the continuous discrete production processes are very hard to model. [89] For modelling and simulation of discrete production processes, it is easy to apply the systems such as GPSS, SimFactory, Extend, Witness etc. The second alternative is a balance model.

Other specifics of metallurgical processes are:

1. Tree structure from roots to leaves.
2. Faulty product does not need to be considered as a faulty product, it can be sold as a product with lower quality. [90]

4.7.2 Example of the Logistic Principle Application to Metal Steel Production

Each company has its own specific structures of production processes, rules and objectives of management, is unique and also is unique from the viewpoint of logistics. [91] Logistics is a management concept, which the following principles applied:

- system approach.
- co-ordination.
- planning.
- algorithmic realization; and
- overall optimization of the chain. [24, 93].

In this case slabs of required sizes and quality are cast by two equipments for continuous steel casting (CC I. and CC II.). The diagram of material flows is in Fig. 83. The cast slabs are transported to the slabs reparation plant where they are repaired before rolling and from there to the cold slabs storehouse or they are directly transported to four push furnaces (PF1 to PF4). After heating up to the rolling temperature they are pushed out from the push furnaces and transported by a roller table for rolling at wide hot mill (WHM – 1700, named also as TŠP - 1700). The field store yard serves to balance the differences in production at times of regular repairs at WHM - 1700 or during operation shutdowns at CC I. or CC II.

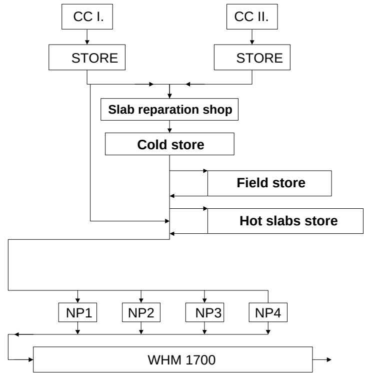


Fig. 83. *Scheme of material flow in the CC – PF – WHM.*

The three main parts of the steel division, WHM - 1700, PF1 - PF4 and CC I. and CC II., have their own system of operation planning.

Each single part is understood as unit of one system, its mutual relations create material flows, but also information relations in the way of operative plans.

One of the logistic goals of the Steel division is to coordinate production operating plans of WHM - 1700, PF1-PF4 and CC I. and CC II. in order to accomplish the maximum portion of slabs are in direct sequence (CC - FP – WHM-1700) thus solving the problem between the difference production capacity of Slabs reparation plant (approx. 1.5 million tons yearly) and production of CC I. and CC II. and WHM - 1700 (approx. 4 million tons yearly) but at the same time the more slabs there are in the direct sequence the less is the energy consumption for their heating up in the push furnaces (cold slabs are of outdoor temperature i.e. approximately 10 degrees Celsius, the temperature of hot slabs is from 150 to 400 degrees Celsius).

The fact is that every hour material with the value of about 200 000 € flows through these aggregates requires very precise systems of scheduling. At WHM - 1700 it is so called schedule of WHM - 1700, 24 hour and 7 days plan, at FP has a schedule of charging and at CC I. and CC II. has a schedule of casting.

Planning, system approach and processes coordination must be controlled by the overall optimization [36, 92]. Individual elements of the production process have different criteria of optimization. For example, for WHM - 1700 slabs groups of the same type in the amount of 20 to 40 are best for rolling from the standpoint of rolling technology because with such amounts the best exploitation of operation and support rolls of roll stands is achieved when changing the slabs groups according to certain rules.

It is therefore an effort of operating planning of WHM - 1700 to form groups with these amounts of slabs. From the standpoint of characteristics of production processes at CC Ist and CC IInd it is necessary to readjust the crystallizer through which slabs are cast with every change of their size. However, the readjustment of the crystallizer means idle time of CC Ist and CC IInd and also creation of a reducing slab which must be adjusted before rolling (if we know how to sell it in the final product) or it becomes scrap. The goal of CC Ist and CC IInd is therefore to cast the greatest series of the same slabs possible. For PF the optimal batch is equal to the length of the dominant II. Zone, see Figure 3 The optimal production batch is the compromise among the technological batches for these three aggregates.

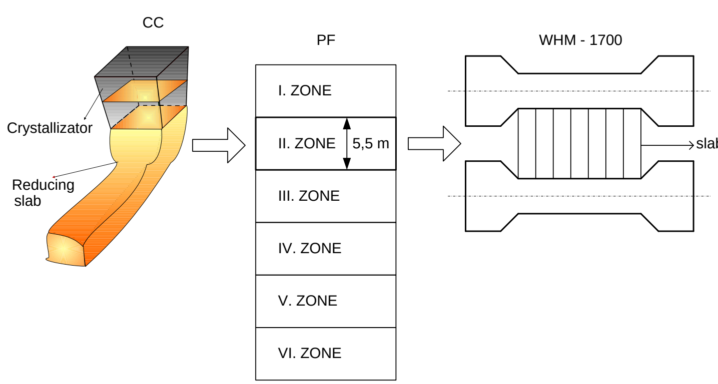


Fig. 84. *Creation of the optimal production batch.*

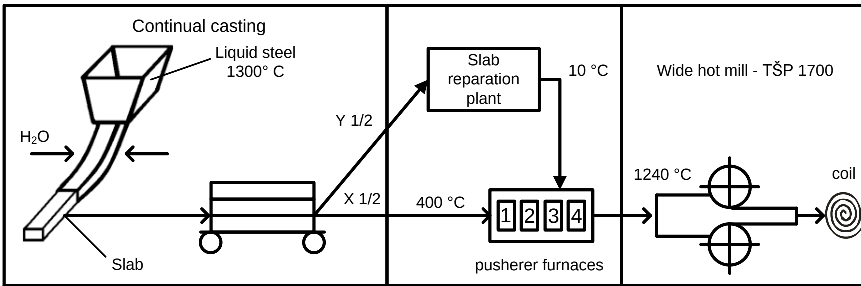
It results from the previously mentioned that local criteria of optimization must adapt to the superior overall criteria, for example maximum profit, minimum energy consumption, keeping the confirmed terms of order etc. [24, 89].

One of other characteristics of logistics is logical organization of individual operations of the production process and the algorithmic consistency of their effectuation. Algorithmic realization ensures logical order of steps, activities continuation, activities repeating, compatibility in communication and realization. Likewise with the algorithm, it can be a definite activity sequence, cycle, alternative selection- decision-making, etc.

4.7.3 The Relation of Management, Logistic and Technological Operation Control in the Conditions of Metallurgical Process

Inner enterprise processes of the company can be divided into three levels:

- economic processes.
- logistic processes (chain of the technological, transportation and cumulating operations).
- technological operations.



CONTROL: - speed of casting - quantity of cooling - ...	- furnace temperature control - ratio of air and gas control	- roller pressure power control - distance roller control
LOGISTICS: - min. number of reducing slabs - optimal sequence of casting - optimal number of slabs in sequence - coordination with TŠP	- increase of the ratio of hot slabs - synchronization of heating and roling - optimal system of storing slabs in the warehouse - choice of proper furnace for heating of certain slab	- size amount off rolling - sequence off rolling of each amount and coordination with heating of slabs in pusherer furnaces - coordination of rolling with continual casting
MANAGEMENT: - minimizing of costs of coils production - fulfillment of terms of delivery products - energy, maintenance, performance costs - division production, etc.		

Fig. 85. *An example of activities and variables for three management levels [18].*

These three groups of processes are characterized by other variables, other managing variables and managing criteria. While technological operation control manages physical, mechanical, thermal and chemical variables like pressure, temperature, liquid level, speed of rotation, ratio among the variables etc., the management criteria are used for example to find out the optimal curve of heating with the aim define economically e.g. minimal heating costs.

When there are the subjects of management of technological and transportation, cumulative processes, which are considered as the chain or network, then we speak about logistics. There are managing time, place, and capacity variables.

Management – management of economical processes of an enterprise is based on the principle of hierarchical managing i.e. the logistics have to respect the aims of the management, as the supervising level (for the whole enterprise to work optimally) and aims of the logistics are moved beyond the base level on the technological process control.

4.7.4 Conclusion

In the 60s and 70s of previous century, automation was the basic dynamic factor of production industry. Toward the end of the 20th century, information systems like Steel man, SAP R/3 etc., which partly include logistics, were the dynamic factor.

The dynamic factor of early 21st century is the logistics. From the logistic point of view, each production process is different, each has its specifications and this is the reason why logistic systems are needed to be developed and implemented as unique, “made-to-order” systems, based on the present conditions of modelling, simulation and information technology and to be applied their knowledge to heuristic models and expert systems.

Metallurgical companies, especially by reason of fast return of investments, are always the leaders of implemented automation, information technologies and they are also the leading companies implementing logistics in their production.

4.8 Heuristic and Logistic Model for Production Scheduling of WHM 1700 in OCEĽ VSŽ a.s. Košice

Production technology modification in OCEĽ s.r.o. company (main division VSŽ)- conversion into a continuous slabs casting (CC) in CC I and II and progressive rejection of slabing, as well as costs reduction for heating in push furnaces (PF) through the use of increased amount of hot batch, but especially by conversion of production philosophy in hot wide line (WHM 1700) in conditions of market economy, i.e. maximal satisfaction of customers requirements, represented by orders, of delivery terms, quality and ordered amounts- were a main reasons for model processing for operative plans in CC, PF, WHM 17000 automatization and co-ordination. This model is not a project, so some concrete information is not mentioned designedly.

4.8.1 Description of Material Flow in Division CC-PF-WHM 1700

Slabs of required dimensions are casted in two devices for continuous steel casting (CC I, CC II) (fig.1). Casted slabs are transported either to the slabs cleaning shop and cold store or by direct sequence into a four pusher furnaces (PF 1 to PF 4) for heating. After heating, slabs are pushed out from pusher furnaces for the rolling in hot wideband line (WHM 1700). Field store is used for differences compensation in production during regular repairs of WHM 1700 or during longer downtime of CC I or CC II. [24]

4.8.2 Purposes, Principles and Rules for Operative Plans WHM 1700, PF and CC Co-ordinatiom and Automatization

Operative Planning Objectives.

Production technology modification in OCEL̕ company- conversion to the continuous slab casting in CC I and CC II with perspective of slabs rejection and maximal effort for customers’ requirements adaptation- results in following solution objectives:

(a) Maximal satisfaction of customers in term of demands is represented by orders and observance of delivery term and ordered amount per week.

(b) Coordination of WHM, PF and CC production plans to achieve the highest possible number of slabs in direct sequence, so difference between slab cleaning shop capacity and CC I and CC II production was resolved, but great acquisitions should be also from energy savings for slab heating in PF. [24]

To achieve energy savings for slabs heating in PF through material flow organization and PF operative planning.

Principles of co-ordination:

(a) Operative planning is timely and by content realized contra directionally to material flow.

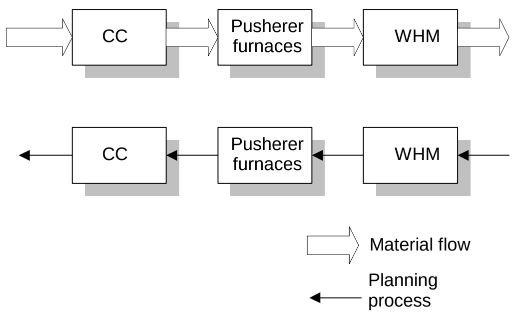


Fig. 86. *Operative plans and material flows directions.*

(b) It was selected interval for 7+7 days for optimal plan WHM 1700 development, because of orders confirmation per “week”. Another 7 days of the plan is preliminary, allowing coordination, feedback of unrealised slabs from first 7 days, longer interval 7+7 days allows more convenient commutation and longer series in CC. Second 7 days allow production of slabs for orders from these 7 days, in the case of capacity CC over WHM dominion, so they will stay in store limited period only.

(c) Plan is developed for 7+7 days. First 7 days, the optimal plan is definite, another 7 days- preliminary. We suppose max. 10% of changes during preliminary plan re-planning into a definite one (moving planning).

Content coordination (figure 87).

(a) Direct sequence slabs are manufactured in CC approx. 6 hours before rolling and they are transported to the PF approximately 2,5 hours before rolling.

(b) Slabs through the cleaning shop, in relation to the technological time, necessary for cleaning, will be casted minimum 3,5 days before rolling.

(c) In the case of CC over WHM output dominion, slabs of non-direct sequence are planned in steel-mill's operative plan for first 7 days, from WHM 1700 operative plan for another 7 days.

(d) Operative planning system has three levels of hierarchy. Operative plan WHM 1700, (OP WHM) for 7+7 days, consists of WHM 1700 schedules for 24+12 hours, containing campaigns.

OP WHM (7+7) => {24+12} => {campaigns}

Operative plan PF is created for 24+12 hours and consists of images two genarations operative plans OPN1, OPN2. Operative plan CC is created for 7+7 days and more detailed one consists of 24+12 hours operative plans, and these plans consists of WHM schedules-campaigns (for 2,5-4hours).

(a) Coordination, mostly of the direct sequence, is based on JIT principle.

(b) Scheduling models are based on heuristic principles. Technological rules are rules, derived from rules of technology and logistics principles. Heuristics are rules, derived from experiences of schemers - logistic-men and employees of operation, based on principle of analogy and induction.

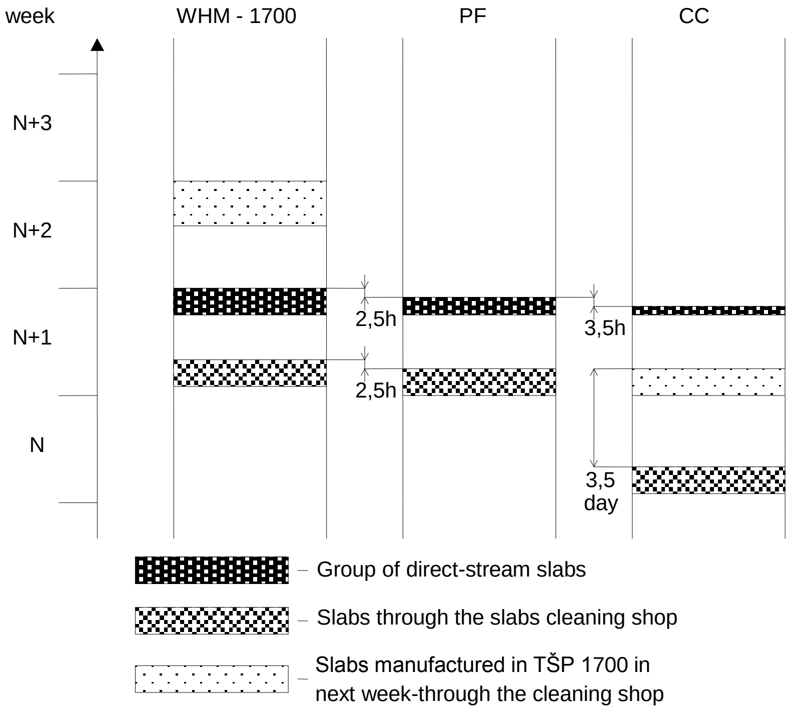


Fig. 87. *Material flow co-ordination between WHM, PF, CC.*

Example:

Technological rules:

Rules of campaigns creation C1, C2, C3 are derived from WHM 1700 cylinders abrasion rules.

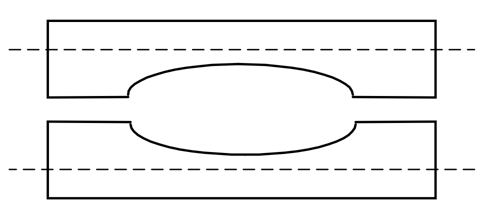


Fig. 88. *Cylinders abrasion.*

Example:

Heuristics:

During large cylinders replacement in WHM 1700, hot batch of slab loading to PF is necessary.

Note:

In term of technological rule we understand such rule, which was created on the base of logic consequence, technological soundness. Heuristic rule (heuristic) is such rule, which is raised on the base of experience, practice, intuition, i.e. by repeating of analogical situation solution and consecutive induction.

4.8.3 Model for WHM 1700 Production Scheduling

Schedule WHM 1700 development is based on orders file for 7+7 days.

During schedule WHM 1700 development, following is necessary:

(a) Distribution of individual orders (represented by slabs groups) in to the campaigns in such way, that:

- all rules (heuristics) of scheduling in WHM 1700 are observed,
- every campaign will be used as much as possible, i.e. the largest possible amount of material, concerning the cylinders life-cycle, will be rolled in campaign.
- term order will be manufactured within required term.

(b) distribution of individual campaigns between support cylinders replacement in such way, that scheduling rules in WHM 1700 will be observed.

(c) To provide WHM schedule to operative plans and schedule-makers on CC I and CC I in sufficient advance- so they have a time for their development and co-ordination.

Heuristics and technological rules for production scheduling in WHM 1700:

Note:

Because of copyright, there is not introduced complete list of rules. In the case of interest, you can find them in the reference [94]. From technology and production management, 16 rules were derived, e.g.:

Introduction of width and size assortments of operating cylinders individual campaigns shall be executed in dependence from support cylinders abrasion condition of final order.

1. Line testing after operating cylinders replacement shall be performed with assortment from 3,0 – 4,0 x 1015 – 1240.
2. Minimum 6 and maximum 12 pieces of slabs shall be used for the beginning of campaign.
3. In campaign, assortment shall be arranged from wider to narrower, because of cylinders abrasion.
4. Allowed size-jumps in individual items planning upwards and downwards are as follows:
   - up to 4,0 mm .... 2,0 mm jump.
   - maximum allowed width pass is +/- 250 mm, etc.

These rules led to the characteristic campaigns development. In term of campaign it can be understood production time period in WHM 1700 between two “large cylinders replacement” and in the same it is time typical assortment structure, in terms of quality, amount and dimension and their typical sequence:

(a) wrapping campaign without small replacement of cylinders - C1.

(b) dynamo-campaign with cylinders small replacement - C2.

(c) wrapping campaign with cylinders small replacement- C3.

Every campaign has its own limitations and rules.

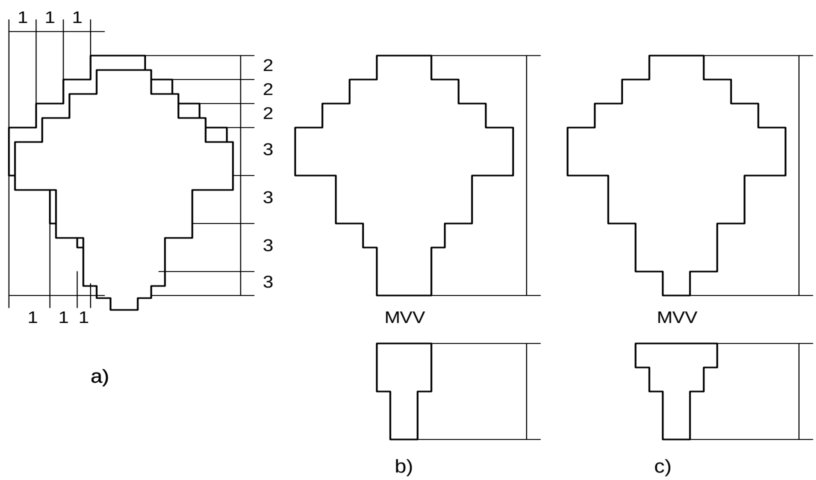


Fig. 89. *a. b. c. Campaign types in WHM 1700 (C1, C2, C3) [24].*

Explanations of figure:

1. Min. difference in band width 80 mm.
2. Max. amount in item 9 pcs.
3. Max. amount in item:

2,0 – 2,5 mm ..... 20 pcs.

2,6 – 3,0 mm ..... 25 pcs.

3,1 – 4,0 mm ..... 30 pcs.

Orders set processing:

Weekly stock of work (7 days) is possible to divide into the groups in accordance with width and direction, to simplify determination of order type, convenient for given place of campaign filling, during individual campaigns filling (Fig. 90).

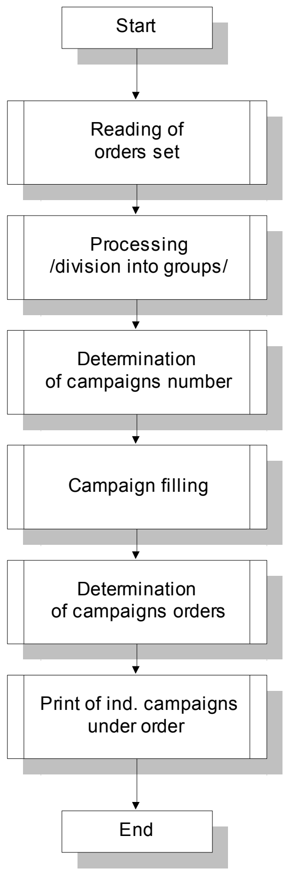


***Fig. 90.** Algorithm of production planning in WHM 1700 [24].*

Disposal in accordance with width:

S1 up to 899 mm.

S2 900 – 1039 mm.

S3….

…

…

over 1380mm.

Disposal in accordance with width has a given structure, to allow a steady secure transfer from one group to the other in individual parts of campaign, without exceeding the max. width jump 250mm.

Disposal in accordance with size:

H1.... up to 2,99 mm.

H2.... 3 – 3,99 mm.

H3.... 4 – 5,49 mm.

Disposal accordance to with size has a given structure, to allow a steady secure transfer from one group to the other in individual parts of campaign, without exceeding the max. size jump for certain band size.

Disposal in accordance with direction:

SM1: 676x, 6844- dynamo sheets.

SM2: 677x, 676x, 684x – it is not possible to roll in first campaign after supporting cylinders replacement.

Method of campaign types and number determination:

At first, we will determine number of dynamo campaigns – NC2 and number of slabs for dynamo sheet production – DC. We will determine approximately, how many slabs is possible to roll in one dynamo campaign- NSC2. Number of dynamo campaigns:

$$NC2 > DC/NSC2,$$

where NC2 is an integer. Then, we will determine, how many slabs, belonging to the group with the widest slabs, will remain. We will determine, in how many wrapping campaigns these slabs can be rolled – we will obtain min. number of wrapping campaigns –NC1. Then we will determine if it is possible to roll other width groups in given number of campaigns. If not, NC1 is reduced by 1 and number of wrapping campaigns C3 –NC3is determined.

We will determine again, if in given number of campaigns, rolling of other width groups is possible. If not, repeat the procedure, till all the width groups are covered by campaigns. In the case, that NC1=0 and number NC3 not cover all the width groups, NC3 is increased to cover them. In such way we will obtain number of campaigns: NC1, NC2, NC3 and we will continue with their filling.

Campaign filling:

Campaign filling depends on campaign type in accordance with planning rules in WHM 1700, e.g. campaign C1 filling.

TRIAL RUN:

(a) begins with number of 6-12 pcs. from group S3, best 1040 or 1050mm, because it is the largest amount, size H1, direction SM4, SM2, SM3 or SM6.

(b) continues with number of 6-12 pcs. from groups width S4, best 1290mm, because it is the largest amount, width H1 or H2, direction SM4, SM2, SM3 or SM6.

CAMPAIGN:

(a) begins with width S6 (if possible), otherwise S5, width H1, H2 or H3 (if trial run was terminated by width H2), direction SM4, SM2, SM3, SM6 or SM8. Number of pcs.- over 6.

(b) continues with the same groups, only size can be change upwards by 1 group and downwards by two groups. Number of pieces over 6, total number of pieces in points 1a and 1b must not exceed number 20-30 in dependence from size, as far as scheme from fig. 111 is not applied.

Campaigns order determination:

Campaigns order is determined in accordance with planning conditions in WHM 1700:

- 1st campaign: it cannot contain SM9 and S6 intersection with H1, H2 or H3 (H1, H2, H3- size groups, S1 – Sn are width groups).
- 2nd campaign: it cannot contain SM3 and S6 intersection with H1, H2 or H3.
- 3rd campaign: it cannot contain S6 intersection with H1, H2 or H3.
- 4th campaign: it cannot contain S6 intersection with H1, H2 or H3.
- …
- campaign: it cannot contains S6 intersection with H1, H2 or H3.
- campaign: it cannot contains S6 intersection with H1, H2 or H3.
- campaign: it cannot contains S6 intersection with H1, H2 or H3.

- …
- N[th] campaign: cannot contains S6 intersection with H1, H2 or H3.

4.8.4 Conclusion

The case study describes the methodology of model development for production schedule WHM 1700 atomization in OCEĽ comp. VSŽ a.s. Košice. It defines rules, criterion, restrictions and objectives, and on the base of heuristics and logistics, it creates model's algorithm. It is an application of theory for production scheduling heuristic models development.

4.9 The Heuristic Approach for Maintenance of Operative Planning Model Design of a Gas Distribution Company

4.9.1 Introduction

According to new estimates, all economic subjects in economically developed countries spend approximately 10% of national income on maintenance. In search of cost saving in maintenance process it puts great accent on effective operational planning. Appropriate organization of these activities has a direct impact not only on the technically safe and reliable operation of devices, but also indirectly on the amount of their operating costs. [95] In the distribution company for oil and gas the maintenance cost are dominate. [99].

Developed methodology is addressed in the enterprise for the first-stage maintenance management, which is directly responsible for the design of planes from the volume of work which are defined by annual plan and from the operative evidence of reported and detected faults [97, 98, 101, 18].

Targets of maintenances management – we define by the norm STN EN 13306as the objectives established and adopted for maintenance activities, whereby they may present for example usability, cost reduction, product quality, environmental protection, safety etc. [96].

Operative planning issues from three main sources, namely from:

1. Annual plan of maintenance, which contains defined planned preventive and corrective actions in certain cycles, which are specified by law, standards or they are defined illative by technical risks management.

2. Continuous assessment of the state of gas devices by ATS and RS indexes, which assess the technical state (ATS), safeness and reliability (RS) by multiple criteria. On the basis of exacerbated values of quantification indexes, gas devices can be integrated to the operative plan of maintenance.

3. Operative evidence of determined failure and escapes which were filed by preventive maintenance and also failure and escape reporting by consumers, for example through breakdown line.

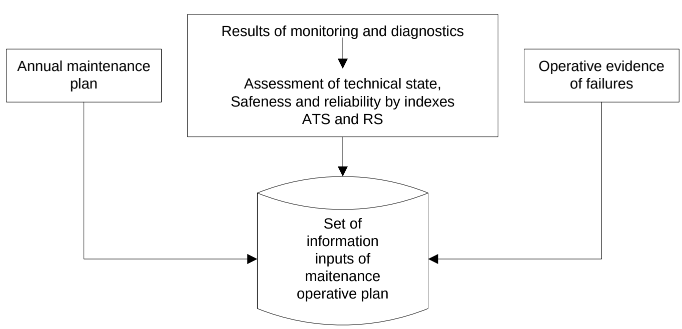


Fig. 91. *Basic information sources of operative planning [99].*

The volume of unplanned maintenance, which is performed after failure of devices, forms the value by 20% from total volume of maintenance in the enterprises for distribution of continuous media. The part of planned (preventive) and unplanned (reported or ascertained) maintenance is different on the part of time, it is 80/20 at average. [99].

Operative maintenance plan is a weekly plan on days, it is the last level of decision about the future maintenance activity within the hierarchy of enterprise objectives.

On the part of maintenance management system analysis in the current enterprises we see as a major shortage of operative planning the absence of one level of planning – capacity planning, that would prove at greater lapse to respond to changes in maintenance requirements.

4.9.2 Methodology for Model Design MOP

The Information Sources for Model of MOP

Information from annual plan

From the aspect of activities this plan includes:

- Regular cycle activities of technical inspection (different types of control and measurements, for example tightness control…).
- Preventive maintenance activities (special inspections and tests, routine and minor repairs of equipment).
- Medium and major repairs in the field of renovation and modernization (repair of technological objects etc.).

The specific form of plan for the demand of operative management of maintenance must be available for each organizational unit (which relates to), for example by the help of software application. It is also important to say that the form of annual plan puts more precisely forever and it modifies by actual assessment of technical condition and safeness of equipment. [100].

Assessment of technical condition and safeness of the network by the indexes ATS a RS.

The methodology for assessment of technical condition and safeness presents the system of multi-criteria assessment of equipment. Each criteria and sub-criteria (technical or economic nature) are rated according to the weight of their impact on the overall technical state assessment (ATS), or safeness and reliability of the network (RS). Long-scheduled selected items evidenced in the operative records are the basis of actual assessment.

Concrete values of indexes ETS and RS are obtained after criteria and sub criteria items up in the concrete time. [103] By their values monitored devices are classed from time to time to three maintenance zones:

C - For devices without failures. It is exercised only basic maintenance and control in terms of laws, notices and standards.

B - For devices with compromised reliability. It increases the cyclicality of controls, it tightens up the regime of diagnosing and measuring, devices are classified into the development plan of reconstruction.

A - For devices with high age and relative reliability. It is given maximum frequency of controls, the most stringent system of measurement; devices are integrated to the planes of extraordinary reconstruction.

Operating managers are charged with responsibility for development of maintenance planes in accordance with evaluation of technical state (ETS), safety and reliability (RS).

Monitoring and operative evidence of the failures:

Maintenance operative management in enterprises for distribution of continuous media must ensure except for aforesaid activities the collection of information about fault rate of devices, too. By the character of measured data this collection can be provision manually, to before prepared blank forms, or automatically, by the help of various sensors and detectors. The administration of actual technical-operative documentation is provision from the results of reports from evaluation of diagnostic control, specialized checking and tests and so on. This is controlled and recorded electronically to software module, for example SAP. By found failures, or emission from the aspect of underground localization, to system GIS, too. Operative evidence subserves the role of feedback of the complete operative management. The use of its actual data has direct continuity to the process of operative planning.

Design of MOP

The first step by daily operative planes creation is assembly of demands on maintenance for the given week, including the delays from the previous period and determination of the priority of fulfilling on the part of its importance. [105] As we reflected, by operative planes of maintenance it is a combination of preventive and corrective maintenance. We used the process of multicriteria decision making for the selection and determination of priorities for several activities of maintenance. By the solution we used the method of weighted sum, in which we determined criteria, by which all basic activities of maintenance exploited in enterprises for continuous media distribution evaluated individually.

Criteria for evaluation of the maintenance activities. [99, 102].

1. Cyclicality – it is a factor which presents statutory or planned cycle for given activity realization. Generally it is a deal, that the cycle of the given activity is more frequent, by it has to get higher items up in this criterion. If the activity is not realized in cycles and it performs only by assignment (for example correction), it must be allocated to it at the highest value.

2. *The importance of the segment* - it is a factor, which takes into account the significance of a network segment, on which the action relates. By maintenance it is in force that the highest significance has the segment with the highest priority of importance.

3. *Impact on safety and reliability* – this factor predicates about it, how it affects a specific maintenance activity to ensure safety and continuity of service distribution network, as well as re-establishing in the event of failure.

4. *Sequence of secondary activities* – it is the factor which expresses the need of the next activities for given activity realization (for example measuring after correction and so on).

5. *Personnel* – qualification fastidiousness – factor which defines quantitative (personnel) and qualitative (qualification) demands for assess activity of maintenance.

6. *Time limit* – it is a factor, which defines limit usage of working standard hours for realization of this activity. If the work expenditure of maintenance activity is higher, the point value of this factor must by higher too.

7. *Economic fastidiousness* – it is a factor, which makes provision for expense fastidiousness and material-technical demands for maintenance activity support.

8. *Conditionality to climatic influences* – it is a factor, which expresses what the influence climatic conditions have to the possibility of activity realization. [104].

There are various activities in maintenance (for example control of the tightness of gas lines), which are directly weather dependent. After the choosing of aforesaid criteria, we used the method of sequence for establishing of their adequate weight. The most important criterion has the number n-1, the second has n-2 etc. The least important criterion has the number 0. By this method we obtained/get the matrix of preferences, which contains these opinions:

- opinions of employee of the management of particular networks operation,
- opinions of employee of the first-stage management of maintenance,
- opinions of employee of maintenance “master”,
- and also our preferences.

Because this valuation obtains our preferences, too, we can say that it was some pseudo-expert appreciation of ranking criteria. For each ranking criterion F_i for i = 1, 2, …8 we calculated the sum of sequential numbers pi, which was rationed to this criterion by participant of valuation. After calculation the weight of each ranking criterion by the relation:

$$W_i = \frac{p_i}{\sum_{i=1}^{s} p_i} = \frac{\sum_{j=1}^{4} p_{ij}}{\sum_{i=1}^{s}\sum_{j=1}^{4} p_{ij}} \qquad (1)$$

$$j = 1, 2, \ldots 4 \qquad whereby \quad \sum_{i=1}^{8} W_i = 1$$

Cardinal extends are determined - assessment within the range of 0 until 10 to items up of maintenance activities (by elected criteria with calculated weight). By the problems of points allocation to assess activities we used services of several experts from enterprises which are concerned with distribution of continuous media within the frame of “east” of SR. Items up was performed by maximization form, i.e. the bigger pointed value, by it the given factor has higher importance among values of the same factor by different activities.

The final overall assessment of this activity was obtained as a sum of items up of criteria k_i multiplied by their weight W_i.

As an example it was appreciated the gas enterprise, to which we specify the similar types of maintenance activities for the other enterprise and by this method it was appreciated 79 basic activities of maintenance. On the part of obtained evaluation these activities were classified into three groups.

Statistically it is visible in the next figure.

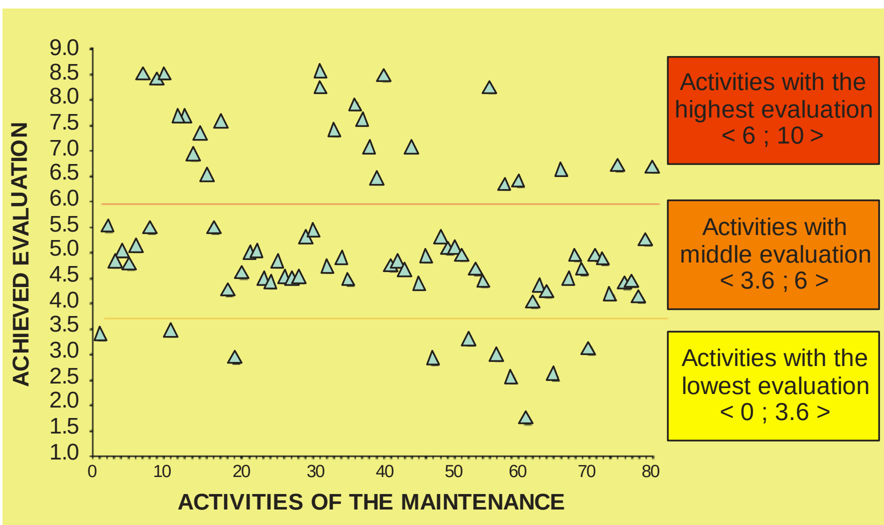


Fig. 92. *Statistic illustration of maintenance activities evaluation [own source].*

Activities with the Highest evaluation (A)	Maintenance activities, which have to be immediately classified do the weekly operative plan as a preferred *(23 activities)*
Activities with middle evaluation (B)	Maintenance activities, which can be classified, do the weekly plan. Their performance can be moved also to the next week. Their realization demands by the period of given month. *(46 activities)*
Activities with the lowest evaluation (C)	Maintenance activities, which from some reason we want to classified do weekly plan. Their realization can be moved also to the next. *(10 activities)*

Activities with the highest evaluation will be classified to the weekly operative plan as the first. Follow it will be the activities with the middle evaluation and finally, by free maintenance volume it is possible to class into the plan also the activities with the lowest evaluation. To restriction of intuitive progress and minimization of the possibility of subjective mistakes by deriving preferences of maintenance activities, we created for this process the algorithm, which is in the next figure. The sequence of the maintenance activities by the day (maintenance schedule) is in competence maintenance manager in this region.

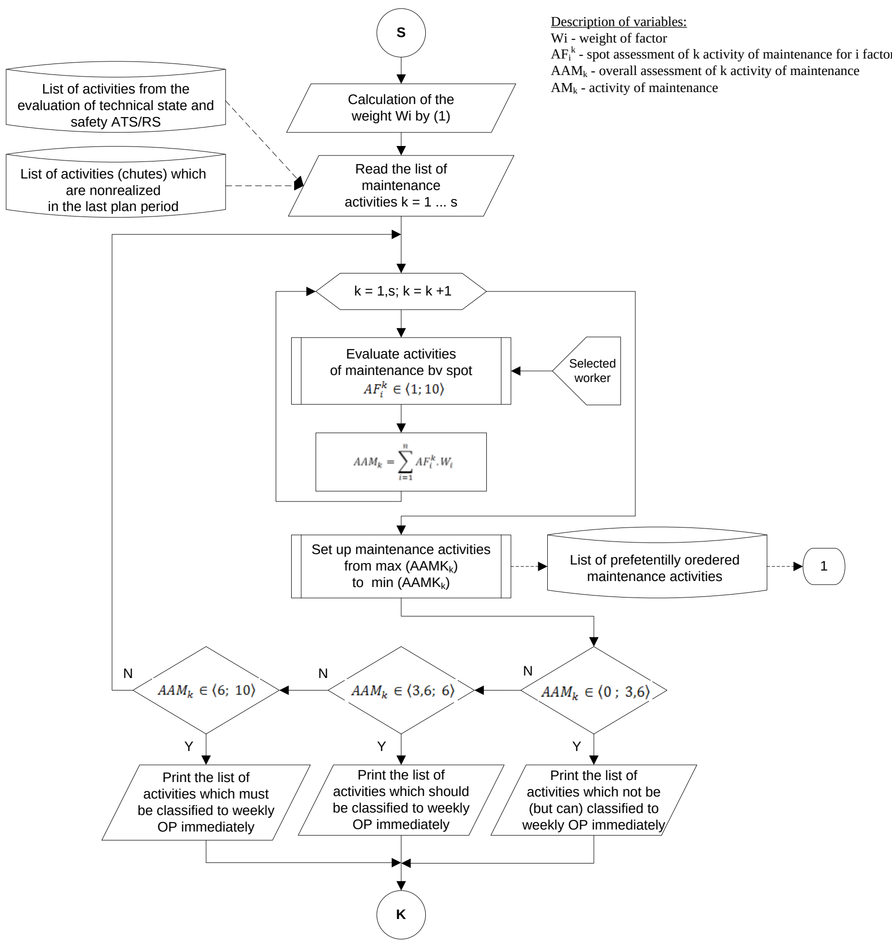


Fig. 93. Process algorithm for design of the MO [own source].

4.9.3 Conclusion

In this article we try to describe the methodology of maintenance operative planning design on in enterprises for continuous media distribution, for types of processes, when the frequency of failures is stochastic, but not explicit. Thereinafter it is described the process, which depends on technical state of devices by activities of planned preventive maintenance, which transfer to the corrective, or preventive way of maintenance planning by planning on the basis of immediate state of devices. The methodology in this article makes provision for the priority of reliability before productivity (applied for example in enterprises of main group of SPP a.s. – Slovak gas industry). We see contribution of this methodology mainly in standardization of decision making by concrete operative planes design.

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