METHODOLOGY FOR PLANNING PRODUCTION PROCESSES WITH THE USE OF DECISION TABLES IN THE METAL INDUSTRY

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Abstract: The study was conducted in a manufacturing company. The publication discusses the methodology for designing the production process using decision tables. The purpose of this article is to draw attention to the use of decision tables in production design. Production, as the main link that adds value to manufacturing companies, is the most important process within the organization. The ability to make decisions, in terms of the production process, is related to the development of the enterprise or lack thereof. Help is needed in making decisions, which should have the best effect on the functioning of the whole company and generate the highest profits. Decisions at the production stage are crucial to the operations of the whole company.

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1. INTRODUCTION

The activity of business entities is inextricably linked with the flow of goods and services, whose primary goal is to create added value and profit. The basic stimulants to a positive financial result are well-planned processes of an enterprise (Ciszak, 2007). Properly planned processes and a good selection of appropriate parameters increases the efficiency and growth of an enterprise (Pawlak & Nowacki, 2017). Each stage of conducting economic activities entails choices pertaining to the decision-making process. The complexity of decision-making revolves around the analysis of a situation, compilation of all the available information, and the selection of the option which is the most beneficial at a given time (Moore, 1975). The process of technological preparation for production is an extremely important aspect of the operation of a production enterprise, as the decisions made with regard to the production process are key to its functioning. The choice of a technological variant or the selection of materials influences the final effect of the processed order and the value of the positive break-even point achieved by the company. Unforeseen events during a production process have a negative effect on the financial result, as well as the credibility of a company in the eyes of its customers. This is why the decisions made in the production process are some of the most significant decisions for an enterprise (Paszek & Partyka, 2014).

2. METHODOLOGY FOR PLANNING PRODUCTION PROCESSES

The technological progress and advancing globalisation force entrepreneurs to seek new possibilities and ways of improving productivity. The interrelation of processes occurring in an enterprise require mutual correlations and integration. It is the same for all processes. Each process is an ordered set of consecutive actions and measures. As a component of the production process, the technological process is also comprised of a set of consecutive measures (Szczubełek, 2014). Proper planning of production actions helps to organise and manage an enterprise holistically (Rut, 2013). The stages of production planning are presented in Table 1.

The complexity of the production process means that production needs to be planned and organised with extreme precision. The production process is the foundation of the functioning, existence and development of any production enterprise. One of the most important elements of the production process is the choice of machines, equipment and tools. Next, it is essential to find a sufficient number of employees with suitable skills and competence. There are many methods of streamlining production planning, but the most important ones are those which support the decision-making process. Decisions made in the production stage are key to the functioning of an enterprise (Tumay, 1996).

Table 1. Production stages; Source: Own study

No	Stage	Actions
1	Material analysis	Stock verification Ordering materials from suppliers in case of a shortage
2	Preparation of a production line	Preparation of machines and equipment Preparation of tools
3	Preparation of a production schedule	Verification of the availability of machines and equipment Arrangement of machines and production equipment
4	Production order	Employee number verification In case of shortages and if possible, transfering employees from other departments
4	Actual production	Manufacture
5	Production completion	Quality check

3. DECISION TABLES

The aim of decision tables is to document and analyse a given system. They complement the classic schemes used for seeking and modifying solutions. The basis for structuring a decision table is the condition: "If..., then...", which is why decision tables enable creating automatic schemes for information processing. Decision tables are composed of a set of rules whose aim is to describe which combination of conditions needs to be met in order to take the right set of actions (Partyka, 2001; Paszek & Partyka, 2014). Table 2 contains a standard decision table.

Table 2. Example decision table (Partyka, 2001)

Table name		**Decision rules** $\mathbf{R_1, R_2, R_3, \ldots R_n}$
Condition set	C_1 C_2 C_3 … C_n	Condition index set
Action set	A_1 A_2 A_3 ... A_n	Action index set

The condition set determines the expressions "If...", which define variables that result in the greatest influence on the decision system. On the other hand, the action set describes the expression "then...", which involves all possible actions. The condition index set is described by symbols Y (Yes) and N (No) and "–" (nothing), which specify if a given condition is met, not met, or if it does not influence the decision. The description of the action index set is analogous to that of the condition index set (Partyka, 2001).

4. UTILISATION OF DECISION TABLES IN PRODUCTION PLANNING

Below is an example of creating a decision table in a production enterprise specialising in metal. The enterprise has been on the market for almost 30 years. Currently, it employs 230 employees. Presented below are simplified rules for some basic products manufactured by the enterprise. The rules describe the choice of materials from which the products are made. Each of the materials has its ascribed technological process. Due to the very complicated and multi-stage production, the production process has been simplified to include the most basic and essential materials.

- Rule 1

If the input material is: 1.5 sheet metal, 70x2 pipe, 10 phi rod, 50x25x2 section, then the cutting process involves a metal cutter and a guillotine, while the technological process involves bending and MIG/MAG welding. The elements are purified with grinders, de-oiled and powder-coated with RAL 5015 colour. The assembly involves M12 zinc-plated washers and M12 bolts.

- Rule 2

If the input material is: 1.2 sheet metal, 25x2.5 pipe, 14 and 18 phi rods, 50x25x2 section, then the cutting process involves laser cutting and metal sheet cutting with a guillotine, while the technological process involves rolling, bending and drilling. MIG/MAG welding. The elements are purified with grinders and galvanised. The assembly involves M12 zinc-plated washers, M12 bolts and torsion springs.

- Rule 3

If the input material is: 1.5 sheet metal, 22x1.5 pipe, 16 phi rod, then the cutting process involves a metal cutter, while the technological process involves bending and MIG/MAG welding. The elements are purified with grinders, de-oiled and powder-coated with RAL 1023 and 9005 colours. The assembly involves M8 zinc-plated washers, M8 bolts and 150x120 extension springs.

- Rule 4

If the input material is: 2.5 and 2 sheet metals, 25x2 pipe, 15 phi rod, 20x22x1.2 section, then the cutting process involves a metal cutter and a guillotine, while the

technological process involves rolling, drilling and MIG/MAG welding. The elements are purified with grinders, de-oiled and powder-coated with RAL 5015 colour. The assembly involves M8 zinc-plated washers, 150x120 extension springs with 608ZZ bearings.

- Rule 5

If the input material is: 1.5 and 0.8 sheet metals, 25x2 and 25x5 pipes, 10 and 15 phi rods, 25x25x1.5 section, then the cutting process involves a metal cutter and a guillotine, while the technological process involves rolling, milling and drilling. MIG/MAG welding. The elements are purified with grinders, de-oiled and powder-coated with RAL 3020 and 9005 colours. The assembly involves M12 zinc-plated washers, M12 bolts and long torsion springs.

- Rule 6

If the input material is: 1.5 and 0.8 sheet metals, 25x1.5 and 13x1.2 pipes, 10 and 15 phi rods, 50x25x2 section, then the cutting process involves a metal cutter, a guillotine and a laser, while the technological process involves bending, rolling, drilling and MIG/MAG welding. The elements are purified with grinders, de-oiled and powder-coated with RAL 5015 colour. The assembly involves M12 zinc-plated washers, M12 bolts and long torsion springs.

- Rule 7

If the input material is: 48x3 pipe, 18 phi rod, 60x30x3 section, then the cutting process involves a metal cutter, while the technological process involves MIG/MAG welding. The elements are purified with grinders and hot dip galvanised.

- Rule 8

If the input material is: 20x1.5 pipe, 14 and 20 phi rods, 50x80x2 section, then the cutting process involves a metal cutter, while the technological process involves bending and TIG welding. The elements are purified manually with grinding sponges, de-oiled and powder-coated with RAL 9003 colour. The assembly involves PP tape and ratchet hinge.

- Rule 9

If the input material is: 10 phi rod, 25x25x1.5 and 14x14x1.2 sections, then the cutting process involves a metal cutter, while the technological process involves bending, drilling and TIG welding. The elements are purified with grinders, de-oiled and powder-coated with RAL 9005 and 7035 colours. The assembly involves plastic caps.

- Rule 10

If the input material is: 2 sheet metal, 30x20x2 and 50x20x2 sections, then the cutting process involves a metal cutter, a laser and a guillotine, while the technological process involves bending, drilling and MIG/MAG welding. The elements are purified with grinders, de-oiled and powder-coated with RAL 9005 colour. The assembly involves plastic caps.

- Rule 11

If the input material is: 0.8 sheet metal, then the cutting process involves a guillotine and a laser, while the technological process involves bending. The elements are purified manually with grinding sponges, de-oiled and powder-coated with RAL 7035 colour.

The company manufactures metal products with the coating of metals. The exact production schedule is presented. It specifies the selection of production materials, production technology, equipment and machine demand and the number of employees needed to complete the order. The diagram is supplemented by a decision table (Appendix 1). This tool is helpful in answering the question whether the order for a given number of finished goods, the company is able to realize (Tumay, 1996).

The choice of production variant of a given product depends mainly on the production volume and the quantity of items produced. By entering the details of the order with the required quantity of products into the system, the answer is obtained whether the production capacity will be able to complete the order or not. If the completion date of the order together with the quantity of products exceeds the production capacity of the company, there is a message about additional possibilities, this is the employment of new people or the transfer of employees from other divisions. The system also determines the availability of machines for a particular stage of production (Von Halle & Goldberg, 2010). The most important issue when creating decision tables is the order in which rules are written and their ordering. The next step is to divide the decision problem into smaller tasks and analogously adjust the decision table to the next task being investigated. Decision-making based on the decision table provides acceptable variants of solutions concerning technological possibilities and profitability of production in the scope of realization of a given order. Strictly connected with the decision-making process are inputs used in the production process, operations and technological processes, which are related to the order, technological posts that will be used during the production and the necessary tooling for the execution of the order (Von Halle & Goldberg, 2010; Paszek & Partyka, 2014).

5. CONCLUSION

Decision tables are used in decision support processes. This system is geared towards computer-based knowledge processing with the use and application of knowledge. The advantage of using decision tables in the production process is undoubtedly the ability to group knowledge and the various stages and decision problems. It also allows for precise management of the production process and quick verification of orders (Paszek & Partyka, 2014).

Progressive globalization and faster and faster flow of information, materials and goods it forces companies to act fast. This is why speed also needs to address customer inquiries, along with an analysis of the company's production capabilities. The production process in the surveyed enterprise is a major process, generating added value. Supporting production decisions leads, above all, to time savings and verification of the most advantageous production option for the trader.

The article presents the use of decision tables in the production planning process. There is a generalized scheme of action during the production processes already in place at the company, while a new order is made for the company. Verification of the data contained in the order, i.e. the date of execution and the number of products and the number of different products, with the help of a decision table, allows to determine precisely whether the subject is able to execute the order or not. If there is a NO message, there are also alternatives that involve delaying the implementation (if possible), transfer of employees from other departments, employment of new employees, purchase of new equipment, etc. The validity of decision-making and their detailed and rapid verification is the most important factor responsible for the functioning of the organization. Decisions make it possible to give specific and specific attention to a given decision problem and to verify the subjective preconceptions of those responsible for making the decision.

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Apendix 1. Decision table

		Rule 1	Rule 2	Rule 3	Rule 4	Rule 5	Rule 6	Rule 7	Rule 8	Rule 9	Rule 10	Rule 11
1	Is the input material is sheet metals 1.5?	Y	N	Y	N	Y	Y	-	-	-	N	N
2	Is the input material is sheet metals 1.2?	N	Y	N	N	N	N	-	-	-	N	N
3	Is the input material is sheet metals 2.5?	N	N	N	Y	N	N	-	-	-	N	N
4	Is the input material is sheet metals 0.8?	N	N	N	N	Y	Y	-	-	-	N	Y
5	Is the input material is sheet metals 2?	N	N	N	Y	N	N	-	-	-	Y	N
6	Is the input material a pipe 70x2?	Y	N	N	N	N	N	N	N	-	-	-
7	Is the input material a pipe 76x2?	Y	N	N	N	N	N	N	N	-	-	-
8	Is the input material a pipe 25x2,5?	N	Y	N	N	N	N	N	N	-	-	-
9	Is the input material a pipe 48x3?	N	N	N	N	N	N	Y	N	-	-	-
10	Is the input material a pipe 13x21,2?	N	N	N	N	N	Y	N	N	-	-	-
11	Is the input material a pipe 22x1,5?	N	N	Y	N	N	N	N	N	-	-	-
12	Is the input material a pipe 20x1,5?	N	N	N	N	N	N	N	Y	-	-	-
13	Is the input material a pipe 25x2?	N	N	N	Y	Y	N	N	N	-	-	-
14	Is the input material a pipe 25x1,5?	N	N	N	N	N	Y	N	N	-	-	-
15	Is the input material a pipe 25x5?	N	N	N	N	Y	N	N	N	-	-	-

16	Is the input material a steel rod 20?	N	N	N	N	N	N	N	Y	N	-	-
17	Is the input material a steel rod 10?	Y	N	N	N	Y	Y	N	N	Y	-	-
18	Is the input material a steel rod 14?	N	Y	N	N	N	N	N	Y	N	-	-
19	Is the input material a steel rod 18?	N	Y	N	N	N	N	Y	N	N	-	-
20	Is the input material a steel rod16?	N	N	Y	N	N	N	N	N	N	-	-
21	Is the input material a steel rod 15?	N	N	N	Y	N	Y	N	N	N	-	-
22	Is the input material a steel profile 50x25x2?	Y	N	-	N	N	N	N	N	N	N	-
23	Is the input material a steel profile 50x25x2?	N	Y	-	N	N	Y	N	N	N	N	-
24	Is the input material a steel profile 50x20x2?	N	N	-	N	N	N	N	N	N	Y	-
25	Is the input material a steel profile 20x22x1,2?	N	N	-	Y	N	N	N	N	N	N	-
26	Is the input material a steel profile 25x25x1,5?	N	N	-	N	Y	N	N	N	Y	N	-
27	Is the input material a steel profile 60x30x3?	N	N	-	N	N	N	Y	N	N	N	-
28	Is the input material a steel profile 50x80x2?	N	N	-	N	N	N	N	Y	N	N	-
29	Is the input material a steel profile 14x14x1,2?	N	N	-	N	N	N	N	N	Y	N	-
30	Is the input material a steel profile 30x20x2?	N	N	-	N	N	N	N	N	N	Y	-
31	Metal cutter	X		X	X	X	X	X		X	X	
32	Guillotine for metal	X	X		X	X	X				X	X
33	Plasma for metal											
34	Laser for metal		X				X				X	X
35	Turning		X		X	X	X					
36	Milling					X						

37	Bending	X	X				X		X	X	X	X
38	Drilling		X		X	X	X			X	X	
39	Welding MIG/MAG	X	X	X	X	X	X	X			X	
40	Welding TIG								X	X		
41	Electric welding											
42	Machine cleaning	X	X	X	X	X				X	X	
43	Manual cleaning								X			X
44	Degreasing prior to powder coating	X		X	X	X			X	X	X	
45	Galvanizing elements		X					X				
46	Powder painting RAL 5015	X			X		X					
47	Powder painting RAL 1023			X								
48	Powder painting RAL 3020					X						
49	Powder painting RAL 9005			X		X				X	X	
50	Powder painting RAL 9003								X			
51	Powder painting RAL 7035									X		X