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HEURISTIC MODEL FOR PRODUCTION SCHEDULING WIDE-STRIP ROLLING MILL

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The article deals with the methodology of creating the production schedule for wide-strip rolling mill, defining the rules, calculating types and number of campaigns, in the defined planning period, filling the campaigns, and campaigns sequence. In model creation is apply the heuristic approach, which is based on experiences of expert in production scheduling in metallurgy. On Induction thinking and analogy are defined heuristics rules. Other rules are defined with the regularities of technology, limitation and optimization criteria. Rules that we do not know resp. we do not want to be modeled we will continue to human expert.

Key words: rolling mill, wide-strip, production scheduling model, campaigns, heuristics

INTRODUCTION

In steelmaking plants technology, for hot-rolled making sheets, the natural bottle neck is a warm wide-strip rolling mill, because there are only one and the other aggregates in the production process is more, but also due to its high price for investment and capacity requirements, especially when the rolled products prevails thin sheets [1, 2] (Figure 1). For this reason, capacity planning and production scheduling is of great importance, both in terms of coordination with the planning of previous aggregates such as blast furnaces /BF/, oxygen converters /OC/, continuous casting equipment /CC/, as well as successive directions such as splitting /SL/, plastics /PL/, zinc plating /ZL/, tinning lines/TL/ and the like, but in particular the determination of the size of batches of rolled slabs and their sequences in order to roll up the maximum number of sheets on the same rollers, minimize roller changes. Material flows among CC and PF has two variants. Direct flow /DF/ of hot slabs or by treatment plant /TP/ in cold store /CS/.

In the case of warm wide –strip rolling mills /WSRM/, are generally applied for production scheduling ”production schedule in campaigns mode”, which integrate a large number of elementary rules /heuristics, technological rules, constraints, optimization criteria/ [2-4].

The main objectives of the operational planning and production scheduling model on the WSRM are [4]:

a) Maximally meet the customer‘s time requirements, represented by orders, and adherence to the delivery date and ordered quantity per week.
b) Coordinate WSRM, PF, CC production plans to achieve as much as possible the straight-through slabs, thus solving the gap between the TP and CC production capacity, but the huge benefit would be from the amount of energy saved to heat the slabs in the PF.
c) Maximize the number of sheets produced on one roll.
d) Ordinary supply of the following dividing, plastic, zinc and tinning lines.

METHODOLOGY AND MODELING RULES

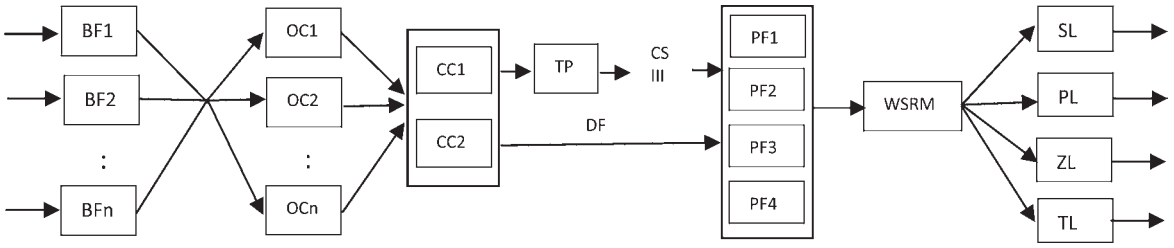

Figure 1 Production flow diagram of steel making plant for hot-rolled making sheets

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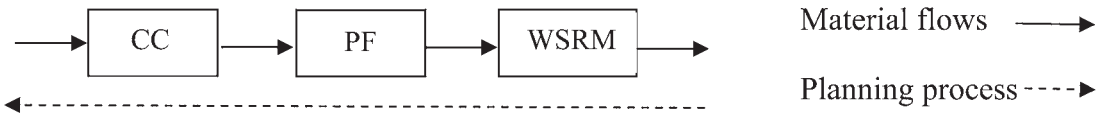


Figure 2 Directions for the preparation of operational plans and flow of materials

A heuristic approach is applied to create the:

- heuristics – are modeling logistics and management experience of the man /H/,
- technological rules-expressing the regularities of technologies /TR/,
- expert rules / which, even after the model is created, will be left on a expert /ER/,
- restrictions - technological, environmental, economic, capacity ... /L/,
- optimization criteria /OK/ [4, 5] and [7].

For this model, where applied rules:

a) Operative planning takes both, content and time, against the material flow direction (Figure 2).
b) To create an optimal WSRM plan, we chose a 7 + 7 day planning period. This is due to confirmation of contracts on „week". The next 7 days is a preliminary plan that allows for coordination, unrealized feedback from the first 7 days, a longer interval of 7 + 7 days allows more advantageous of cumulation and longer series on CC. For the next 7 days, in the case of the prevalence of the CC capacity above WSRM, it is possible to produce the slabs for the orders from these 7 days, and thus they will only have a limited time in the warehouse.
c) The plan is formed for 7 + 7 days, every week. For the first 7 days, the optimal plan is final, the next 7 days are preliminary. A maximum of 10 % of the changes are foreseen when rescheduling the rolling plan to final (Sliding Planning).
d) Straight-line slabs are produced on CC approximately 6 hours before rolling and into the PF they charge about 2,5 hours before rolling.
e) Treatment slabs in TP will be cast at least 3,5 days before rolling.
f) In the case of prevailing capacity of CC over WSRM take orders /no direct sequence/ to operational plan of CC from the production scheduled for the next 7 days production schedule WSRM.
g) The WSRM operational plan for 7 + 7 days consists of 24 + 12 hours WSRM grafikons, which are further comprised of campaigns. On the basis of the WSRM Operational Plan, an operational charging plan for the PF will be created for 24 + 12 hours.
h) The operational plan of CC is composed of 7 + 7 days and more detailed is composed of 24 + 12 hours operative and is consistently coordinated with the WSRM operational plan.
i) Coordinating, in particular, the direct sequence slabs /DF/ is on the JIT principle.

It do not provide a complete list of policies for authorization. The reader can find them [1, 4].

From the analysis of technology and production management was deduced another 16 rules, for example:

j) Embedding the width and thickness assortment of individual campaignsdepending on the state of wear of the support rollers of the final order.
k) Run of the track after the replacement of the working cylinders, make with assortment of soft sheets and width of about 1000 mm.
l) At the run of the track, get minimum of 6 and a maximum of 12 pieces of slabs.
m) In the campaign to sort assortments from wider to narrower, due to wear of cylinders and other … .
o) Permissible thickness jumps in the planning of individual items up and down. These policies have led to the creation of distinctive campaigns. Under the are rigorously define e.g. to 4,0 mm of thickness ..... 2,0 mm jump… .
p) Maximum permitted width transduction is ± 250 mm, etc. campaign, is understood the production period of the WSRM between two "large rollers exchanges" and too the typical composition of the assortment in terms of quantity, quality and size and their typical sequence˝(Figure 3).

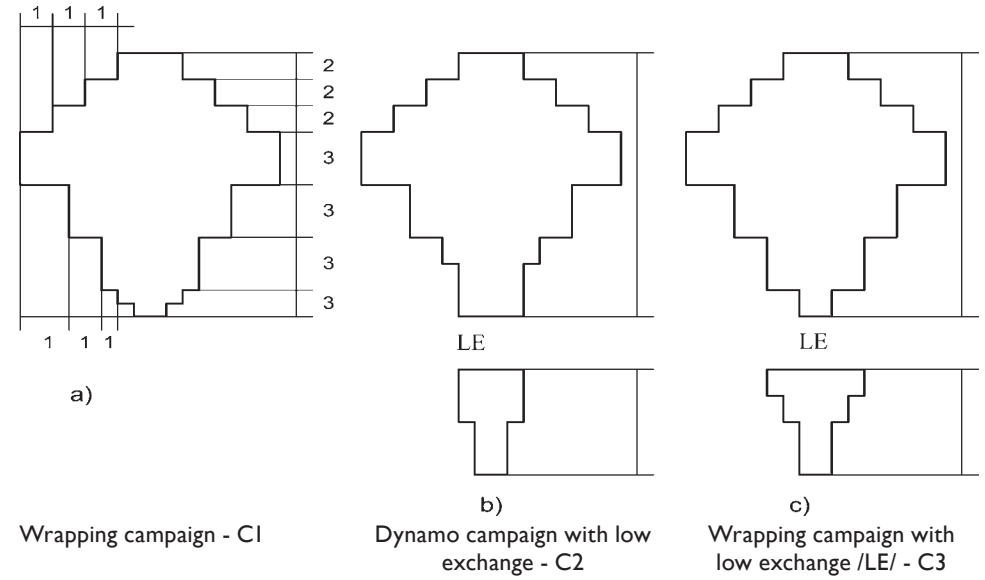
FLOW CHART OF CREATING THE PRODUCTION SCHEDULE MODEL

Weekly work stock (7 days) is appropriate to divide into groups by width, sheet thickness, and their processing direction so that it is easier to determine the type of job that is appropriate for the place in the campaign. The distribution of orders to groups by width, quality and next direction, makes it easier for them to fit into the campaign without fear of exceeding the maximum width, respectively thickness jump [4, 6].

How to determine the number and types of campaigns? First, the number of campaign dynamos is determined, and it calculates from the number of dynamos slabs with maximum width and maximum number of frames per campaign. The number of wrapper campaigns is determined in the same way. Based on the number of the smallest slabs and their maximum number in a single campaign, the number of campaigns with little exchange or no exchange is determined. Campaigns within 7 days plans are around 40. Filling in campaigns. Campaigns are matched to the type of campaign according to planning policy on WSRM /rules described above/.

Extreme and super priority contracts accumulate in a minimum of campaigns to prioritize them in terms of production time in determining campaign order.

Determine the sequence of campaigns. WSRM operate in three-shift continuous operation (Figure 4). One



Each campaign has its own limitations and rules [1, 4] and [6].
1. maximum difference in strip width is 80 mm,
2. maximum quantity in item 6 - 9 pcs,
3. maximum quantity in item e.g.: 2,0 – 2,5 mm ... 20 pcs, 2,6 – 3,0 mm ... 25 pcs ... .
/It do not provide a complete list of policies for authorization/.

Figure 3 Typical campaign structure

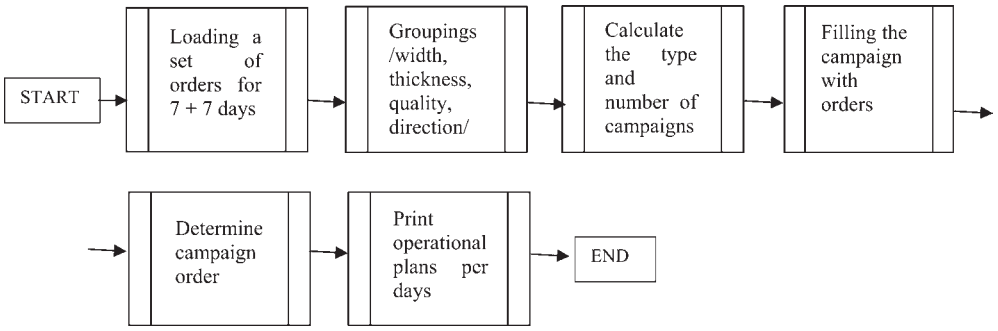


Figure 4 Production planning algorithm at WSRM

shift of the week is regular maintenance. Planning week starts with a shift after maintenance with 3 - 4 campaigns with less demanding precision. Then, followed by aggressive campaigns, the campaigns with the highest accuracy requirements, the latter are again campaigns with less accuracy and quality requirements.

CONCLUSION

The article describes the methodology of creating a model for the automation of the production scheduling of the wide-strip rolling mill. It defines the objectives of the rules, criteria, limitations, modeling procedure. It is an application of the theory of creating heuristic production scheduling models. Applying this model, under real conditions, up to 98 % of all orders received were included. The model also allows direct logistical input for the automated schedule planning for unclassified orders.

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Note: The responsible translator for English language is RNDr. Ladislav Pivka, CSc., Institut of Computer technics, Technical University of Košice, Slovakia