R. LENORT, R. KLEPEK, A. SAMOLEJOVÁ, P. BESTA

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PRODUCTION PATHS – AN INNOVATIVE CONCEPT FOR HEAVY MACHINERY PRODUCTION PLANNING AND CONTROL

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The paper introduces a new concept for planning and control of complicated heavy machinery production which is based on the principle of „production paths" – production paths planning and control concept. The concept reflects the limited applicability of traditional concepts and systems for production planning and control in conditions of heavy machinery industry that is specific by the limited repeatability of product structures and volumes, by complicated and variant material flows and unbalanced capacity utilisation. The production path represents a production capacity reserved by time or a space and is determined for the realisation of products with the same level of production repeatability. The given principle enables categorisation of the complicated production to „fast" and „slow" production paths. The fast production path is designed for processing of products specific either by a mass or series production type. The slow path, on the other hand, is designed for the resources reserved for a production of few series or single-pieces. The proposed concept significantly reduces difficulties of heavy machinery production planning and control. It cuts work in process inventory and improves the material flow continuousness, the balance and utilisation of production resources as well as the whole production process. The benefits from the implementation of the production paths concept are verified on the forged pieces machining process.

Key words: Production planning and control, Production path, Heavy machinery, verified, forged pieces

INTRODUCTION

Production planning and control is a complex process, which requires an enterprise to work out a dynamic production plan and adjusts manufacturing processes rapidly [1, 2]. Production planning and control ensures the production systems fulfil individual customer orders while meeting specifications, remaining within budget, and delivering on time [3].

The planning and control of heavy machinery production has the following specific features:

- Limited repeatability of the structure and volume of the individual products in the requirements for a given planning period.
- Variable technological procedures and production methods, variable number and order of operations performed at individual workplaces.
- Material backflows that make the products pass through selected workplaces even several times.
- Different product processing times at individual workplaces (the mutual deviations are substantial, ranging from minutes to hours).
- Occurrence of floating bottlenecks caused by high dependency of the equipment performance on the type of processed product (floating bottleneck changes its position in the production process, depending on the processed assortment [4]).

In these conditions, the application of the traditional concepts and systems for production planning and control is very difficult and it is necessary to look for new, more efficient approaches.

The objective of this article is to present a new concept for planning and control of complex heavy machinery manufacturing, which allows increasing the smoothness, uniformity and permeability of material flow – production paths planning and control concept.

PRODUCTION PATHS PLANNING AND CONTROL CONCEPT

The concept of planning and control of complex heavy machinery production is based on the principle of "production paths". A production path is a time or space-reserved production capacity, intended for the realization of a product segment with the same degree of repetition of production. Spatially specified capacity can be defined as a set of production resources, which are designed exclusively to manufacture a single product segment. On the other hand, capacity defined in terms of time means that the processing of a selected segment is taking place while utilizing the production resources only for a limited period of time. It means these resources are used for various production paths.

In terms of repetition of production, the product portfolio can be divided into two boundary categories [5]:

R. Lenort, A. Samolejova, P. Besta, Faculty of Metallurgy and Materials Engineering, VŠB – Technical University of Ostrava, Czech Republic
R. Klepek, Logiconsult v.o.s., Czech Republic

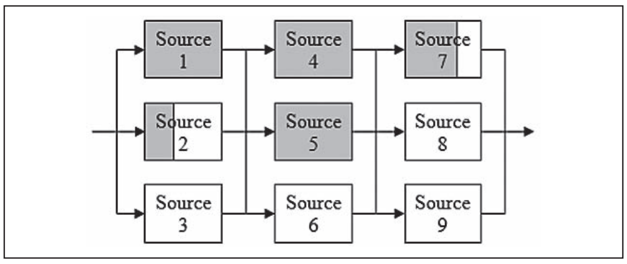

Figure 1 Schematic illustration of production divided into fast and slow paths

1. Small-batch and unit production – produces goods in batches of one or a few products designed to customer specification.
2. Large-batch and mass production – a large volume of standardized products is produced.

The production paths are created and controlled in order to divide the material flow at least into two groups:

1. "Fast production path" – a capacity reserved for processing a segment of products with a mass or large-batch character of production.
2. "Slow production path" – a capacity designated for production of small-batch and unit products.

The production paths defined spatially and in terms of time are shown schematically in Figure 1. The arrows indicate the material flow. The fast production path is displayed in gray colour, the slow one in white. Sources 1, 3, 4, 5, 6, 8 and 9 have spatially defined paths, while sources 2 and 7 have their path defined only in terms of time.

The concept is based on two fundamental assumptions. Firstly, the production is characterized by a variability of material flows (production can run alternatively, using different manufacturing sources). Secondly, sufficiently large production volume can be found for the fast production path. Suitably selected criteria are used to identify it, while respecting the production technology in particular.

Fast production path is the source of continuous material flow with a balanced load of selected production facilities and workplaces (elimination of floating bottlenecks), with minimum adjustment and conversion times, and work in progress volume, while maximizing the capacity utilization and product passage through the process. Significant simplification of the process of planning and control in this part of production and the possibility of applying the well-known logistics principles [6] represent other positive effects, leading to further improvement of the production performance parameters.

Although the slow production path requires responding to the complexity of the material flows, the dynamic transfer of bottlenecks and the control of buffers prior to these restrictions, but on a significantly smaller scale (attention is limited only to selected facilities or workplaces from the entire production process).

As a result of the changing structure of production in the individual planning periods, it is necessary to identify the production path assortment and balance of production capacity load for each of these periods again.

The application of the production paths in processes, where it is allowed by the variability in the space arrangement of equipment and workplaces, diversity and length of life cycles of manufactured products, can be supplemented by putting together equipment dedicated to the individual production paths or by arranging workplaces into complex groups (production nests or cells). However, this can usually be done only in spatially defined production paths. For time-defined paths, it is possible only in case of significantly prevailing production of selected segment of products. The time definition of the production paths is mainly associated with processes where the variability of the space arrangement of the process is limited or processes with a limited number of production resources.

If a logistics chain consisting of different production technologies is planned and controlled, the production path principle is applied to each of them. In this case, however, there is a situation where a different group of production assortment, suitable for fast production path, is identified in each link of the chain. This contradiction must be solved systemically for the chain as a whole (the global optimum must have priority before the different sub-optima of the individual links).

CASE STUDY

The application of the proposed concept has been verified in the forged pieces machining plant. Forged pieces are turned and ground here (or otherwise technologically treated) according to customer´s requirements. The equipment is allocated into production nests according to the operation they perform; each nest usually consists of more devices (see Figure 2).

The product mix includes products manufactured in small and medium-sized batches (from a single piece to hundreds of pieces) with various complexity of material flows and capacity requirements for the individual devices. For the purposes of the application of the production path concept, the production range is divided into three groups:

1. Simple production – a group of products with a simple production technology, a single passage through all production nests and even processing times in the individual nests.
2. Medium-complex production – meets the characteristics of simple production, but the processing times are uneven.
3. Complex production – a group of products requiring special production technology, multiple passages through certain production nests and significantly uneven processing times.

Based on the analysis of the shares of the individual groups, it was possible to create spatially defined production paths (allocation of the selected devices to a specific production path for the entire planning period):

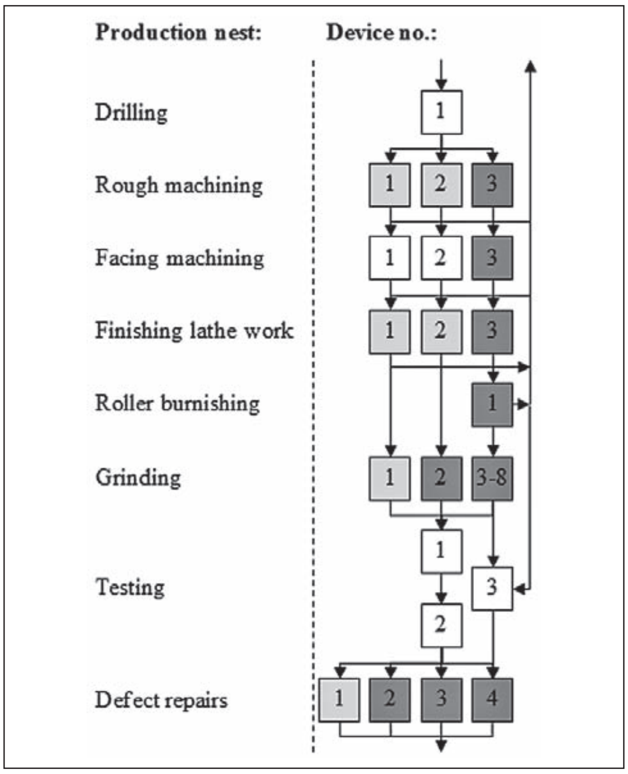

Figure 2 Scheme of the researched production process

- Fast production path – preferably includes a group of the Simple production. If the capacity of the planning period is not covered by this group, it is completed with a group of the Medium-complex production. The products are subsequently cumulated into production batches. In Figure 2, the fast production path includes the devices marked with light gray colour.
- Slow production path – a group of the Complex production is allocated to this path as well as the remaining part of the Medium-complex production group. In Figure 2, slow production path includes the devices marked with dark gray colour.

The devices marked with white colour represent time-defined production paths. Products of both fast and slow production paths are processed during specific part of the planning period.

CONCLUSION

The verification of the production paths planning and control concept taking place in an environment of complex heavy machinery processes has proven its viability and has shown its potential benefits and limitations.

The application of the concept in the researched process has led to an average increase in production by 28 %, a decrease in the amount of delayed supplies from a 6-day volume to a 2-day volume, a decrease in production in process by 10 % (in spite of the increased production batches), a reduction of equipment idle times caused by adjustments by 40 % per produced piece, and a decrease in the share of nonconforming products by 45 %.

However, the question of how to make the control of a slow production path more efficient remains to be answered. In this case, it isn´t possible to profit from the advantages of mass production, as it includes complicated material flows and floating bottlenecks. That is why a methodology for determining and controlling the buffers before floating bottlenecks in heavy machinery production has been designed to serve this purpose [7].

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Note: The responsible translator for English language is Petr Jaroš (English Language Tutor at the College of Tourism and Foreign Trade, Goodwill - VOŠ, Frýdek-Místek, the Czech Republic).