PRODUCTION COMPLEXITY AND ITS IMPACT ON MANNING

Harlin Ulrika[1,2] Bäckstrand Gunnar[1,3], Fässberg Tommy[2], Anna Brolin[3,4], and Gullander Per[1]

1. Swerea IVF AB, Mölndal, Sweden
2. Product and Production Development Department, Chalmers University of Technology, Gothenburg, Sweden
3. Virtual Systems Research Center, University of Skövde, Skövde, Sweden
4. Mechanical and Manufacturing Engineering, Loughborough University, Loughborough, Leicestershire, England

ulrika.harlin@swerea.se

ABSTRACT

The impact of increased production complexity is investigated from a manning perspective. A holistic view is needed to avoid sub optimisation as decreased complexity in one part of the production system may lead to increased complexity in other parts. Based on the industrial challenges of production complexity studied in the companies, a model for describing the impact of increased production complexity on organization, operations, and man-hour planning, is suggested to include: i) an operative, tactical, and strategic planning perspective of human resources/manning, linked to each other, ii) a holistic perspective of the impact of countermeasures on work tasks, and iii) how support concurrently can be developed due to increasing complexity, i.e. organizational support, methods and tools.

KEYWORDS: Production system, man-hour planning, management

1. INTRODUCTION

Production systems are subjected several challenges causing increased production complexity needed to be managed. There are continual demands on production related to quality, cost, production volume, deliverability, enhanced efficiency, and added flexibility. The new range of products that reduce environmental impact also requires new production methods and challenges the entire production value chain, i.e. increasing complexity of products and thus processes. In addition, a major challenge for industry is to achieve ecological, economical and social sustainability. Altogether, these challenges have an impact on companies´ ways of organizing work, operations, work conditions in workplaces, planning and manning. In studies within the research project COMPLEX (Support for Operation and Man-hour Planning in Complex Production), production complexity in production systems is investigated. The aim of this paper is to present results related to the impact of increased complexity on manning. The results are based on empirical studies from Volvo Cars Corporation.

2. THEORETICAL BACKGROUND

In the context of the production system, production complexity may be initiated by several factors, e.g. regulations, market requirements, products, changes etc. Production complexity parameters needed to be managed is illustrated in the proposed framework for production complexity [1, 2]. In the attempt to manage production complexity, a holistic view is needed to avoid sub optimisation as decreased complexity in one part of the production system may lead to increased complexity in other parts [2]. Studies focusing on plant management have identified a number of parameters that, in the future, will affect production complexity. The most important are increased product variant range, increased amount of customer-driven variants, higher production volumes, shorter product lifecycles, and increased or maintained numbers of short-term employees provided by manpower supply companies. These production complexity parameters needs to be managed as they also may affect issues related to organization, competence, information flow etc. in all parts of the plant, as well as other internal and external partners [1, 2]. During realization of planned desired changes in production systems, several critical events and uncertainties need to be handled. These events represent a dynamic aspect of complexity and are important components of a system's complexity [1]. If the production complexity increases, also the proportion of automatic, skill-based behaviour is assumed to decrease requiring an increased "knowledge-based behaviour. Thus, it is necessary to increase the knowledge of required human resources and human requirements to perform necessary work tasks on a component or piece in the production flow [3]. Further, research on the critical events emerging during production ramp-up show the need of development of information strategies to support decision making and proactive behaviour [4, 5, 6]. Insufficient use of information combined with complexity is already today a contributor to the creation of internal rejects [3].

From a production flow point of view, many different steps are executed in the value stream of a component within a plant; from delivery of incoming components, repacking, assembly, until the finished product leaves the plant. Each of these steps contains many different principles e.g. sequencing or kitting, manual or automated assembly. Companies introduce these principles for many reasons, for instance to reduce perceived production complexity or to handle the complex assembly environment. Which principle that is used for each step in the component value stream, will have effects on work tasks needed to be performed in the production flow. Thus, a holistic perspective is needed for planning of human resources needed in terms of time, required man hours, competence and support.

The large amount of changes and uncertainties needed to be handled require development of organizational strategies and decision. One approach to support the design and decision of appropriate Levels of Automation (LoA) is developed to ensure processes, which are able to handle current and future challenges [7]. Different levels of automation may be used for many different reasons; to ensure stable robust processes, reach sufficient flexibility or it can also be a parameter to handle complexity [8].

According to Gonzáles-Benito [9], development of proactive strategies in production, support the achievement of operational performance. Management of uncertainty in complex systems is also found crucial for safe and efficient system design [10], and development of a proactive behaviour [11, 12]. Other studies highlight the need of regarding management of critical events, such as production disturbances, in three perspectives; operative, tactical and strategic [13]. Thus, there is a need to further develop methods and support to increase the knowledge of the impact of increased production complexity on the work organizing, operations, work conditions in workplaces, planning, manning, etc.

3. INDUSTRIAL STUDIES

3.1 Production complexity related to effects of perceived complexity

The perceived production complexity is investigated through semi-structured interviews with personnel with different functions and roles in operations, production engineering, internal logistics and man-hour planning. Additional data is collected through two industrial workshops with the aim to identify the most crucial areas for improvement opportunities. The results are categorized in a time perspective; short, medium and long term.

The time horizon from a *short term perspective* focus production planning on a daily - weekly basis requires detailed planning of manning needs, and planning of human resource needs for each shift. Examples of the impact of increased complexity on individuals perceived production complexity are: i) Increased competence requirements for new personnel and experienced personnel (difficulties for recognition of different variants of the product) resulting in longer training time required, ii) Difficulties to identify “changes/up-dates” in the work instructions, iii) Decreased possibility to influence the work pace, iv) Lack of “spare time” needed to correct errors or repair time losses, and v) Decreased possibility to utilize tools, and “visual support systems” due to time pressure.

The time horizon from a *medium term perspective*, focus production planning on a monthly – yearly basis. Examples of the impact of increased complexity on individuals perceived production complexity are: i)

Different product variants requiring different time causes difficulties in re-balancing and production planning, ii) Difficulties to follow pre-set planning rules, iii) Complicated work instructions for each product variant, iv) Difficulties planning for manning needs due to the mixed sequences of light and heavy product variants, v) Time-consuming to up-date instructions, material handling etc., vi) Increased number of additional articles will effect time required for material supply, and v) Requirements of re-planning of daily work.

The time horizon from a *long term perspective* focus production planning from a yearly basis as well as future needs within approximately five years. Examples of the impact of increased complexity on individuals perceived production complexity are: i) Difficulties to calculate changes and uncertainties impact on manning, e.g. volume fluctuation, changes in the product development projects, changes in the production system, takt/pace changes, and ii) Need of key indicators/factors to support long-term man-hour planning.

3.2 Production complexity related to Levels of Automation (LoA)

When comparing two work stations with different levels of complexity, the cognitive LoA was found to be higher at the station regarded as the most complex [2]. The difference was mainly due to the use of pick by lights to handle the choice complexity. Such support systems are associated with increased time consumptions for work tasks when installing and maintaining the system while the time required for work tasks for operations in the station could be slightly reduced due to better decision support. It is apparent that different strategies for levels of automation will have an impact of the distribution of work tasks and required times for work needed to be carried out for operations “within” and “outside” a station. For instance when a high level of mechanical LoA is utilised the required time for work tasks needed to be carried out for operations within a work station can be expected to decrease due to a more efficient process. At the same time the need for other kind of work tasks will increase due to more need for maintenance as well as preparation and planning activities during the implementation phase.

3.3 Production complexity related to propagation in the production flow

In order to study how work tasks were affected when different principles of logistics were used for material handling, a study was conducted. Twelve different components were followed throughout the value stream from the delivery to the factory until the components were mounted on a product. All different principles and steps used in logistics and assembly were mapped. Time-data were gathered from IT-systems and time studies.

The generic principles identified throughout the production flow were the following: internal transportation, re-packing, replenishment, securing right article, assembly and control. Each of these principles consists of many different sub principles. For example the principle replenishment had the sub principles of box delivery, pallet delivery, sequencing and kitting. When examining how the distribution of work tasks and time required has changed due to different principles, it is evident that when using sequencing (internal and external) a shift in work tasks occurs. This sub principle is used in favour for box delivery, 40 % required time for sequenced parts compared to 60 % for box delivered parts. Sequencing is used due to space limitation on the assembly line driven by the large variety of parts and products assembled on the line.

4. DISCUSSION

Results from the studies highlight the impact of production complexity from an operative, tactical, and strategic perspective of human resources/manning.

Strategic perspective of manning – Focus is here set on the overall man-hour requirements for operations and support functions in a plant. Long term man-hour planning includes planning of the proportion of temporary personnel taking market requirements, product introductions, and flexibility into account. Thus, the strategic manning is a foundation for how tactical as well as operative manning is defined and the principles defined in the strategic level can influence the perceived production complexity.

Tactical perspective of manning – Focus is here set on the production flow including operators and support functions manning needs. The tactical planning principle is to form the basis for the daily planning. This includes available human resources, development of required competences, etc. It has to take in to consideration how the strategic principle described earlier should be managed. On this level issues such as calculations regarding number of personnel needed and time needed to produce a specific product, production capacity and capability, training needs, station complexity etc. has to be managed. Tactical manning can be regarded as a way of managing complexity and it can be base on the production complexity index as one parameter as well as on the strategic manning principles [14].

Operative perspective of manning – Focus is here set on shop-floor operator work, i.e. within a team area, shifts etc. This includes operative planning of human resources, and individuals required to handle the re-planning on day-to-day basis taking issues as complexity level of work stations, absence etc. into account. The operative level will need to handle “parameters” such as absence, re-scheduling, product changes and introductions, training and introduction of new employees. Changes of the complexity parameters can also affect the cycle time in the production line and thereby create a dynamic bottleneck.

For planning human resources/manning on the shop floor, a production complexity index on a station/work place could support strategic, tactical as well as in operative planning [14]. A further development of the assessment of automation levels is to assess the level of production complexity in a station to be able to minimize the risk that such bottlenecks occur in a production cell/team area. An increase in production complexity can be managed differently depending on the root cause. E.g. new product introductions that affect the cycle time due to an increase in complexity can be managed by training, allow a decrease in cycle time. But it should also be possible to re-balance the production line from a complexity perspective and thereby create a production complexity level that is not affecting the cycle time.

There are several approaches, countermeasures to manage the production complexity. However, the study shows that there is a need to have an overall view, a system perspective while implementing planned changes and countermeasures to reduce the perceived production complexity. For example, if implementing kitting as a possible countermeasure, non-value adding activities, such as walking and searching, will decrease and instead most likely affect other work tasks in the production flow, that might result in higher requirements on competence and information as well as further developed decision support as information systems [15]. The affected work tasks will then consist of material handling of the kitting boxes, maintenance of the support systems and transport of the kitting boxes to the assembly line.

To conclude, when companies manage production complexity by using techniques such as sequencing and kitting, a shift in work task is made. Therefore, implementation of changes and different countermeasure to cope or minimize the perceived production complexity may decrease the perceived complexity in a local area, but increase the perceived complexity and human resources needed in terms of time, man hours and competence other kind of work tasks in the production flow or in earlier phases of product realization.

5. CONCLUSION

Based on the industrial challenges of production complexity studied in the companies, a model for describing the impact of increased production complexity on organization, operations, and man-hour planning, needs to include following dimensions: i) an operative, tactical, and strategic planning perspective of human resources/manning, linked to each other, ii) a holistic perspective of the impact of countermeasures to visualize how work tasks are effected, and iii) how support concurrently can be developed due to increasing complexity, i.e. organizational support, methods and tools. These areas need to be further developed as increased production complexity seems has impact on work tasks resulting in changed requirements on competence and information as well as on decision support, such as information systems.

6. ACKNOWLEDGEMENTS

The COMPLEX-project is funded by Vinnova within the programme Production Strategies and Models for Product Realization.

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