Managing Production Ramp-up

- Requirement on strategy content

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Abstract

To compete as a manufacturer in today's environment, with severe competition an rapidly decreasing product life cycles, the ability to manage production ramp-up successfully has become a vital issue. It's evident when reviewing previous research that knowledge and skills about how to manage a production ramp-up often is lacking. Consequently this means a lack of comprehensiveness which often results in inferior ramp-up management. The intention when managing a production ramp-up strategy is to facilitate decisions that lead to best possible usage of time, financial means and resources when trying to meet preset ramp-up performance targets. In order to accomplish this some sort of production ramp-up management framework needs to be in place. In this paper a proposal for a production ramp-up management framework is suggested. This framework is meant to be a support when deciding upon a new, existing or a combination of production ramp-up strategies to carry out a production ramp-up. The framework suggests that the changes needed in the manufacturing strategy content, critical factors affecting the production ramp-up and previous production ramp-up evaluation should guide when choosing production ramp-up strategy.

Keywords: production ramp-up management, strategy content, production ramp-up strategy

1. Introduction

Manufacturers are today facing constantly increasing market requirements and a more and more global and severe competition. This environment amongst other things implies that the manufacturers, in order to sustain competitive, have to be flexible enough to respond to the customer's ever increasing volatile demand in order to be competitive.

One determining factor for the manufacturers to be flexible and that enable them to respond to these volatile customer demands is the capability of introducing new products in new or existing production systems successfully. The capability in this context is most often thought of as how time and cost efficient the whole product realization process is when trying to meet the goals and targets that have been established. The product realization process includes both development of the product and the production system (Bellgran & Säfsten, 2005). More specific the last phase in the product realization process, normally referred to as the production ramp-up, which is the link between development and manufacturing becomes critical for success when introducing new products and production systems in manufacturing. The production

ramp-up has been identified by several researchers (Adler, 1995; Almgren, 1999a; Berg *et al.*, 2005; Berglund *et al.*, 2001; Clawson, 1985; Langowitz, 1988, 1989; Schuh *et al.*, 2005; Terwiesch & Bohn, 2001; Terwiesch *et al.*, 1999; Van der Merwe, 2004) to be a turbulent phase with a wide range of critical factors affecting the production ramp-up performance. It has also been identified in previous research that the performance during the actual ramp-up to a very large extent depend on how preparations prior to the ramp-up have been dealt with (ibid.). These findings implies that it is essential with a well suited production ramp-up management during the whole product realization process in order to handle critical factors and successfully land the production ramp-up. It seems when reviewing the production ramp-up area that skills and knowledge regarding how to manage production ramp-ups still is lacking. Therefore it seems adequate to try to develop a framework supporting the management of production ramp-ups. During the steady-state production conditions the manufacturing strategy content is the guideline for managing a certain manufacturing task. It therefore seems likely that the shift in manufacturing strategy content, that a production ramp-up might induces, can help guiding how to manage a production ramp-up. Following questions were formulated in order to accomplish a basis for suggesting a production ramp-up management framework.

- What are the existing theories of production ramp-up management and production ramp-up strategies?
- How can the manufacturing strategy be used to guide production ramp-up management?
- How could the production ramp-up management be guided and what should be taken into consideration?

The literature review regarding production ramp-up management and production ramp-up strategies was carried out by scrutinize the literature in the production ramp-up area. When doing the search for literature article databases were consulted moreover commonly refereed books in this area were consulted. When reading the selected articles the focus primarily was to find out if any suggestions on production ramp-up management and production ramp-up strategies were to find.

Chapter two, three and four constitutes the theoretical framework in this paper. Theories and earlier research findings regarding production ramp-up management, production ramp-up strategies and manufacturing strategy are dealt with in these chapters. In chapter five a framework for managing production ramp-up is suggested and discussed and final some general conclusions and discussions are dealt with in chapter six.

2. Production ramp-up management

Inappropriate production ramp-up management often ends up in short-term and long-term productivity deviations (Baloff, 1970). Many of the factors that influence the outcome of the production ramp-up are actually possible to control by a well thought thru production ramp-up management. Baloff (1970) states that policies that are effective during steady state production are often inappropriate during a production ramp-up. Moreover he suggests some general guidelines, presented in the bullet list below, for managing production ramp-ups.

- Changes regarding product specification, product mix, labor crew etc. should be minimized and if possible postponed until steady-state production conditions have been established.
- Due to the relearning time after the first initial production run the run length should be considered. The costs for lower productivity with short run lengths should be compared to the cost implied by lengthen the production runs.
- Firms that are engaged with frequent production ramp-ups should consider using some sort of production ramp-up team concept.
- Compensations policies should be developed and implemented so that motivation amongst the labor during the production ramp-up is accomplished.

Baloff (1970) concludes that these guidelines only cover a few of the critical factors impacting the production ramp-up and he also means that the impact of different factors will vary between one production ramp-up situation to another. Explicit definition of critical factors affecting the production ramp-up in a specific situation will be helpful when managing a production ramp-up (Baloff, 1970). Moreover he suggests that from these taxonomies on critical factors an appropriate production ramp-up strategy, which is the way that these critical factors are dealt with, can be formulated.

It is not necessarily a formula for success to use experienced managers and supporting them with well-worn procedures when performing production ramp-ups (Clawson, 1985). On the contrary he means that a flexible management style and a new set of procedures are needed in order to manage production ramp-ups successfully. Production ramp-up management is a critical element for new products success (Langowitz, 1989). She means that one of the areas that have to be managed is the fit between product design and manufacturing/factory which in many cases is overlooked. Since these fits are established early on in the product realization process this means that it would be beneficial if the production ramp-up management was dealt with on an early stage.

3. Production ramp-up strategies

Schuh *et al.* (2004) suggests four different ramp-up strategies that depending on the specific production ramp-up situation suits differently well. Parameters to consider when deciding upon a certain ramp-up strategy are utilization, product variety, ramp-up time and decoupling level. In this context the decoupling level concerns whether the pilot production of the product or products are performed on a separate or existing line. They mean that a volume first strategy, which suits production ramp-ups with high production volumes and low product variety, is and has been the predominant approach in the automotive industry. Moreover they argue that new ramp-up strategies are needed in order to handle constantly increasing product and technology complexity. Moreover it should be possible with these new strategies to exploit the market potential early in the products life cycle better. The intention is to make profit on an initially reduced variant complexity and after that to increase volumes on secured processes. All these three new ramp-up strategies, see table 1, have in common that the approach is to ramp high margin product variants firsts.

Ramp-up strategy	*Aims for*	*Suits*	*Focused parameters*
Slow motion	Parallel ramp-up of several variants on a constant and low volume level until all processes are verified.	Production systems with highly automated processes.	Product variety Decoupling level
Dedication	Ramp-up of all different variants with accumulative volumes and a gathered launch of these. Elimination of problems on an early stage that not will occur.	Production systems with high product variety and high logistic capability.	Product variety Utilization
Step-by-step	Sequential ramp-up of consecutive variants with high complexity.	Production systems with enormous technical complexity	Product variety Decoupling level

Table 1. *Three production ramp-up strategies proposed by Schuh et al. (2004) there high margin variants first are supported.*

Consequently the choice of production ramp-up strategy is to a large extent dependent on the technology complexity, logistic complexity, product variety and the ability to exploit the markets potential. Schuh et al. (2004) discusses these strategies from an automotive industry perspective and the applicability of these production ramp-up strategies in other industries is not discussed.

Clark & Fujimoto (1991) did in their research in the automotive industry identify different strategies that were used for ramp-up of new products in final assembly. The strategy constitutes of a combination of choices on how to manage the ramp-up with respect to three different aspects. These three aspects are choice of ramp-up curve, operation pattern, and work force policy. According to Clark & Fujimoto (1991) the effectiveness of a ramp-up to a large extent depend on the fit between the manufacturing capabilities and the choice of how to approach these three aspects. Two distinct ways of carrying out a production ramp-up are discussed by Clark & Fujimoto (1991), see table 2. One approach termed as “shut-down” and the other termed as either “block introduction” or “step-by step”. The difference between “block introduction” and “step-by step” is how big and how many steps that are taken in order to complete the transition from existing production to new production.

Ramp-up curve	*Explanation*	*Implications*
Shut down	Production of the old model is shut down totally before production of the new model is initiated	This approach may imply significant production and sales losses. To reduce this risk a steep ramp-up curve is strived for.
Block introduction & Step-by-step	Production of the old model is gradual faced out and production of new product is faced in simultaneously.	Smooth transition with minimized sales losses but issues such as material handling, work assignments, and scheduling becomes more complex.

Table 2. *Two different approaches for performing a production ramp-up (Clark & Fujimoto, 1991).*

Quality, production cost and tramp-up time are according to Clark & Fujimoto (1991) central targets that a production ramp-up should meet. How the achievement of these targets can be fulfilled is influenced on the choices regarding operation pattern and work-force. The operation pattern is essentially a choice of adjusting either line speed, empty hangers or operating time in order to gradually increase production during ramp-up. The other choice concerns whether the work-force approach should be to lay-off/call-in workers, keep the work force stable or to initially increase the workforce and when gradually decrease it to a normal level. Clark & Fujimoto (1991) did in their research identify two different production ramp-up strategies commonly used within the automotive industry. These two ramp-up strategies constitutes of a combination of the three choices (ramp-up curve, operating pattern and work-force), see table 3. In table 3 the intentions and implications with each of these two production ramp-up strategies also can be viewed.

Ramp-up curve	***Operating pattern***	***Work-force***	***Implications and intentions***
Step-by-step	***Empty hanger***	***More workers***	Implies stability and control of the operating conditions and work assignments. The intention with this approach is to minimize confusion in the production and to facilitate learning during ramp-up.
Shut down	***Line speed***	***Lay-off/call-in***	Implies initially low complexity both due to material handling and work force involvement but in the long run task continuity and operation stability will suffer. The intention with this approach is to overcome the conflict between production and learning by separating production of existing and new products.

Table 3. *Two production ramp-up strategies with different implications and intentions according to (Clark & Fujimoto, 1991).*

The copy-exactly ramp-up strategy is a third ramp-up strategy that can be found when reviewing the literature. Terwiesch & Yi (2004) means that it is not unusually that there is a tension between learning and process change consists during a production ramp-up. On one hand the company wants to start accumulate knowledge so the discrepancies between how the process should be operated and how it is actually operated can be sorted out as soon as possible. On the other hand further refinement of the process which might imply new equipment, upgrades of software, increases in automation might also be desirable due to either external or internal demands. What the copy-exactly strategy really implies is that the process prior to the start of production is frozen at some point in time so that a potential refinement of the process is blocked. It is shown by Terwiesch & Yi (2004) that it can be optimal to delay process change, even if change would be for free. This is valid for production ramp-ups there the initial understanding of the transferred process is low, if the process is difficult to improve, if small modifications can have large effects, and if the overall lifecycle is short (C. Terwiesch & Yi, 2004).

4. Manufacturing strategy

Manufacturing strategy is one of several functional strategies with the intention to support the business strategy in an integrated fashion (Hill, 2000; Skinner, 1969; Wheelwright, 1984). Today most researchers agree on the importance of having a manufacturing strategy that supports the overarching business strategy and that fits well with and complements the other functional strategies. The functional strategies that are defined can vary slightly between different businesses but four common functions for which strategies are defined are marketing/sales, manufacturing, research and development and accounting/control (Wheelwright, 1984).The manufacturing strategy, just as the other functional strategies, can be divided into two separated parts which are termed strategy content and strategy process (Dangayach & Deshmukh, 2001; Slack & Lewis, 2002; Swink & Hegarty, 1998; Swink & Way, 1995). The content part make up the strategic direction which constitutes of decisions regarding which competitive priorities to focus and what overall approaches that should be adopted within each of the different decision categories (Slack & Lewis, 2002; Swink & Way, 1995). The process part on the other hand is more concerned about how the strategy is formulated and implemented in practice in order to achieve the fit between the decision categories and the competitive priorities (Slack & Lewis, 2002; Swink & Way, 1995).

4.1 Manufacturing strategy content

The manufacturing strategy content constitutes of the competitive priorities and the decisions within a set of decisions categories. The competitive priorities are strongly linked to the business strategy and are set up so that the market requirements can be met and the different decision categories constitutes of decisions needed to deal with in order to fulfill these objectives (Slack & Lewis, 2002). The total pattern of these decisions within the different decision categories are commonly referred to as the manufacturing approach. The competitive priorities which most commonly are mentioned are cost, quality, delivery and flexibility (Hill, 2000; Wheelwright & Hayes, 1985).

Researchers have during the years given slightly different suggestions on which decision categories that should be dealt with when formulating a manufacturing strategy. However the most common categories that are frequently mentioned in some form can be found in proposal suggested by (Skinner, 1969). In table 4 this proposal on decision categories and some of the most important decisions and alternative routes for these decisions within each category are presented.

Decision Categories	*Decisions*	*Alternatives*
Plant and equipment	- Span of process	- Make or buy
	- Plant size	- One big plant or several smaller ones
	- Plant location	- Locate near markets or near materials
	- Investment decisions	- Invest mainly in buildings, equipment, inventories or research
	- Choice of equipment	- General-purpose or special purpose equipment
	- Kind of tooling	-Temporary, minimum tooling or "production tooling"
Production planning and control	- Frequency of inventory taking	- Few or many breaks in production for buffer stocks
	- Inventory size	- High inventory or a lower inventory
	- Degree of inventory control	- Control in great detail or in lesser detail
	- What to control	- Controls designed to minimize machine downtime, labor cost or time in process or to maximize output of particular products or material usage
	- Quality control	- High reliability and quality or low costs
	- Use of standards	- Formal or informal or none at all
Labor and staffing	- Job specialization	- Highly specialized or not highly specialized
	- Supervisors	- Technically trained first-line supervisors or non-technically trained supervisors
	- Wage system	- Many job grades or few job grades; incentive wages or hourly wages
	- Supervision	- Close supervision or loose supervision
	- Industrial engineers	-Many or few such men
Product design/Engineering	-Size of product line	- Many customer specials or few specials or none at all
	- Design stability	- Frozen design or many engineering change orders
	- Technological risk	- Use of new processes unproven by competitors or follow-the-lead policy
	- Engineering	- Complete packaged design or design-as-you-go approach
	- Use of manufacturing engineering	- Few or many manufacturing engineers
Organization and management	- Kind of organization	- Functional or product focus or geographical or other
	- Executive use of time	- High involvement in investment, production planning, cost control, quality control or other activities
	- Degree of risk assumed	- Decisions based on much or little information
	- Use of staff	- Large or small staff group
	- Executive style	- Much or little involvement in detail; authoritarian or nondirective style; much or little contact with organization

Table 4. *Important manufacturing strategy content decisions and alternative routes for these, based on (Skinner, 1969).*

Another proposal has been suggested by Wheelwright (1984) which can be viewed in table 5. The decision categories concerning capacity, facilities, technology and vertical integration is normally referred to as the structural decisions and once in place it normally demands substantial capital investment to alter or extend these (Wheelwright, 1984). Workforce, quality production planning/materials control and organization on the other hand are referred to as infrastructural decisions and are historical viewed as more tactical in nature compared to the structural (Wheelwright, 1984).

Decision Category	*Decisions*
Capacity	amount, timing, type
Facilities	size, location , focus
Technology	equipment
Vertical Integration	direction, extent, balance
Workforce	skill level, pay, security
Quality	defect prevention, monitoring, intervention
Production planning/materials control	computerization, centralization, decision rules
Organization	structure, reporting levels, support groups

Table 5. *Decision categories for a manufacturing strategy, based on (Wheelwright, 1984)*

A mentioned before the most central with the strategy content is which decisions to make for the different decision categories so that an approach in order to meet the performance objectives. This task to translate the business strategy into suitable approaches within the different categories requires a lot of resources, time and management perseverance (Wheelwright, 1984). In spite of that the decision making for within all these categories is not a one off. Since both markets demands and the potential manufacturing capabilities constantly evolve it is necessary to continuously reconsider the approaches within all of the manufacturing strategy decision categories in order to preserve the best possible fulfillment of the competitive priorities. According to Wheelwright (1984) the root cause to many companies with manufacturing problem is that the different decision categories becomes incompatible with each other or that the decision categories becomes incompatible with the competitive priorities which are to be achieved.

5. Framework for managing production ramp-up

The importance of managing production ramp-ups successfully has been highlighted by several researchers (Almgren, 1999a; Baloff, 1970; Berg & Säfsten, 2005; Clawson, 1985; Haller *et al.*, 2003; Langowitz, 1988; Schuh *et al.*, 2005; Terwiesch et al., 1999; Van der Merwe, 2004). Already in the 70ies Baloff (1970) reported from his research how inappropriate ramp-up management could result in poor productivity performance during production ramp-up. Nevertheless new research reports gives evidences that the issue of managing successful production ramp-ups still suffers in many manufacturing companies. It can also be concluded from the literature review in this paper that the suggestions on production ramp-up management so far seems to be fragmented. So far researchers have focused on a few aspects each and no one has tried to suggest a general production ramp-up management framework. Moreover the proposed production ramp-up strategies are suggested to fit differently well depending on the level of complexity. Nevertheless it is not clear in these strategies what actually constitutes the production ramp-up complexity

The problems or critical tasks to be solved and managed, thereby also which manufacturing approach to choose, are constantly changing as a company undertakes new and different combinations of products and processes Hayes & Wheelwright (1979). Each new product that is introduced might imply that changes to the

prevailing manufacturing approach will be better off for that particular product in order to achieve the competitive priorities set up for manufacturing. If it is decided to undertake the manufacturing of such a product probably the least appropriate approach would be to leave the manufacturing of that product undifferentiated to the prevailing manufacturing (Hayes & Wheelwright, 1979). Furthermore Hayes & Wheelwright (1979) points out the importance for a company with a multiple product range, most probably also in different stages in the product life cycle, to differentiate the manufacturing approach for each product.

As been mentioned in previous sections the manufacturing approach, which is one part of the manufacturing strategy content, is made up by several decisions taken within different decision categories in order to best fulfill the competitive priorities.
What manufacturing approach to choose is according to Hayes & Wheelwright (1979) very much linked to the introduction of new product and processes. Further our view is that a production ramp-up most often is a consequence of introducing either a new product a new production system or both. It therefore seems appropriate that the management of a production ramp-up should be linked to the manufacturing strategy.

The reminder of this section will describe our proposition on how the manufacturing strategy, the knowledge of critical factors affecting ramp-up and production ramp-up evaluation could be the basis from which the production ramp-up management can be guided.

5.1 Outline of the proposed ramp-up management framework

Our view is that a production ramp-up most often is a consequence of introducing either a new product a new production system or both. The task during the production ramp-up is normally expressed in terms of increasing the volume output from a zero level to a steady-state production with a volume output which has been planned for. Starting to scrutinize the production ramp-up phenomenon it will soon be obvious that the step needed to be taken within manufacturing in order to fulfill a planned volume goal is much more complex and puts much more demand on how the production ramp-up is managed than first will be thought of.

The core activity of a manufacturing company is according to the author to perform different manufacturing tasks. Here the manufacturing task is seen as the task to meet the competitive priorities outlined in the manufacturing strategy by using the existing manufacturing capabilities as optimal as possible. The manufacturing approach the author see as the total pattern of decisions, specified as one part of the manufacturing strategy, regarding which capabilities to use and how to use them for a particular manufacturing task. The author means that the management of a production ramp-up includes the fulfillment of changing all manufacturing capabilities needed in order to accomplish the new or slightly changed manufacturing task with the decided manufacturing approach, see figure 1.

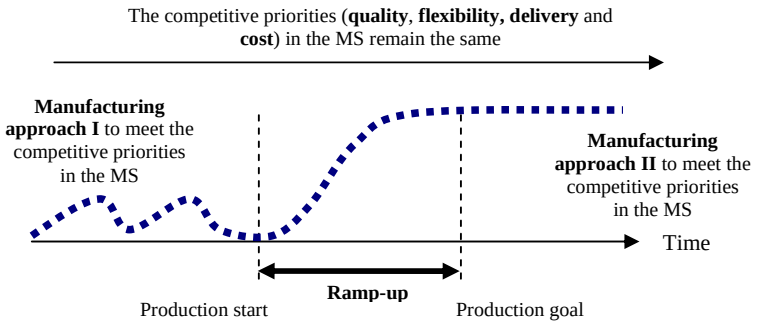

Figure 1. *Change of manufacturing approach in connection to a production ramp-up.*

The incremental change that is needed to ramp-up the production successfully also means that the approach i.e. the pattern of decisions in the manufacturing strategy most probably will have to be changed. This means that the approach part in the manufacturing strategy is seen as a pattern of living decision which continually is changed in order to fit the changes that are undertaken within the manufacturing. However the competitive priorities specified in the manufacturing strategy, which are the long term guidelines for the manufacturing, will remain the same, see figure 1.

Thus the task when managing a production ramp-up is to make sure that the competitive priorities can be met by undertaking a new or slightly changed manufacturing approach which most often is a consequence of introducing a new product or production system or both. The production ramp-up should also be managed so that time and cost for the production ramp-up are minimized.
When managing a production ramp-up you need to consider ***what*** is needed to be done, ***how*** should it be done, ***who*** should do it and ***when*** should it be done in order to ramp-up production successfully. In figure 2 the proposed framework for production ramp-up management is visualised. The considerations about changes needed to be done in the manufacturing approach should be done early on in the product realization process. This is both due to the close interaction between product and production system and also due to the fact that changing the manufacturing approach is most often not a quick fix.

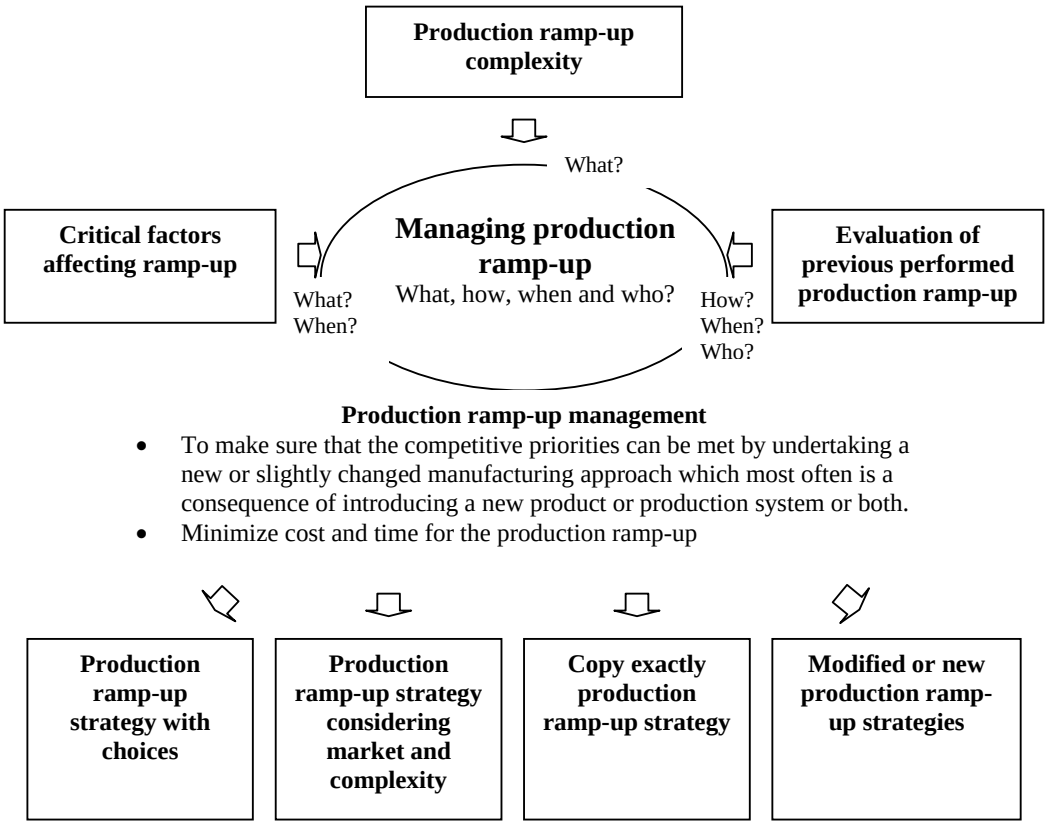

Figure 2. *A proposition of a production ramp-up management framework.*

The difference between the manufacturing approaches needed before and after a ramp-up can be seen as the **production ramp-up complexity**. These differences and the scope of them constitute the base for guiding the management on ***what*** needed to be done in connection to the production ramp-up. Above this earlier knowledge regarding **critical factors affecting the production ramp-up** should be taken into consideration. This knowledge could then give further and additional guiding on ***what*** needed to be done and also ***when*** it should be done. What critical factors that affect the production ramp-up have been dealt with by many researchers.

Critical factors before production ramp-up	***Critical factors during production ramp-up***
Fit between product and process	Volume, quality and delivery performance for existing production
Learning and training	Time for testing
Supplier verification	Time for calibration, maintenance and engineering trials
Involvement from manufacturing	Breakdown of equipment
Management of the realization process	Engineering change orders
	Learning and training
	Overtime
	Supplier relations

Table 6. *Critical factors affecting the production ramp-up.*

Some of the critical factors that could be considered and that have been suggested by many researchers were summarized by (Berg & Säfsten, 2005). In table 6 these critical factors are divided in two categories; critical factors before production ramp-up and critical factors during production ramp-up.

As a final input for the production ramp-up management the **evaluation of previous performed production ramp-ups** could be valuable, this can give useful information regarding both ***how*** and ***when*** different tasks needed to be undertaken and also ***who*** that should undertake these. To know what areas needed to focus when managing a production ramp-up should be an outcome from the suggested production ramp-up management framework. This outcome is achieved by considering differences in the manufacturing strategy content, critical factors and production ramp-up evaluation. A production ramp-up strategy is a tool for achieving the outcome suggested by the framework. Depending on what areas that are pinpointed as important to manage different ramp-up strategies suits differently well. As the proposed production ramp-up framework figure 3 suggests one decision the production ramp-up management can be to make use of some of the existing ramp-up strategies that have been proposed by (Clark & Fujimoto, 1991; Schuh et al., 2004; Terwiesch & Yi, 2004) in their research. These ramp-up strategies can be said to fit production ramp-up situations with different complexity and prerequisites differently well. It can also be the case that no existing production ramp-up strategy fits the present ramp-up situation and therefore a modified or new ramp-up strategy need to be adopted. As proposed in the production ramp-up management model the initial consideration regarding the complexity, critical factors and evaluation of earlier ramp-ups could guide whether an existing or new production ramp-up strategy should be adopted.

5.2 Production ramp-up complexity

One factor that influences how the production ramp-up best is managed and what ramp-up strategy to prefer is the complexity of the production ramp-up situation (Clark & Fujimoto, 1991; Schuh et al., 2004). As described previous in this paper the author see the task during the production ramp-up phase as changing the manufacturing capabilities from one level to another in order to accomplish a new manufacturing task. The scope of this change can according to the author be seen as the production ramp-up complexity. Therefore it is of importance to understand which components that makes up the production ramp-up complexity and to take notice of these when managing a production ramp-up.

Almgren (1999a) means that the complexity of a production ramp-up situation can differ considerably depending on if either the product or the production system or both are new or existing, see figure 3.

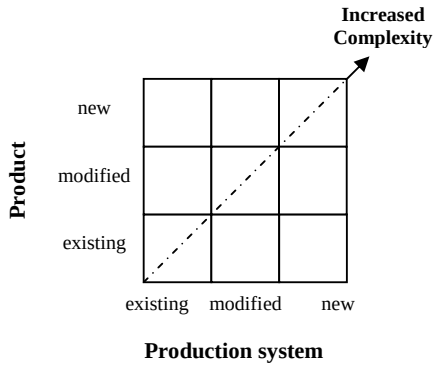

Figure 3. *Model for classification of ramp-up situations (Almgren, 1999a).*

What for certain is true is that a production ramp-up is a phenomenon their at least one, most probably some, of the many dimensions concerning the production system and the product need to be changed to some extent. The production ramp-up classification model, suggested by Almgren (1999a), could be seen as a starting point for judging which amount of resources, time and effort that would be needed in order to successfully carry out a production ramp-up with a certain complexity. But since this model gives very little insight regarding the details further considerations have to be done. Especially when it comes to the change of the production system, which consists of many dimensions needed to be scrutinized in order to better understand the change needed and the implications of this change, further insights would be useful. So what is referred to as the production system in Almgren (1999a) model for production ramp-up classification the author suggest is an aggregation of all these changes that has to be done within the different decision categories that constitutes the approach part of the manufacturing strategy content. Thus the complexity of a production ramp-up can be viewed in terms of change between an existing and a new manufacturing approach. There the new manufacturing approach has to be adopted in order to make sure that the competitive priorities defined in the manufacturing strategy still are fulfilled even if the manufacturing task has changed i.e. that either the product or the production system or both are new or changed.

Which changes needed to be done should be identified by comparing the differences in the existing and the new manufacturing approach. There the manufacturing approach is a part of the manufacturing strategy content and constitutes the total pattern of all the decisions in each decision category. As was mentioned previous in this paper different suggestions has been given on what decision categories and decisions to consider in the manufacturing strategy. What decision categories and decisions to use can vary but the important thing is that all important differences are covered. For suggestion on which decision categories and decisions to consider see table 4 or 5. By comparing the decisions in the existing and the new manufacturing approach both the complexity of the production ramp-up and the categories needed to focus when managing production ramp-up can be identified.

6. Conclusions and discussion

It can be concluded that knowledge and skills regarding production ramp-up management seems to suffer within the manufacturing industry. Moreover there are still now comprehensive management models for ramping production suggested.

Since this lack of a comprehensive production ramp-up management framework one proposal is suggested in this paper. So far the framework is very much a composition of theories and findings from earlier research. Next step should be to evaluate if this framework can be used in reality for guiding the management of production ramp-up. The framework is also scope for further development there for example additional critical factors that affecting ramp-up and new production strategies can be included.

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