FLEXIBLE AUTOMATION AS A COMPETITIVE BUSINESS FOR MANUFACTURING SMEs

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Abstract: This paper describes and analyzes the establishment of an automation SME cluster. The cluster aims to strengthen the participating companies' as well as the region's competitiveness by offering flexible automated production solutions. It was observed that the combined know-how in the cluster could match the future needs of customers, and that leverage could be obtained if the cluster proceeds in its ambitions to use the collected production technology competence. However, the major challenge will be to find collaboratively developed automated solutions between customers and suppliers that are favorable both for individual companies and the longterm development of the cluster.

Keywords: company network, flexible production, value mapping

1. INTRODUCTION

As early as in 1989, Garsombke & Garsombke made a study about the linkage between improvements in robotization, increased automation and performance in small and medium enterprises (SMEs). Their study indicated that SMEs that where early adopters of new technology, such as automation in general, increased their output and profitability (Garsombke & Garsombke, 1989). However, since then the demand of increased flexibility in automation has been raised, and it has been concluded that there is a need for more research in this area, even including corporate culture and the choice of manufacturing strategy in relation to which flexibility that best fits the business (eg. Beach et al, 2000).

The right technology level within an SME is of high importance and must meet the company's overall strategic vision and direction (Thomas et al., 2008). As industrial robots have continuously been improved during the last decades, but still the development has "not reached its limits" (Brogårdh, 2007, p.79), it is also a need to continuously follow the technology trends. Today, automation solutions using robots include a huge amount of different specific technology areas, such as different types of sensors, vision systems, robot programming, maintenance, system integrators, robot developers, etc. Furthermore, the market for using industrial robots, if the robots are flexible enough together with different technology and measurement systems, will increase from traditional spot welding in automotive to more flexible assembly and disassembly manufacturing cells. (Brogårdh, 2007) Individual SMEs obviously would have difficulties to cover all this technology know-how in-house, but through collaboration in a network each firm could improve its chances to offer a larger range and gain new orders.

To establish a cluster of companies in one place – covering unusual competitive success in particular fields, can according to Porter (1998) lead to better use of resources since critical mass is gathered. The competitive advantages rest on making more productive use of inputs, which requires continual innovation. A robust organizational form can be achieved in a cluster if it consists of independent and informally linked companies, and they can together offer advantages in efficiency, effectiveness and flexibility (Porter, 1998). Clusters affect competition in three broad ways (Porter, 1998):

1. Increasing the productivity of the companies in the region
2. Driving the direction and pace of innovation, which affect the future growth
3. Stimulating the formation of new businesses, which strenghten the cluster itself

The aim of this paper is to analyze the first steps in establishing a cluster, i.e. a company network, of collaborating SMEs focusing on delivering flexible automated production solutions.

2. THEORETICAL FRAMEWORK

2.1. Flexibility in manufacturing

SMEs with robust and highly responsive manufacturing systems including a culture of continous technology implementation have greater market share including better financial and technology sustainability (Thomas et al., 2008). In order to reach high responsiveness in manufacturing, SMEs need to manage different types of flexibilities. The importance of manufacturing responsiveness, also known as flexibility, has been emphasised since the early 1980s, when the manufacturing challenges were expressed in Browne's "taxonomy of flexibility types" as depending on Machine, Process, Product, Routing, Volume, Expansion, Operation and Production (Browne et al, 1984), complemented with system view to include also Material, Program and Market by Sethi and Sethi (1990). Gerwin (1987) contrasted with the manufacturing flexibility types Mix, Changeover, Modification, Rerouting, Volume, Material and Sequence. Altogether these are dimensions to take into consideration when planning manufacturing services., However, there is often a lack of knowledge when it comes to the relationship between business and manufacturing strategy, and it is important to understand which kind of manufacturing flexibility that is preferable for which kind of business environment (Beach et al, 2000).

2.2. Flexible automation requirements

Rapid model changes at original equipment manufacturers (OEMs) have great impact on the flexibility to respond to new requirements in production, which results in that suppliers need to provide new and intelligent industrial automation solutions (Scholl, 2012). Different drivers for automation in assembly have been presented by Heilala and Voho (2001) which are related to production volume, batch sizes, flexibility and number of variants. If the product has few variants and is produced in high volume and in large batch sizes it is easy to develop a dedicated automated production solution (Heilala and Voho, 2001). This is the reason why high level of automation often is presented as the opposite to manufacturing flexibility. However, many products usually have a number of variants, are produced in medium-sized batches and variable production volumes due to the specific variant. This demands a higher flexibility and therefore a more flexible automated solution (Heilala and Voho, 2001). The challenge is to develop cost effective, flexible automated, or semi-automated, solutions that facilitates the flexibility needed.

Flexible manufacturing systems can be achieved by combining information systems; computer controlled manufacturing equipment (such as CNC and PLC) and material handling systems. Variety can have an impact on the manufacturing process in several ways: high inventories, feeding complexities, excessive capital investment, and change in assembly sequence, and complexity in line balancing. (Dean et al., 2009)

There are many reasons that justify a transition towards increased automation. The nine listed below are among the most common (Goover, 2001):

1. To increase labor productivity
2. To reduce labor cost
3. To mitigate the effects of labor shortages
4. To reduce or eliminate routine manual and clerical tasks
5. To improve worker safety
6. To improve product quality
7. To reduce manufacturing lead time
8. To accomplish processes that cannot be done manually
9. To avoid the high cost of not automating

2.3. Flexibility as a business opportunity

For SMEs, cost and flexibility in a production system are very important, since the products usually are manufactured in low volumes (Gunasekaran, 1999; Johansen et al, 2010). For an SME it is important to be

prepared to make decisions related to the manufacturing process performance and improve these based on accurate and timely information (Deleryd et al., 1999). Thomas et al. (2008) argue that it is important for SMEs to get a deeper understanding of the concept of variation, identification of causes of variation and management of these causes. Barton and Thomas (2009) put forward the abilities for European companies to compete through value adding activities, such as services, customization and flexibility, which require either significant resource allocation at the company or a flexible and adaptable supply chain capable of rapid responses.

Further, to increase competitiveness, it can be advantageous to automate as many tasks as possible and integrate these with the communication network and databases that provide the necessary information flow to achieve an efficient process (Selladurai, 2004). From a survey, Thomas et al. (2008, p. 167) could identify *"a need for a coherent approach to Technology Implementation, which is sympathetic to SME needs and requirements*". However, there are many obstacles, and in order to achieve efficient technology implementation in SMEs, Thomas et al. (2008) conclude that there is a need for research on development of formal models applicable for SMEs. Furthermore, they identified a distinct lack of top management commitment including unrealistic expectations of the implementation time of new technology, a limitation of financial and human resources, as impediments towards supporting complex technological systems, and that all SMEs participating in the study found that the implementation process of new technology was the most problematic.

2.4. Business strategy perspectives

Manufacturing SMEs usually base their offerings on physical products (transaction-based), i.e. they invoice their customers related to number of produced units (Oliva and Kallenberg, 2003). The concept of product-service systems (PSS) transition (eg. Oliva and Kallenberg, 2003) is a framework to evaluate possibilities to offer manufacturing services instead of more traditional business offerings based on goods/products. This impose a transition towards a more relationship-based business. Moreover, marketing theory that has evolved from a value chain perspective to networks and relationships is a tool to analyse value constellations (Normann and Ramírez 1993) relevant for addressing future demands of manufacturing flexibility. Yet another framework from the market strategy field can facilitate analysis of market value for, in this case the SMEs in automation, were the so-called "profit pools" (Orit and Gadiesh 1998). It suggest a way to structures financial data about volumes and profits in an industry, and can serve as decision support for a firm to navigate strategically through market threats and opportunities.

3. METHODOLOGY

The case used in this paper originates from the work of establishing a regional cluster focusing on automation in the Gnosjö region, Sweden. Together with a company in the region that had already started a transition towards PSS, the regional business coordinator initiated a discussion about the possibilities to establish a cluster for automation suppliers. During these initiating discussions it was identified that the network establishment needed facilitation from the academy with the aim of transferring knowledge about PSS and Integrated Product and Service Engineering (IPSE) in combination with production research within the area of automation and production system. Furthermore, a steering committee consisting of regional business coordinators and the experienced PSS company's CEO was established with an external chairman appointed from a national institute.

3.1. Selection of studied companies

The unit of analysis is the cluster consisting of member companies. During the study the cluster was established, and member companies were invited. The criteria for membership was (1) business activity mainly within the field of industrial automation, (2) geographical proximity to the Gnosjö region (www.gnosjoregionen.se) and (3) willingness to collaborate with the aim of establishing a network for regional competitiveness through automation solutions. All together, the companies have long tradition of developing automated manufacturing solutions, or parts of such solutions, for their customers. Finally, the network consists of 21 selected SMEs with businesses related to automation in different ways, mainly acting as automation suppliers.

3.2. Data collection methods

Methodologically, the research was conducted as a case study of the cluster, including workshops, site visits and interviews with managers of 21 companies participating in the network, complemented with a customer and market analysis based on interviews and a survey to customers and cluster members. Furthermore, the regional business coordinator as well as the steering committee have been interviewed and several meetings during the pre-study as facilitators prior to the decision to start the establishment work for the cluster.

An action research approach were adopted, where the authors have had the oppourtunity to participate in the work of establishing the cluster as facilitators in different workshops about the industry segment – automation – and business creation. In order to prepare the workshops and semi-strucutured interviews with the 21 CEOs for the participating SMEs, 10 yrs of financial data for each company was collected and analyzed. Official company web sites were retrieved and any other publically available information about each company was collected. All semi-structured interviews and workshops were thouroghly documented, e.g. recorded, photographed and notes were taken each time by the two researchers simutaneiosly. Moreover, each interview was complemented with a factory tour with possibilities for the researchers to make own observations at each member company.

4. RESULTS

4.1. Pre-study results

The first data collection in this study was performed at the company that was identified by the regional business coordinator for initiating the cluster. It was estimated as a visionary company that had already started its transition towards PSS, which could serve as an inspiration and engine for change in the region. Its transition emerged from its know-how and skill in building automated manufacturing equipment and solutions for certain applications. With a new recruited CEO and a very skilled and experienced engineer/project manager they combined a successful knowledge team – a strong business mission focusing on customer value together with engineering know-how. This company identified the need for offering the pre-studies to their customers – i.e. being paid for consulting engineering hours, the after sale service and maintenance. Today, they offer engineering consultancy, hardware development of automated equipment and production processes, installation, education of operators, service and maintenance. Their experience in this transition, from a traditional automation supplier with an offer based on equipment towards a PSS supplier within automation offering a combination of goods and services, is that it is manageable but in the region it might be difficult to recruit the needed competence. Therefore, this company decided to support the region to establish a cluster for companies that deliver, develop or are a supplier of automated equipment and/or solutions.

The pre-study indicated the potential for a company to start a transition towards a more PSS approach and that the region needs to identify a couple of specific areas, such as automated manufacturing solutions. Furthermore, it was shown that a company must have enough resources to grow both in number of employees and competence areas in order to succeed. Therefore, funding was applied for establish a regional network for the automation companies in order to identify how these companies can support each other to grow and hopefully collaborate in a PSS manner in the region.

4.2. Expectations of the cluster

When funding was approved companies were selected and invited to participate in the establishment of a regional cluster. In sum, the member companies have a total turn-over of 300 MSEK (year 2012) with about 300 employees all together. For this region this is representing a large company. However, the employees at the companies differ from one up to 80, i.e. some of the companies are very small, but with specific competence within automation and valuable customer or supplier relationships. In the interviews the selected companies expressed the following expectations on the network from a regional perspective:

- Increase awareness among customers about modern production technology
- Promote the region as a skilled automation partner
- Increase the attractiveness of the region for skills
- Learning about the companies in the region and help customers to find the right partner
- Train customers in the means of automation
- Defining the concept of automation – what is included or not

Moreover, the interviews revealed the following more specific business related drivers for collaboration, e.g. this was identified as the companies thoughts about “what’s in it for me”:

- Access to advanced and new technology within the network
- Increased flexibility – both in technology and in business
- Safer deliveries
- Faster time to market
- Stimulate creativity

In order to support the establishment of the network itself the following workshops were used to identify how flexible automation could support a competitive business:

1) Value mapping for each company's value constellation (see results above)
2) Identify each company's offering and sales process – as is
3) Analysis of business offerings related to service offerings
4) Customer value and profit pools (positioning the network competence in the automation industry)

4.3. Value constellation mapping

The first workshop in the company network aimed for facilitating each company to perform their own value mapping. This was performed after some inspiration speech about trends within automation and business models. At this first workshop 15 out of 21 companies attended.

The value constellation mapping (Normann and Ramirez, 1993) was performed by the participants two and two – representing different SMEs. This was a way to support the participants to get to know each other and also get the opportunity to discuss the tool value mapping.

The result from the first workshop can be described in two ways. First of all, the companies started to talk and interact carefully with each other and after a while the room was full of energy and discussions between the different company CEOs. All participants presented their own value map for the whole group, which they knew from the beginning that they should do. Some companies were very open with their value map and some was more careful about what they lift forward.

The more explicit result was that many of the companies presented very similar value maps and keywords, even if they worked more or less separately. The companies identified their value in know-how from idea to final solution, which most often is a product with drawings, developed hardware in combination with standard components including programming and installation at the customer. It appeared that the companies need to be flexible in their development of new automated solutions and supply automated solutions that meet their customers' high requirements on productivity rates and quality.

4.4. Automation Offering – development potential

Results from the second workshop, where each company identified its offering and sales process, indicate that the companies have different experiences in combining hardware with engineering know-how to the customers. There is a potential in how to further develop the way to collaborate in early project phases with the customers, in order to deliver manufacturing and automation knowledge combined with hardware and software in an automated manufacturing system adopted to the customer needs. The companies in the network, however, all together have a knowledge from machine design, robotics, machine development, production technology, virtual tools, 3D printing, electrical design, welding, etc., which in a beneficial way can be utilized in different business offers (see Table 1). Their know-how within the production technology in combination with automated solutions has a high level.

During the workshop, it was intensively discussed customer value and how to invoice and get paid for long term projects. As a complement, the in-depth interviews showed that the SMEs are dependent on final payment when the customer project is closed. Sometimes the payment is coming a couple of month after the closing of the financial year, which contributes to fluctuations in the financial data.
In the third workshop the offerings from each company were mapped in the continuum from goods (100%) to service (100%) (Oliva and Kallenberg, 2003). The offerings in the cluster companies varied over the whole spectrum. The discussion about the business offerings and how to offer knowledge based services continued on a deeper level, especially how to offer and get paid for knowledge-based services were discussed. Many companies provided such services free of charge to their customers. The discussion was also about how to improve customer awareness of delivered value, not only payment.

Table 1. Summary of automation profit pool and the studied company network competence.

Industry mapping through profit pools	**Core competences within the member companies**	**Industrial representation by the member companies**
Project management	*Mechanical engineering* – such as mechanical design, hydraulic	Material – such as Polymer, Metal, Wood and some carbon fibre composite
Needs, Quality, Conceptual ideas, Finance	*Production technology* – such as tool makers, injection molding of plastics, assembly, welding	Robotics – such as dressing, programming, grippers
Design (Mechanical, Electrical, Software)	*General engineering* – such as 3D-CAD, PLM system, creative problem solving ability, project management, industrialization, facilities planning, quality	Special automation machine solutions including feeding solutions
Manufacturing / Assembly including purchasing	*Robotics and Electrical Design* – such as programming (robot, PLC, CNC, ...), robot simulation, control cabinet assembly	Service and Maintenance
Machine assembly and test	*Service* – such as troubleshooting, machine service, maintenance	Training
Installation and validation		
Training		
Service and After sales		

The last workshop covered customer value and profit pools, with the aim of positioning the network competence in the automation industry. Identified actors in the automation industry are summaries in Table 1, where the first column list the different profit pools relevant for the automation industry according to the participating SMEs, the second column the core competence within the member companies and the third column which industrial segments the studied SMEs are acting within.

In the studied cluster the customers can utilize the following identified opportunities:

- Within the network there are huge and appropriate factory layouts that can be used to assemble and test production cells before delivery
- The network has competence to delivering from early phases in product development (i.e. different levels of prototypes) to machine assembly and installations worldwide
- The companies in the cluster interacts with four of the largest robotic suppliers e.g. ABB, Yaskawa, FANUC and KUKA, which enables possibilities to deliver customized solutions
- Huge amount of highly maintained and/or new CNC machines and machining workshops
- Many toolmakers and electricians familiar with the industrial automation demands
- A network surrounding the cluster with several key technology suppliers, such as vision suppliers, to obtain tailored solutions.

4.5. Customer and market analysis

A customer and market analysis was performed by the regional business coordinating office with support from the researchers and the member companies. The customer identification was based on workshop results (the value constellation mapping, business offerings and interviews with each company). First of all, a trend to move back production to Sweden was noted. The survey results and interviews indicate, furthermore, that both customers and automation suppliers express a desire to increase collaboration in order to achieve automation advantages. This need is expressed independently of different industries (plastic, metal, wood, carbon composites, foundry, automotive, and process industry). As expected, small companies face more challenges related to investment and resources for automation. Furthermore, challenging for the future is that automation supplying SMEs need to manage global competition and high uncertainty. On the other hand, the analysis shows that the creative and business environment-conscious company, able to manage software development and integration of digital data, sees the coming opportunities. It is further identified that there is a notable need for extensive competence and advanced knowledge in order to stay competitive.

5. ANALYSIS

The trend in manufacturing, to be more efficient and increase the productivity, is a huge manufacturing challenge. The interviewed CEOs at the SMEs are aware about the problems related to convince the customers about the benefits in investing in automation and furthermore, that the more and more customized products demands automation solutions that sometimes are highly flexible. This corresponds to the nine reasons that justify a transition towards automation according to Goover (2001) but the key is to bridge the reasons into a competitive business, both for the automation supplying SME and the customer. When mapping the competencies in the case study (see Table 1) it is clear that the studied network has the production technology know-how that Dean et al. (2009) argue for is needed to provide customers with a flexible automation solution.

Based on the case study, the manufacturing SMEs express that their ability to contribute to their customers' value by offering automation solutions could be further developed. This is supported by Barton and Thomas (2009) who argue for extended offerings. The leverage from the cluster was recognized, which is further in-line with their research. However, it is a balance for the customers to identify when and how to include suppliers in their product development process, due to sensitivity in product data.

The SMEs could perform a transition towards delivering automation solutions and services in order to reduce risks both for themselves but also for their customers. Especially, the studied cluster could benefit if one company faces the customer with secured resources within the cluster, as the mean to reduce risk ("as service players" according to Oliva and Kallenberg, 2003, p.171). Since Beach et al. (2000) concludes that the relationship between business and manufacturing stragety must be further developed, these companies must further develop their way to collaborate for business oppourtunities. In this work forward, to establish a company network, it is important to understand where the companies compete and where they can improve their competitiveness by collaboration. This is supported by Porter (1998) through his analysis that clusters can affect competition in different ways.

The cluster idea seems to be a relevant way to organize (Porter,1998) with the gathered critical mass in automation. However, the case study clearly viewed the need to manage sensitive information since many of the member companies perceived the others as competitors. During the course of the workshops trust was evolved between the member companies and some collaboration were established in joined business projects. Furthermore, the region has now a common base to use in strategic discussions about automation and SMEs nationally.

Moreover, the analysis shows that the member companies represents largely the automation industry but each company itself cover just a small part. This indicate the sensitivity to be a small company but also the advantages of collaborating in a cluster. The market and customer survey indicated that there is a customter need for broader offerings than one of these SMEs can manage themselves, both based on resources, technologies, material and financially. The challenge for the established cluster will be to meet the expectations from the member companies and manage the future collaborative issues – both business, knowledge and competence related.

6. CONCLUDING DISCUSSION

It is possible to establish a cluster that originates from the same technology base – in this case automation solution suppliers. The manufacturing SMEs in this case have so far managed business on their own, but face important challenges related to increased customer demands, fast knowledge transition related to new technologies (e.g. vision, simulation, software integration, digital data management, new material characteristics) and global competition from similar suppliers. Most of them are too small to manage a complex order that integrates several different technologies. Therefore, the cluster can be a solution for future businesses but there is a need to develop relationship-based trust among the members, for long term knowledge development and joint order-winning offerings. However, the major challenge will be to find collaboratively developed automated solutions between customers and the members in the cluster that are favorable both for individual companies and the long-term development of the cluster.

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