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Opportunities for robotic automation in wood product industries: The supplier and system integrators' perspective

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Abstract

In this study, the opportunities for automation in the poorly automated wood product industry are highlighted. This is accomplished by conducting a qualitative interview study of suppliers and system integrators for industrial robots active in this particular industry sector. Five case companies are chosen in order to explore the unique dimensions responsible for successful automation implantation in wood product companies. Results show that a low understanding of automation opportunities, unclear requirements specifications, and small production volumes are the main problems for suitable automation solutions. Although wood is a fragile and changeable material, existing technology allows its manipulation with industrial robots.

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1. Introduction

Throughout many industries, automated systems and industrial robots are widespread and cover an extensive range of different manufacturing applications and processes. As leading industrial sectors in regards to automation

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of production systems, the automotive and the electronics industry can be named. At the end of 2015, the operational stock of industrial robots in the automotive industry is about 620,000 and in the industrial branch of electrics/electronics about 330,000 [1]. Together those two sectors account for over 57% of all operational industrial robots worldwide. It is expected that these numbers increase in the next couple of years.

For enterprises active in those industries, the planning and realization of flexible automation technology is an appropriate way and of crucial importance when the goal is to improve manufacturing capacity [2] or to avoid outsourcing to low-cost countries [3]. Production managers and technicians in companies active in those sectors have gained significant knowledge and experience of how to conduct automation projects with industrial robots since the 1960s. With successful, as well as with failed automation projects, the responsible personnel learnt what is possible and what is not [4].

However, in industries with low or no experience of the utilization of automation, discrepancies between what is requested by a company and what is actually the best way and feasible to fulfill these demands, can be observed. Company leaders are often interested in automating the most complex processes in their production, making an automation project hardly performable [5]. This phenomenon can be witnessed when attempting to copy successful automation projects from other industry sectors to industries with little to no experience of automation. Here, the lack of understanding crucial underlying factors, such as programming time and cost, additional equipment, or the personnel's insufficient competence complicate automation projects. In many cases, this can result in poor experiences and loss of trust in new technologies [6]. Automated systems are often also very closely connected to some kind of digital data input, supporting the execution of machining operations. Therefore, automation projects often go hand in hand in with information technology (IT) projects. When executing IT projects, factors for their failure or success have been researched thoroughly [7]. However, this is only possible because the crucial influencing factors for the outcome of projects are known.

One of the least automated industrial sectors is the wood product sector. According to [1], only 0.2% of all industrial robots in operation worldwide are installed in the woodworking processes. The wood product sectors consist of the furniture industry, industrial timber house building, carpentry as well as joinery industry [8]. Here, manufacturing processes are mainly manual and characterized by a low understanding of possibilities for further development of production processes and systems [9]. In regards to automation of manufacturing processes, the wood product industry is lagging behind by about 20 to 30 years in comparison to the automotive industry, which can be understood as the manufacturing sector with the highest degree of automation [10].

2. Objective

The objective of this study is to identify factors, which have to be considered when industrial robots are to be implemented in manufacturing processes of wood product industries. The focus is hereby put on the possibilities and opportunities from the perspective of automation practitioners with the expertise and the experience of implementing automated systems in common wood working manufacturing processes. Consequently, data is collected through an interview survey in Sweden.

3. Research design

For selecting appropriate interview objects, the method of convenience sampling in combination with the snowball method has been used. Convenience sampling describes a sampling method where respondents are chosen by personal knowledge or 'friendship' [11]. In addition, snowball sampling is an appropriate and effective sampling technique when trying to reach a population which is unknown, 'hidden' or few in numbers [12]. Noy [13] describes snowball sampling as a data accessing method where contact information is provided for the researcher by other informants. The so-called snowball effect is, of course, repetitive because the researcher contacts all the 'new' informants given by 'old' informants.

In this study, large manufacturers of industrial robots, active on the Swedish market, have been chosen as a starting point on basis of the own knowledge of the researchers. Those respondents, which stated that they are not active in industrial applications in woodworking sector, were eliminated as candidates for an interview. Robot manufacturers, which only provide equipment for research to e.g. universities or sell to system integrators, were

excluded from the list of respondents because this study focuses on industrial applications of industrial robots only. All robot manufacturers, which are active in the wood product market did participate, and key personnel were interviewed. Representatives from both groups were also asked to refer to system integrators who they know of being active in the woodworking sector. The contemplated system integrators were contacted and again, asked to participate in the study and also ask to share information about competitors or other enterprises. As illustrated in Fig. 1, the research technique was repeated until the circle was closed and no new informants could be identified this way.

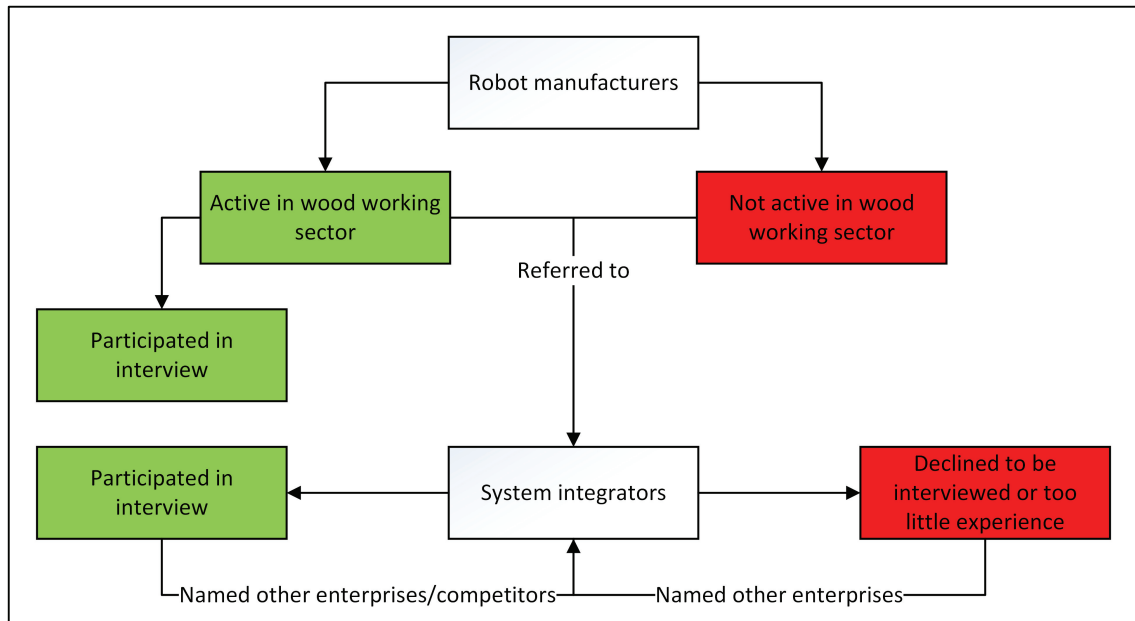


Fig. 1 Overview of the applied method of convenience and snowball sampling technique in this study

System integrators, who were willing to participate in the study, and had necessary experience and knowledge, were finally interviewed. Some system integrators participated or stated that they (according to themselves) have too little experience to have an input to this study. In Table 1 an overview is given over five participating respondents and their affiliations as well a short background of their company. In total, six robot manufacturers and 18 system integrators were contacted.

Table 1 Overview of the five respondent (sorted by number of employees)

Case no	Line of business	Size (in Sweden)	% of total robot sales to wood product industries	Position of respondent	Years of experience with robots	Active markets
1	Robot manufacturer	150	20%	Senior sales manager	20	Worldwide
2	Robot manufacturer	45	10%	Marketing manager (CSM)	15	Worldwide
3	System integrator	40	20%	Senior sales manager	12	Scandinavia
4	Special equipment and system integrator	13	50%	Chief Executive Officer (CEO)	7	Scandinavia
5	System integrator	7	40%	CEO	38	Regional

With the exception of one participant, all interviewed persons had more than ten experience of working with industrial robots in general and compelling knowledge in integrating industrial robots into wood product industries and can therefore be seen as experts in their field. This was to guarantee knowledge in this area and uphold a good external validity of the quality of the replies. In the case where the interviewed person only had seven years of experience working with automation in wood product industries, the person works for a company with over 50 years' experience in manufacturing and installing specialized wood working or automation equipment. Therefore the participant was deemed to have the necessary expertise to contribute to this study.

Data was gathered by semi-structured interviews, where all respondents were asked the same set of questions, either in person or via telephone. Follow-up questions were asked when suitable. The length of the interviews varied between 30 and 60 minutes. All interviews were recorded for the purpose of transcription. The transcript was then sent out to each of the respondents for approval and correction. Only the final transcript was then used for data analysis.

4. Results

In the following, the results of the interviews are described in accordance with the numbering of the cases presented in Table 1.

4.1. Case 1

The consensus in company 1 is that the potential for automation is enormous in wood product industries. Only about 1% of all Swedish wooden furniture manufacturers have implemented industrial robots in the production processes. As main driving forces for automation, the senior sales manager mentions increasing competitiveness, quality enhancements, and an improvement in the working environment.

Their senior sales manager sees a lot of potential, especially for packaging and palletizing if the production volume is high enough, regardless if it is furniture, joinery, or cabinet manufacturers. In addition, particularly robotization of manufacturing processes for furniture yields often in positive side-effects, e.g. reduction of monotonous and straining production steps. According to the senior sales manager, successful automation implementation always requires that the customers' managers fully support the project and understand automation. Furthermore, customers without any previous experience have to start small.

During the manager's 20 years of working with industrial robots, the usability of the robots has increased considerably. In the early days of automation, the demands on the personnel in regards to competency were much higher than it is nowadays. Smart solutions, such as easily manageable interfaces, allow the workforce with low experience of industrial robots to operate automated cells. When implementing new robot cells, the personnel is at first often nervous about losing their jobs. In such situations it is key to show how their working conditions will improve due to the robots, and that their jobs often reach a higher quality and opens up for new work at different positions.

As biggest hinder for automation in wood product industries, the senior sales manager mentions the fear of failure of the customer's managers as well as their low competency in regards to production. They often lack a manufacturing strategy and are uncertain of which goal they actually want to achieve. Wood as a material is not a problem as long as the quality of the raw material is homogenous enough.

4.2. Case 2

The marketing manager (CSM) of company 2 states that it is always interesting to work with companies that are willing to improve and develop their production processes. The driving forces for automation are according to the CSM to achieve the possibility to stay ahead of the competition and to manufacture more sustainable, particularly an increase in working conditions and safety issues. Furthermore, the product quality is often enhanced.

The biggest potential for automation in wood production industries is for the furniture industry in handling material and tending computer numerical controlled (CNC) machines specialized on woodworking. Packaging and palletizing are also very promising areas.

As a prerequisite for automation, the CMS notes that the products must be prepared for automated production. Often their design is not optimally adapted for handling with industrial robots. The design is made for manual manufacturing. Here, the CSM mentions that an adaption or change is necessary for many furniture manufacturers. Moreover, many customers have a too long ‘wish list’ of what industrial robots should be capable of in the manufacturing process. It often takes some time for the customer to understand the limitations and to apprehend a more realistic view of robot applications.

Even if the initial knowledge or competency of the personnel might be too low, the most significant factor is that the responsible persons have the drive to acquire the necessary competence to operate new equipment. Problems when dealing with solid wood can often be solved by using extra equipment, e.g. vision systems or more intelligent tooling.

4.3. Case 3

The senior sales manager of company 3 states that wood product industries have a very high potential for automation because most work is still done manually. As main driving forces an increased production capacity and enhancements of working conditions, as well as ergonomics, can be achieved by the implementation of industrial robots. Without automation, the sales manager states, production is in danger to disappear from high-cost countries, especially for wood product companies with relatively low profitability. The senior sales manager mentions as well that it is important to demonstrate for wood product companies that it is possible to build simple, but still flexible industrial robot cells.

The potential for development is high throughout the different industry branches. Of course, it is mostly developed in mass production for furniture. The senior sales manager mentions that big parts of the wood product sector are in need of remodeling of its production systems and developing new production strategies.

One of the success factors for automation in wood product industries is to adapt the level of difficulty of the robot cell, i.e. rather start with a limited application than with the whole process and continue when the process is understood by the workforce. This is to avoid failures. However, especially in the beginning, the system integrator has to take a lot of responsibility for the robot cell in comparison to e.g. a robot cell in the metal-working industry. Otherwise, the low degree of competency is the biggest problem for wood product industries when implementing and operating industrial robots. Wood as a material is not a problem to handle. All materials have their problems, and automation solutions have to be flexible enough to handle possible conflicts.

Personnel, both in the workforce and on management level made mainly positive experience because automation projects led to an improved working environment and eliminated tough and monotonous manufacturing processes.

4.4. Case 4

Although, company 4 had about 50% sales of industrial robot cells to the woodworking sector in 2016, their chief executive officer (CEO) states that those numbers have been very low for this year. Usually, sales to wood product companies are about 80-90% of their sales volume. The CEO expects to return to those numbers during 2017. The company sees the woodworking sector as very interesting due to the low degree of automation in all of the different areas of the wood product industries. As the biggest driving forces for automation, the CEO of company 4 remarks that improvements in ergonomics and higher productivity are most crucial. The very changeable material wood itself is different than other materials, e.g. metal sheets or plastics, but they do not consider this as a problem and with existing technology all their cases could be solved.

Their company has implemented many good examples of machine tending cells with a robot feeding one or two CNC machines. But also machining operations, e.g. drilling or milling are interesting for them because of the higher degree of freedom of industrial robots in comparison to CNC machines.

Case company 4 finds that the biggest problem when implementing industrial robot cells in the wood product sector is the quality of the delivered raw material. Their customer has to put higher demands on their raw material

supplier, and the delivered material has to come in a certain order so that a robot can manipulate it. According to their experience, delivered goods to robot cells are often unstructured and not organized. This complicates automated manufacturing in an unnecessary way. Their customers often lack good understanding of machine safety, and they want to solve too many tasks with just one robot at the same time. Moreover, the manually carried production steps are not that suitable for automation with industrial robots and a new way of manufacturing has to be developed. The CEO emphasizes that this is especially the case with customers which have a very positive attitude towards automation.

Particularly small and medium-sized enterprises (SME) are afraid of the amount of new knowledge they have to acquire in order to be able to operate an industrial robot cell. However, according to company 4, the required knowledge is often far lower than what is believed in the first place. They have not met any reluctance or bad experience during automation projects with personnel of customers fearing for their jobs. As biggest problem, the CEO mentions that especially SMEs have too little knowledge about the possibilities of automation. The wood product companies they meet are often convinced that it is not possible to build robot cells flexible enough for their specific demands.

4.5. Case 5

Company 5 has primarily experience in installing robot cells for wood furniture companies, mainly machine tending and assembling of furniture. As leading force for automation the CEO of company 5 states that higher production efficiency and profitability are the only way to keep jobs and companies in high-cost countries.

Their CEO states that painting of furniture with industrial robots is as well very interesting and has a lot of potential. However, the best solutions are often achieved when implementing fully automated machine cells with industrial robots and special machinery, e.g. CNC machines. The CEO mentions that wood as a material is more complicated than other materials and especially solid wood objects can be very difficult to handle due to their sensitivity to humidity. In addition, the correct sorting and position of the delivered raw material are crucial.

The CEO has often made the experience, that many potential customers think that *“robots will solve all their problems”*. In these cases, they have to explain to their customers carefully what is possible and why things have to be done in a certain way.

The competency, i.e. the inexperience of working with automation equipment in many wood product companies is not a problem and the operator's dedicated to the equipment can often acquire all the necessary skills. After implementation and successful installation of industrial robot cells, case company 5 has often been met with a positive attitude from their customers in regards to automation. This is mainly based on the elimination of monotonous production steps and simplifying work.

As biggest hinder for automation in wood product industries, two factors have to be named according to CEO. First, the low production volume decreases profitability too much, because it requires very flexible cells with a lot of expensive programming. Second, solid wood has to be handled very carefully because it changes very often in certain manners if humidity is not constant during the entire manufacturing process.

5. Analysis and discussion

In Table 2 the content analysis of the five interviews is presented. The content is filtered according to four categories: driving forces for automation with industrial robots, suitable applications with industrial robots in wood product industries, requirements and hinders for automation. Those four categories are used because they allow for identifying factors for implementation of industrial robots into wood product industries. As main driving forces a reduction of the monotonous workload, improved working conditions, and ergonomics are named several times. In addition, improved competitiveness and an increase in production capacity are also mentioned. The respondents are mostly convinced of that machine tending operations of CNC machines have good prospects, especially if the production volume is high. As requirements for automation, several aspects are mentioned. Those are competence and new skills of the workforce to operate industrial robots. Continuingly, management involvement is required as an adaption of the products, i.e. design for manufacturing or design for assembly. As hinders, the respondents mentioned the lack of knowledge about the possibilities for automation as well as unclear requirements specifications of which tasks the automation equipment should perform. For machine tending cells the positioning

and quality of the incoming goods also play an important role. Dimensions and shapes need to be good enough to manipulate with robots. This is primarily the case for workpieces consisting of solid wood.

Table 2 Content analysis of the interviews

Category Case no	1	2	3	4	5
Driving forces	Ergonomics; reduced monotonous workload; improved competitiveness	Improved competitiveness, sustainability, safety, quality and working environment	Increased production capacity; ergonomics; keeping production in the country	Increased production capacity; ergonomics	Keeping production in the country; improved production efficiency
Applications	Packaging; palletizing	Machine tending	Machine tending of high-volume furniture	Machine tending and operations	Machine tending; painting
Requirements	Management involvement; change management for production stuff	Adaptation/redesign of products; new competence for responsible persons (to create key personnel)	Start small and grow with experience; relying on consultants (external key personnel)	Competence of personnel	Competence for personnel; Control over delivered (raw) material quality
Hinders	No clear requirements specifications; personnel afraid to get cut	No clear requirements specifications; problems with handling of solid wood	Traditional view on manufacturing; missing knowledge of possibilities	Fear for new technologies; Competence of workforce; quality of delivered 'raw material'	Missing knowledge of possibilities; low production volume; problems with handling of (solid) wood

Main driving forces are increased competitiveness and productivity, as well as improved ergonomics and working environment. In addition, also quality improvements of the products have been mentioned. Of course, those driving factors do not differ from other industries, e.g. plastics, electronics of automotive industry [1]. However, an improvement and reduction of the many manual and monotonous working conditions would have a big impact and also create more attractive workplaces. Keeping the companies competitive and therefore a possibility to remain in a high-cost country such as Sweden is a factor known in other industries [3].

Machine tending operations are seen as the most promising opportunity for automation, mainly because it is simple and similar to many installations in e.g. metal-working industries. In those industries, fully-automated machining cells have been so successful because they often work in several shifts and also tend more than one machine. Economic reasons can make it difficult to implement machine tending cells if work is only carried out in one shift per day.

One of the main concerns of many wood product companies, regardless if it is the furniture industry or industrial timber house building, is that wood as a material is more complicate to handle with automation equipment. All five cases state that is more difficult, but in the end, no problem to solve with existing technology. A consensus can be made about the level of competence of the personnel of wood product companies. The knowledge and skill set of both managers and operators are low and there is a lack of understanding of automation and automated processes. In addition, all five cases mention that customers have to be slowed down in their efforts to automate because they understand industrial robots as some kind of all-problem-solving technology. This also meets what is described from other industries [5]. Open communication is necessary to avoid misunderstandings and potential failures. One case even stated that failures in this industry sector could rapidly create a poor reputation and hinder many efforts for further development with industrial robots. The same phenomenon was observed by Granlund and Jackson [6].

Another important factor, mentioned by the case companies, is that wood product industries have to start a dialog with their suppliers and put higher demands on the quality, structure, grading and sorting of the delivered goods.

6. Conclusions and future work

Especially in high-cost countries, wood product companies are put more under pressure to stay viable and competitive. Many companies are looking for automation solutions, but do not possess the knowledge of where to start or what is crucial. Therefore, a maturity matrix or readiness model tailor-made for wood product industries can serve as a reference or guideline to where the most effort has to be put into to ensure successful automation implementation. The goal of this study, to identify which factors influence automation in wood product industries, is a first step in developing such a model. The results presented are similar to findings in other literature as driving forces, requirements or hinders for implementation of industrial robots [3, 5, 6]. Interestingly, wood as the material itself is not seen as the main issue, although it which can change its shape quite rapidly. Wood product companies are convinced that the raw material or work pieces they use are not suitable and only very hard to handle with machines. The method used in this study produced a number of companies which were interested in participating. However, it is unclear how many system integrators actually have been missed because they are maybe too small or extremely niched and therefore unknown for their competitors. In addition, this study includes only five cases, which is too little to draw a general conclusion. Nevertheless, those interviews fulfilled their main purpose of this study. It allowed identifying the underlying factors for successful automation implementation in wood product industries. They can mainly be described as issues of competency, managerial issues, and strategy, technology, material and products.

In order to achieve a working, yet simple readiness model, the number of interviews has to be increased to ensure a better quality of the results. On the one hand, it is expected to increase the number of same main findings, and on the other hand to find some outlining and unique factor for the wood product industries. It will also be interesting to investigate to which extend the concept of Industry 4.0 and collaborative robots will have an impact on and to which changes this can lead to in existing production systems.

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