MANUFACTURING PROCESS IMPROVEMENTS USING VALUE ADDING PROCESS POINT APPROACH: A CASE STUDY

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Manufacturing functions need to be capable of constantly developing new manufacturing lines, cells, and pieces of equipment in order to maintain their operational competitiveness. This paper explores a unique approach to analyzing and designing manufacturing processes referred to as the Value Adding Process Point (VAPP) approach. This approach particularly focuses on the points where value is added to materials in manufacturing processes. The approach is mostly used at Japanese companies and it has contributed to developing unique manufacturing lines, cells, and pieces of equipment that tend to be simple, slim, and compact, and require low investment cost. The approach has also contributed to achieving major improvements in different performance measures in manufacturing. However, the approach is rarely known internationally. Moreover, the amount of practical information on how to apply the approach at companies has been limited in the scarce literature on the approach. The purpose of this paper is to introduce the VAPP approach to a broader audience and also to provide practical information on how to apply the approach by describing a case study in which the approach was applied at a Swedish manufacturing company. At the company, the application was made in a manner of experiential learning. In this paper, it is described how the VAPP approach was applied, what outcomes were generated by the application, and how participants in the case study experienced the application of the approach. Discussions are made as to usefulness of the approach and effective use of the approach.

Keywords: Manufacturing; process improvement; innovation; value-adding; process design

Introduction

Manufacturing functions at high-wage countries have to be highly competitive in order to provide value for the companies. If these functions develop manufacturing processes only by imitating competitors’ solutions or relying on external suppliers, the functions may soon risk their survival. They have to be active in creating new knowledge and constantly develop new manufacturing processes, for instance manufacturing lines, cells, and pieces of equipment. In Japan many manufacturing functions have been exposed to strong competitive pressure from fast-growing internal and external competitors located for example in East and South East Asia. As a response to the pressure, many of them have intensified efforts of developing unique manufacturing lines, cells, pieces of equipment. To support the efforts, some of the companies have employed an improvement approach that particularly focuses on the points where value is added to materials in manufacturing processes. In a machining tool, for example, the point of value adding is where the drill contacts the work to perform cutting. In the improvement approach persons are prompted to conceive an ideal state where a manufacturing process is realized only by the materials and the parts of the human body and/or pieces of equipment directly involving the point of the value adding. In other words, any other parts of the human body and/or pieces of equipment are considered as wastes. Such a perspective seems to contribute to generating unique manufacturing processes and pieces of equipment which tend to be simple, slim, compact, and require low
investment cost. The improvement approach also has contributed to achieving major improvements in different performance measures in manufacturing. This paper explores this approach referred to as the Value Adding Process Point (VAPP) approach.

There are only a few articles and books that describe the theories of the VAPP approach (Nakamura, 2003; Shinoda and Nakamura, 1996; Shinoda and Niwa, 2000). Several reports have been published describing the application of the approach at Japanese manufacturing companies. However, these books, articles, and reports are written in Japanese and consequently the approach is rarely known internationally. Although the approach has a potential for being used at a larger number of companies, the above mentioned articles, books, and reports do not provide sufficient information on how to apply the approach in practice. The theories of the approach only provide basic procedures of how to use the approach. The most of the reports only partially describe how the companies applied the approach.

The purpose of this paper is to introduce the VAPP approach to a broader audience and also to provide practical information on how to apply the approach by describing a case study in which the approach was applied at a Swedish manufacturing company. At the company the approach was applied at four different sections of the factory in a manner of experiential learning. The application was driven by the main author of this paper.

Describing an application case of the approach was the main purpose of the case study, but the case study also had two additional purposes. One was to identify tools that could support application of the VAPP approach. Companies using the approach seem to devise their own tools when they applied the approach, which raises an assumption that there is still much room for identifying support tools for the approach. The other purpose was related to the ideal state mentioned earlier, that was to analyze how users of the approach could generate technically feasible solutions as close to the ideal state as possible. When generated solutions are closer to the ideal state, the solutions can be more unique and contribute more to improvements in manufacturing. However, in the literature on the approach there is little discussion about how to come nearer to the ideal state.

This paper is organized in a following way. In the next section the VAPP approach is introduced. It is followed by the presentation of the study method adopted in the case study. Later, how the VAPP approach was applied at the Swedish manufacturing company is described. Finally the results of the case study are discussed and conclusions are drawn.

The VAPP approach

In this section the VAPP approach is introduced. The basic concept of the VAPP approach is explained, and then the approach is compared with other improvement methods. Application examples of the approach at Japanese manufacturing companies are also presented.
The basic concept of the VAPP approach

In this paper, theories of the VAPP approach are explained based on a book written by Nakamura (2003), because it provides the most comprehensive description of the theories. A literal meaning of value adding process point is the same as “process point” denoted in a TPM tool, Process Point Analysis (JIPM, 1996): an area or space where a tool contacts a workpiece and transfers force or other kinds of energy to the workpiece in order to transform the workpiece into a desired shape. However, in the VAPP approach, the value adding process point is defined in a more extended way than its literal meaning. In this paper the definition is explained by using a milling process as an example (see Figure 1). The VAPP approach is partially based on the systems theory (Hubka and Eder, 1984). A manufacturing process can be seen as a work system whose task is to transform materials, energy, or signals from a certain state (input) to a desired state (output). However, in the VAPP approach only the materials that are to be the whole or parts of the final products are focused because value is added to those materials. In the approach these materials are called objects. In the example in Figure 1, the milling process is considered as a work system whose task is to transform a specific shape of the workpiece (the object) to a desired shape.

Figure 1: The basic concept of the VAPP approach, an example of a milling process

A transformation process from inputs to outputs normally includes more than one partial process. Among the partial processes, there should be one or a few processes that cannot be eliminated regardless of any means to accomplish the task of the work system. In the VAPP approach these ineliminable processes are the ones in which value is added to objects. In the approach these
processes are referred to as Value Adding Processes (VAPs), and other partial processes as non-VAPs. VAPs and non-VAPs are expressed by describing what actions are done on the objects and the actions are expressed with verbs. In the milling example in Figure 1, the partial processes are placing the workpiece on the fixture, removing the designed part of the workpiece, and cleaning the workpiece. The VAP is the second partial process. In the milling example, the VAP is realized by the milling center contacting the workpiece and transferring the necessary force to it. At the same time the fixture contacts the workpiece to hold its position. In the VAPP approach, physical entities directly contacting objects and transferring/receiving force or other kinds of energy to/from the objects in order to realize a VAP are referred to as work heads. The milling center and the fixture are the work heads in the example. How work heads interact with objects at a VAP significantly influence the output quality of a work system (in the milling example, the output quality can be measured by, for instance, dimensions and surface roughness of the milled workpiece). Certain attributes of the objects and work heads (e.g. hardness, shape, heat conductivity) and certain controllable parameters affecting the interaction among them (e.g. turning speed of a work head) need to be considered in order to ensure the output quality. In the VAPP approach, those attributes and parameters are called conditions for quality conformance.

It can be inferred that objects, work heads, interactions among them, and conditions for quality conformance at a VAP (or VAPs) are key elements of a work system. A Value Adding Process Point (VAPP) is an essential mechanism for realizing a VAP. A VAPP consists of objects, work heads, interactions among them, and conditions for quality conformance at a VAP. A VAPP is described by using those elements. In a simpler expression, a VAPP is what is essentially done at a value adding process in a work system.

**Designing and analyzing a work system using the VAPP approach**

The VAPP approach is an approach to designing and analyzing a work system with the specific focus on VAPPs. Nakamura (2003) suggest a basic procedure for designing a work system focusing on VAPPs:

- Identify objects and define the task of a work system.
- Identify the VAPs in the work system
- Decide work heads and interactions among the objects and work heads at the VAPs. Identify conditions for quality conformance at the VAPs.
- Design physical structures that enable the VAPPs. Add non-VAPs if necessary. Design structures that enable the non-VAPs.

In the VAPP approach it is aimed to realize a simple work system as much as possible. A simple work system is a system in which VAPs are realized with few physical entities, little energy, time, and information. Nakamura (2003) provides a general principle to achieve a simple work system. The principle is to conceive one of two specific ideal states. One is a state in which the task of a work system is accomplished only with VAPs. An image of this state is that the objects in a work
system realize the VAPs by themselves without any external influence. The other is a state in which the task is realized only with VAPPs, in other words, with the objects, the work heads, and the interactions among them. Nakamura (2003) also provides some complementary guidelines for achieving a simple work system. Examples are shown in below:

- **Compact VAPs.** Consider if VAPs can be done at the same time and place.
- **Minimize the frequency of “holder” changes.** Objects are maintained at certain positions by various kinds of *holders*, for instance hands, jigs, tables, pallets, containers, and conveyer bands. The less frequently the holder changes occur in a work system, the less complicated the system tends to be.
- **Choose appropriate work heads and identify conditions for quality conformance at the VAPs.** Well-designed work heads and well-controlled VAPs can reduce the amount of non-VAPs, such as finishing, cleaning, inspections, etc.

In an analysis of a work system focusing on VAPPs, Nakamura (2003) suggest to use several perspectives. Examples are shown in below:

- **Compare the amount of time, space, energy, and physical entities used at VAPPs and the amount of those used in the work system.** For instance, when a factory is a work system, the amount of time, space, energy, and physical entities used at the factory is much larger than the amount used at the VAPPs.
- **Focus on objects and follow how they are handled in a work system.** In a factory for instance, the value should be continuously added to the objects until they become the finished products. In reality however, the objects are frequently moved up, down, to the left or right, and turned or rotated between the VAPs.
- **Identify the frequency of holder changes in a work system.**

**Comparison of the VAPP approach with other improvement methods**

One of the most common approaches to improving efficiency in manufacturing operations is waste elimination that involves identification and elimination of non-value adding activities (e.g. Liker, 2004; Womack and Jones, 1996). In the VAPP approach value adding is also focused but the approach deals with wastes differently from the waste elimination. In the approach, VAPPs are considered necessary in a work system, but any other physical entities in the work system are regarded as wastes. VAPPs are firstly identified, and then it is considered how to add as few wastes to the VAPs as possible in order to realize the task of the work system. The difference in dealing with wastes between the waste elimination and the VAPP approach is illustrated in Figure 2.

Other similar improvement methods to the VAPP approach are Value Engineering (VE) (e.g. Cooper and Slagmulder, 1997; Park, 1999; Younker, 2003) and Work Systems Design (WSD) (Nadler, 1967). Since WSD is considered equivalent to a specific type of VE called “zero-look VE” (Nakamura, 2011), only WSD is compared with the VAPP approach. Both methods are based on the systems theory in which the task of a work system is defined by the relation of
inputs and outputs. WSD also recommends conceiving an ideal state where the task of a work system is accomplished with no cost and no time. However, a major difference of the VAPP approach from WSD is the identification of VAPPs. In WSD, generating technically workable solutions from an ideal state mostly relies on human’s effort. While in the VAPP approach, identifying work heads, interactions of the work heads with objects, and conditions for quality conformance at VAPs provides a more concrete way of generating workable solutions from the ideal state. Another major difference is that the VAPP approach aims to realize a simple work system as much as possible and provides the principle and guidelines to achieve it. WSD does not have such explicit emphasis on the simplicity.

Waste elimination

![Diagram showing VAPP approach]

**Application examples of the VAPP approach**

There are several reports describing application of the VAPP approach at Japanese manufacturing companies. Some of the reports provide detailed descriptions of how the VAPP approach was applied but most of the reports only partially describe how it was applied at the companies. Table 1 shows a brief summary of the application cases.

<table>
<thead>
<tr>
<th>Company</th>
<th>Application of the VAPP approach</th>
<th>Source</th>
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<tbody>
<tr>
<td>Sekiso</td>
<td>A routine was established in which engineers had to consider at least three alternative work heads for a VAP when they designed pieces of equipment. The company also made an effort to identify and document the work heads and the conditions for quality conformance at each VAP in the factory. These activities contributed to maintaining a high level of manufacturing quality and also reducing investment cost in pieces of equipment to half.</td>
<td>(Kato, 2008)</td>
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<tr>
<td>Fuji</td>
<td>Simple and low-cost manufacturing lines and pieces of equipment were developed by using the VAPP approach. The company made a chart that describes each of the VAPs in the factory. The company also made effort to compact the VAPs at the factory. One of the application results was reducing investment cost of a new assembly line by 30 percent.</td>
<td>(Shinoda and Kono, 1997)</td>
</tr>
<tr>
<td>Univance</td>
<td>A corporate-wide initiative was launched aiming to create new ways of realizing VAPs and to eliminate parts of the pieces of equipment that were not directly involved in the VAPs. A target was to reduce investment cost and size of pieces of equipment to one fifth.</td>
<td>(Sawa, 2007)</td>
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<td>Canon</td>
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A novel approach of designing a new assembly line was created. In the approach, the line was designed from the assembly completion and backwards, based on the thinking that assembly parts should be fed at the immediate points where the parts are de-assembled. 25% higher productivity was achieved in the new assembly line. The area of the line was reduced to half. 

(Tanahashi, 2009)

The company promoted the development of simple and low-cost pieces of equipment consisting of the least necessary functions and structures to realize the tasks of the equipment. The effort of developing simple pieces of equipment contributed to shortening the development lead time more than 50%. 

(Harada and Adachi, 2000)

The VAPP approach was used to develop a simple and low-cost piece of equipment. A conceptual design was made by objects, work heads, and other supporting structures being successively sketched in a large piece of paper. The VAPP approach was used to stimulate production engineers to focus on simplicity and consider a wider range of alternatives without much relying on existing solutions. 

(An interview with an ex-senior manager at the company)

For instance, Mitsuba (Tanahashi, 2009), an automotive supplier, applied the VAPP approach when designing a new assembly line. When the design team disassembled a finished product, they thought that it would be minimum waste adding if each assembly parts were fed to the immediate points where the disassembly took place. With this consideration, the team designed the assembly line backward; they identified work heads and conditions for quality conformance from the assembly completion to the start of the assembly. This design approach was new for the company because they were used to design assembly lines from the beginning of the assembly and forward. As a result, productivity increased by 25 percent in the new line, and the area used for the new line was less than half of the previous ones.

An application case at company X, an automobile and industrial equipment manufacturer, is not reported in an article but was heard during an interview with an ex-senior manager at the company. The interview was for another study than the VAPP approach, but the manager mentioned the VAPP approach when he was asked how managers at the company trained young production engineers to be more innovative. He also explained an application example of the approach. In the example, production engineers were requested to make a conceptual design of a simple and low-cost machine that should make holes on car bodies. A workshop was organized where the engineers first sketched an object (a part of a car body) in the middle of a large piece of paper. Then, they sketched work heads around the object. Later they sketched structures that could realize the VAPP. Along with the conceptual design, notes on reliability, safety, operability, robustness, environmental impacts, etc. were written on the same piece of paper. The manager told that production engineers tended to rely on the existing solutions when they designed pieces of equipment but the VAPP approach helped them to focus on simplicity and think beyond the existing solutions.

The companies shown in Table 1 seemed to have applied the VAPP approach in order to develop unique manufacturing lines, cells, and pieces of equipment that were simple, compact, and required low investment cost. Development of such lines, cells, and equipment is in tune with lean manufacturing (Edwards, 1996), and reducing amount of wastes within the structures of pieces of equipment is considered as a later stage of lean manufacturing efforts (Iwaki, 2005). The VAPP approach seems to be a helpful approach for companies desiring to achieve a high level of lean manufacturing.
Although the above mentioned application examples show some information on how the approach can be applied at companies, the amount of the information is still not enough to fully understand how to apply the approach in practice. Moreover, the ways of applying the approach at the companies in Table 1 seems to be highly diverse, which raise an assumption that the study on practical use of the approach has not been sufficiently explored. The need of presenting more practical knowledge of the approach in the literature gave the motivation of conducting the case study described in the next section.

Method of the case study

As mentioned earlier, the main purposes of the case study presented in this paper is to describe how the VAPP approach can be applied in practice. The case study had also two additional purposes that are to identify support tools for application of the approach and to analyze how users of the approach can generate solutions close to the ideal states specified in the approach. A Swedish manufacturing company was selected for the case study. The application of the VAPP approach at a non-Japanese company was expected to be experimental and exploratory, because the VAPP approach was rarely known outside of Japan and there was limited amount of practical information on how to apply the approach. Due to the uncertainty about outcomes of the case study, it was decided to conduct a single case study. With increased knowledge of the application, multiple case studies were expected to be conducted. In this respect, the results of the present study should be treated with caution due to their limited generalizability. Nevertheless, reporting the results of the present study was considered valuable because of the rareness of the reports describing application cases of the approach. The specific company was selected because the production manager was receptive to the VAPP approach and our research team had previously established some degree of trust with the company. As explained later, the case study took a form of action research. Creating trust and an open relationship with managers and employees of a case company is essential to conduct action research and increase the validity of it (Gummesson, 2000; Westbrook, 1995).

The case company was a medium sized company developing, manufacturing, and selling electrical products for industrial use. The company had been highly profitable and its manufacturing unit had been considered as one of the main contributors to the company’s profitability. The manufacturing operations mostly consisted of assembly and were divided to seven manufacturing groups depending on the types of operations, for instance circuit board assembly and product final assembly.

Since the books and articles related to the VAPP approach were written in Japanese, the main author of this paper, hereafter referred to as the researcher, who could read Japanese, took an active role in applying the VAPP approach at the case company. During the periods of the case study from January to June in 2011 and from February to June in 2012, there were four separate opportunities to apply VAPP approach at four different manufacturing groups. At the first three opportunities, the researcher acted as a designer who analyzed the existing assembly lines and cells at the groups and proposed design recommendations for lines and cells by applying the VAPP approach. At the forth opportunity, the researcher was a facilitator of a workshop where the participants applied the VAPP approach to improve their operations. The researcher was not
involved in any implementations of the design recommendations. Members of the company decided what parts of the design recommendations they wanted to implement and when and how to implement them.

The application of the approach at the four groups was not planned all in advance but rather planned in succession. The case study process was inspired by *experiential learning cycle* put forwarded by Kolb and Fry (1975) (see Figure 2). The experiential learning cycle consists of experience, reflection, conceptualization, and experiment. One cycle corresponds to one application opportunity in the case study. The case study started with experiment instead of experience. At the experiment stage, the researcher or participants in the case study applied the VAPP approach. The researcher explained the approach to the participants. The theories of the approach were considered rather complicated. Therefore, the theories were simplified when explained to the participants. At the experience stage, the researcher or the participants gained experience of the approach. In parallel, how the approach was applied and what outcomes were emerged by the application were observed by the researcher. This was followed by the conscious reflection of the obtained experience and the observation. Reflection is a critical part of the experiential learning because it integrates action and research (Coughlan and Coghlan, 2002; Raelin, 2000). The researcher reflected on his experience and observation of the application. Interviews were performed with the participants in order to understand their experience of and reflection on the application. Finally at the conceptualization stage, propositions were built based on the experience, observation, and reflection. A plan for the next cycle was also discussed with the production manager at this stage. Actions, comments, drawings, ideas, sketches, reflections, etc. made during the learning cycles were empirical evidence of the case study and were continuously documented.

![Figure 2: The case study process inspired by Kolb and Fry’s (1975) experiential learning cycle](image-url)
Results of the application of the VAPP approach

In the case study, the VAPP approach was applied at four different manufacturing groups. Here, these groups are referred to as Alfa, Beta, Gamma, and Delta. How the approach was applied, what outcomes were emerged, and how participants in the case study as well as the researcher experienced the application are described in the following subsections.

Application of the VAPP approach at the manufacturing group Alfa

The role of Alfa was to assemble key components of the final products. Alfa was selected for the first application of VAPP approach, because this group had been considered as the bottle neck. The production manager requested the researcher to analyze the manufacturing process at Alfa and suggest design recommendations by applying the VAPP approach.

The analysis began with the explicit focus on the objects, i.e. the parts assembled at Alfa. How the objects were moved and processed was carefully observed. How often the objects changed the holders, i.e. the things maintaining the objects at certain positions such as hands, tables, pallets, and fixtures, was also observed. Then it was observed how the shop floor operators and the pieces of equipment were involved with the objects. When observed in this way, the objects were mostly moved, picked, or placed, without much receiving value-adding. Problems were identified by considering why the objects were handled in the observed manner. Later ideas for improvements were generated by referring to the principle and guidelines for designing a simple work system mentioned previously in this paper. As the principle suggests, the ideal states were conceived (the task of the work system being realized only by the VAPs or VAPPs). In order to structure and visualize the above-mentioned object focused analysis, an analysis chart was devised (see Figure 3). The chart in Figure 3 shows only a part of the manufacturing process at Alfa.

At the “Object” row in the chart, each step of what was done to the objects is described with verbs. The verbs boxed with the thicker lines represent the VAPs. The triangles under the verbs mean the holder changes being occurred. How the work heads worked on the objects are described in the row of “Work heads”. When the analyst of the operations notices something related to the involvement the operators and pieces of equipment in the VAPs and non-VAPs, it is described in the row of “Persons and equipment”. The problems identified during the observation are noted in the row of “Comments”, and the ideas for the improvements are written in the rows of “Ideas”.

Based on the above mentioned analysis, a conceptual design was created, again by referring to the principle and guidelines for a simple work system. In this paper, a conceptual design is a drawing, mirroring the finished design in whole including some but not complete details. A conceptual design should be mostly technically feasible but some parts of the design may need development to make it implementable. In the created conceptual design, the VAPs became closer each other. The non-VAPs were reduced by about 40 percent. The frequency of the holder changes was also reduced by more than 50 percent. The conceptual design included an idea for a piece of equipment which was new for the company (see Figure 4). At the group Alfa some of the parts were assembled using epoxy adhesive in an off-the-shelf ventilation cabinet. A typical size
of the key components assembled at Alfa was about 10cm, 10cm, and 7cm in length, width, and height respectively, while the size of the ventilated space in the cabinet was about 80cm, 200cm, and 110cm. The large and enclosed ventilation area in the cabinet caused a tendency of the operators bringing many assembly parts into the cabinet, resulting in increasing the risk of mixed
parts, the amount of the in-process stock, and the frequency of unnecessary picking and placing of the parts in the cabinet. From the perspective of the VAPP approach, the ventilation should be needed only around the surfaces of the parts adhered. This led to design a compact ventilation cabinet, which had the size of approximately 30 to 40 cm in each dimension. The compact ventilation cabinet allowed to have the adhesion process near to the other VAPs.

The analysis result and the conceptual design were presented to and discussed with the production manager and a production engineer. They agreed to the problems identified in the analysis. They also appreciated the most part of the conceptual design except some details. They thought that the VAPP approach was an interesting analysis and design method, because the approach gave them a detailed insight as to how the objects were handled at the shop floor and how they should be handled. They and also the researcher had not had such an insight before the application of the approach. Being inspired by the conceptual design, the production engineer designed and implemented a new shop floor layout that enabled simpler material flows at Alfa. A prototype of the compact ventilation cabinet was developed. At the moment when the case study ended, the prototype was tested.

**Application of the VAPP approach at the manufacturing group Beta**

The case company planned to move the location of Beta from the main factory to another location nearby in order to deal with the future volume increase of the products. The employees at Beta were responsible for assembling interface components of the products. The relocation of the shop floor was considered a chance to improve the productivity. A project team was formed to design new assembly processes including a new shop floor layout. The project members were mostly shop floor operators at Beta. A production engineer and a group leader at Beta also joined the project. The researcher was asked to analyze the assembly processes at Beta and propose new ones by applying the VAPP approach and then to discuss them with the project team.

The object focused analysis was conducted in the same way as at Alfa. The analysis chart was also used. Similar to the case at Alfa, the analysis showed that the objects were frequently picked, placed, and transported without value adding. When redesigning the assembly processes, two assembly flows (here named flow A and B) for high volume components were focused. Conceptual designs were created for these flows in the same way as at Alfa, by conceiving the ideal states and referring to the guidelines for simple work systems. In the conceptual designs, the VAPs became more concentrated in smaller areas. For instance, a large piece of central test equipment for all types of the components, which had been located separately from the assembly stations, was replaced by small pieces of test equipment being integrated in the assembly stations. The result of the analysis and the conceptual designs were discussed with the project team members. The analysis chart helped to communicate the way of thinking in the object focused analysis with the project team members. Most of the members favored the design for the flow A. The design included simpler movements of the objects and the VAPs concentrated in the small areas which the member thought would lower the workloads. On the other hand, the members were not certain about the design for the flow B. Although the basic concepts of the design was the same as the one for the flow A, the design for the flow B was significantly different from the existing way of working. The members were reluctant because it was difficult to estimate
whether the proposed design would work properly. Later the members experimented on the design for the flow A. The design was planned to be implemented when the necessary pieces of equipment became ready for the installation. The design for the flow B was not implemented at the end of the case study.

Through the application of the VAPP approach at Alfa and Beta, the researcher experienced that creating feasible solutions from the ideal states required a strong imagination and search for a broad range of possible alternatives. During the discussion with the project members, the researcher observed that the members rarely thought beyond the existing operations and the pieces of equipment that they had been used to. It was considered that creating a climate where employees could distance themselves from the existing operations and pieces of equipment and consider a wider range of alternative solutions would be necessary when they would use the VAPP approach by themselves.

**Application of the VAPP approach at the manufacturing group Gamma**

The company planned to launch a new product family. Due to its different mechanical features and expected future volume, a new assembly line needed to be developed. Gamma was a group for assembling those new products. Two production engineers were assigned to develop a new assembly line. When the researcher was involved in their design activity, they had already made an interim design. When the engineers presented an initial design to the production manager, he, who had already observed the application of the VAPP approach at Alfa and Beta, requested them to consider reducing the frequency of holder changes and the area of the assembly line as small as possible. The length of an assembly line in the interim design was about 45 percent shorter than the one in the initial design. The researcher’s involvement was to identify further improvements in the interim design by using the VAPP approach and discuss with the engineers.

In the review of the interim design, the design approach employed at Mitsuba (Tanahashi, 2009) described in the second section was considered as a suitable way to review the design. The design approach at Mitsuba was to design an assembly process backwards and consider how to feed assembly parts where the parts disassembled. This approach indicated where the pieces of equipment such as jigs, devices, and part-feeders should be ideally placed. The Mitsuba’s approach was adopted because this ideal thinking might help to identify further improvements in the interim design. During the review, a finished product was disassembled by one step then the pieces of equipment used to assemble the disassembled parts were placed as close as possible to the point of the disassembly. Then, the product was further disassembled by a step and the relevant pieces of equipment were placed close to the pointe of the disassembly. This was repeated until the beginning of the assembly.

After the review, a conceptual design was created and proposed to the production engineers. In the design, pieces of equipment were placed closer to the points of assembly than the ones in the interim design. The length of the assembly line was about 20 percent shorter. Since the assembly line included an adhesion process similar to the one at Alfa, a compact ventilation cabinet was also suggested. The proposed design was discussed with the above-mentioned engineers. They agreed to some of the solutions in the design but some others they needed further consideration. Nevertheless they generally appreciated the VAPP approach, because, similar to the previous
application cases at Alfa and Beta, the VAPP approach helped the engineers to have a detailed insight as to how the objects should be handled and how pieces of equipment should be designed and placed. One of the engineers commented that the VAPP approach had him consider more carefully how to design and install pieces of equipment from operators’ perspective who daily handled the objects. The engineers had no time to develop additional new pieces of equipment because of the limited time before the new product launch. However, they had time to relocate pieces of equipment inspired by the proposed design. In the final design approved for the implementation, the length of the assembly line became about 16 percent shorter than the one in the interim design, which was more than 50 percent improvement from the initial design.

After the VAPP approach had been applied three different places, the confidence in the approach among members of the company increased enough that the production manager allowed to have employees to apply the approach by themselves in the next application opportunity.

Application of the VAPP approach at the manufacturing group Delta

The process at Delta was to pack products, instructions, and accessories into carton boxes and make them ready for the transportation companies to fetch them. In this occasion, employees at Delta were assigned as the users of the VAPP approach. As mentioned previously, it was considered that preparing a climate where employees could distance themselves from the existing operations and pieces of equipment and consider a wider range of alternatives was necessary when the employees used the approach by themselves. A workshop was considered a suitable way for the employees at Delta to learn and experiment with the approach. The workshop was facilitated by the researcher. Ten employees, including shop floor employees at Delta, and a shop floor leader and a production engineer responsible for Delta, participated in the workshop. The workshop was designed to contain four steps. Firstly, the VAPP approach and application examples at manufacturing companies were explained. Then the participants were asked to sketch the VAPs at Delta with the purpose of building a consensus among them about what VAPs were at Delta. Thirdly, the participants were asked how persons and pieces of equipment could be involved in the identified VAPs as little as possible in order to realize the process at Delta. They were asked not to change many of the work heads at the identified VAPs. Possible solutions were generated and sketched through brainstorming. Finally, the participants evaluated the solutions and voted on which solutions they desired to implement.

A workshop climate was created by consulting the literature on innovation and two researchers from our research team who were specialized in innovation management. In the innovation management research, researchers have identified characteristics of groups and organizations that excel in radical innovation (McLaughlin et al., 2008; Tushman and O’Reilly III, 1997). Here, radical innovation is a type of innovation involving development of new processes that are distinctly different from the existing ones (Dewar and Dutton, 1986). Since the participants were asked to conceive an ideal state that was radically different from the existing operations, it was considered that a workshop climate should be supportive to radical innovation. Therefore, the researcher tried to create a workshop climate by emulating the characteristics of groups or organizations that are proficient in radical innovation. For example, the researcher created an atmosphere of playfulness, trust, and openness by for instance exercising brainstorming warm-
ups (Couger, 1995; Kelley and Littman, 2001). In the workshop, unlearning, external knowledge gathering, an autonomous way of working, risk-taking, and experiment were encouraged. At the end of the workshop, the participants made a sketch of a future process at Delta by combining the solutions they had chosen for implementation. In the sketch, the packaging process became more straightforward and compact. Some of the solutions were implemented a few weeks after the workshop. Experiments on other solutions were also conducted.

A few weeks after the workshop, interviews were conducted with the participants. Each participant was asked two questions: general impression on the VAPP approach and what he or she thought influenced the participants to think closer to the ideal state posed in the workshop. Most of the participants experienced the use of the VAPP approach in a positive way. Many participants perceived that the approach helped them to think from a different perspective than they have been used to. For instance, one of the participants told that the approach stimulated thinking of what was really value-adding in the operations and at the same time encouraged magical or fantastic thoughts that he had not had before. Concerning the second question, the workshop setting helped them to think closer the ideal state. Several participants mentioned that the playful and open workshop atmosphere, the ideas of other participants, and the visualized ideas in the sketches helped them to approach to the ideal state.

**Summary of the results of the case study**

Empirical evidence collected during the case study was generally related to the following themes: outcomes emerged by the application of the VAPP approach, how the approach did or did not contribute to the analysis, design, and implementation activities, and how the approach was applied in practice. The outcomes, observations, and experiences obtained thought the application of the VAPP approach are summarized in accordance with the mentioned themes (see Table 2). Discussions will be made by referring to this summary.

Table 2: Summary of the results of the case study

<table>
<thead>
<tr>
<th>Outcomes emerged by the application of the VAPP approach</th>
<th>How the VAPP approach did or did not contribute to the analysis, design, and implementation activities</th>
<th>How the VAPP approach was used in practice</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Production engineers who participated in the case study appreciated the approach (A, B, G)*</td>
<td>• The approach helped to design lines and cells where VAPs were more connected and concentrated (A, B, G, D)</td>
<td>• Object focused analysis was used (A, B)</td>
</tr>
<tr>
<td>• Production manager understood the effect of the approach and asked production engineers to use some parts of the approach (G)</td>
<td>• The approach helped to design lines and cells where movements of the objects were more straightforward (A, B, D)</td>
<td>• To support the object focused analysis, an analysis chart was devised and used (A, B)</td>
</tr>
<tr>
<td>• Most of the shop floor leaders and workers who participated in the case study were positive about the approach (B, D)</td>
<td>• The approach provided a detailed insight as to how objects should be handled (A, G)</td>
<td>• Conception of the ideal states (the states where the task of a work system is realized only by VAPs or VAPPs) was encouraged (A, B, D)</td>
</tr>
<tr>
<td>• Motivation for improvement increased among the workshop participants (D)</td>
<td>• The thinking that anything but VAPPs was waste helped to generate a new idea of a simple piece of equipment (A)</td>
<td>• Guidelines for designing simple work system (e.g. compacting VAPs, and reducing frequency of holder changes) were considered (A, B, G, D)</td>
</tr>
<tr>
<td>• Conceptual designs were created</td>
<td></td>
<td>• An assembly line was designed</td>
</tr>
</tbody>
</table>
which were used in the improvements (A, B, G, D)
- A new layout was implemented (A) or tested (B) which enabled simpler movements of the objects
- A new idea for a simple piece of equipment was generated and tested (A)
- The length of an assembly line became half (G)
- The approach helped to design lines and cells more from a shop floor workers’ perspective (G)
- Simpler handling of objects were favored by the shop floor workers (B)
- The approach stimulated idealistic thinking in a design activity (D)
- Some proposed solutions were considered too radical to be implemented (A, B, G)
- The approach helped to design lines and cells more from a shop floor workers’ perspective (G)
- Effective use of the approach required unlearning and search for a broad range of alternative solutions. A workshop was organized where the participants could use the approach in a creative environment (D)
- The approach was applied in a manner of experiential learning (A, B, G, D)
- The theories of the approach were rather complicated. The theories were simplified when they were explained to the participants (A, B, G, D)

Discussion

In the previous section, the results of the case study have been presented. In this section, discussions are made especially from three perspectives. Firstly, possibilities of applying the VAPP approach at other non-Japanese companies are discussed. Secondly, usefulness of the approach is discussed. Finally discussions are made in terms of the secondary purposes of the case study: to identify support tool for the approach and to analyze how to generate solutions close to the ideal states specified by the approach.

Possibilities of applying the VAPP approach at other companies than the case company

The results of the case study show that the VAPP approach was generally accepted by the manufacturing unit of the case company. The acceptance was increased gradually as the participants in case study observed, experienced, or understood how the approach could contribute to the improvement activities. This paper can be one of the few papers that describe application of the approach at companies located outside of Japan. Before the case study, the researcher expected that little national context, or national culture in particular, should affect the application of the approach, because the approach mainly focus on objects in manufacturing processes and have less influence on human and organizational factors which are more affected by national cultures. As expected, the researcher did not observed any national cultural issues during the case study. It seems that the VAPP approach can be applied at many manufacturing companies in different countries, although this has to be verified more by applying the approach in other countries than Japan and Sweden.
Usefulness of the VAPP approach

It should be mentioned that the usefulness of the VAPP approach cannot be fully evaluated based on the results of the case study, because every aspect of the VAPP approach was not used in the study. For instance, the concept of conditions for quality conformance is an important part of the VAPP approach, but it was not used in the case study. The conditions for quality conformance need to be considered especially when work heads are redesigned. However, in the case study most of the existing work heads were not changed, and instead much focus had been paid to how to realize the assembly operations only by the VAPPs as much as possible. At the case company the approach was applied only to the assembly operations, but the application examples at the Japanese companies described earlier in this paper show that the approach can be applied to development of large and complex pieces of equipment such as machining tools and automation systems. Even though all the aspects of the VAPP approach was not used in the case study, the results of the study show that the approach was useful for improvement activities in manufacturing. As described in the previous section, the approach helped to design manufacturing lines and cells where VAPs became more connected and concentrated and movements of the objects became simpler. The thinking of anything but VAPPs was waste helped to generate an idea of a simple piece of equipment. An arising question can be whether similar outcomes could be achieved by using other improvement methods such as the waste elimination and Value Engineering. The question cannot be answered base on the results of the case study, because other improvement methods were not used in order to compare with the VAPP approach. It is assumed that simpler material flows and more connected VAPs can be proposed by using for example the waste elimination approach. However, the explicit focus on VAPPs and the pursuit for realizing simple work systems in the approach probably helped more to generate ideas of simple lines and pieces of equipment. For instance, an idea for the simple ventilation cabinet described in the previous section could be more likely to be generated with use of the approach.

From the case study, it was learned that pursuing a simple work system is an important concept in designing manufacturing processes. Simpler movements of objects tend to result in simpler movements of operators and simpler pieces of equipment. Such a simple system often requires a less complex control and maintenance system. However, it is not seldom to encounter opposite situations in factories, for instance, complicated movements of objects causing the realization of complex automation systems.

Identification of support tools and analysis of how to approach to the ideal states

As mentioned earlier, identifying support tools for the VAPP approach was one of the additional purposes of the case study. During the case study, an analysis chart was devised to support the object focused analysis described in the previous section. The analysis chart was used at the two manufacturing groups at the case company and found helpful to structure the object focused analysis and also to communicate the way of thinking in the analysis with the participants in the case study. However, the usefulness of the chart still needs to be verified more, since the chart was not used by the participants themselves. The analysis chart is similar to an analysis diagram.
devised by Shinoda and Niwa (2000). The diagram assists to describe how objects and work heads are handled in manufacturing operations in a detailed and structured way. However, the procedure of making a diagram is too complicated and time-consuming (Shinoda and Niwa, 2000). The analysis chart was intended for an easier and simpler use, although it is less structured than the diagram.

In the case study, a specific workshop was devised as a support tool for the VAPP approach. In the workshop, use of the approach and creative thinking were facilitated. Such a workshop was considered necessary because an effective use of the approach required unlearning and search for a broad range of alternative solutions. The results of the case study show that the creative workshop helped the participant to be more free from the existing operations when they used the approach. Organizing workshops in design activities is frequently mentioned in design methods (e.g. Cooper and Slagmulder, 1997; Nadler, 1967) and also frequently practiced at companies. In this paper, the importance of organizing a creative workshop is emphasized, because organization of such a workshop is not mentioned in any literatures on the approach.

The other additional purpose of the case study was to analyze how users of the approach can generate solutions that are close to the ideal states specified in the approach (i.e. the task of a work system being realized only by the VAPs or VAPPs). In the case study, the participants and the researcher experienced that it was generally difficult to derive workable solutions from the ideal states. On the other hand, there were some factors that positively influenced the generation of solutions close to the ideal states. Three factors were noticed in the case study: using concrete guides to the ideal states, applying the VAPP approach in an early phase of process development, and facilitating one’s creativity.

In the case study, some concrete guides, such as minimizing frequency of holder changes, compacting VAPs, and placing pieces of equipment at the point where a product is disassembled, were helpful to approach to the ideal states. Such guides should exist more than those used in the case study. It is desirable to obtain a comprehensive list of such guides when approaching to the ideal states.

As for the second factor, it was particularly difficult to generating solutions close to the ideal states when the approach was applied in the improvements of the existing operations. Many design constrains hindered approaching to the ideal states. On the other hand, a major improvement was achieved at Gamma because it was a design of a new assembly line and there were much fewer design constraints than the improvements of the existing operations. The VAPP approach is still useful for improving existing operations, but the chance of generating solutions close to the ideal states is higher when the approach is applied at an early phase of manufacturing process development.

The third factor is rather obvious. In the study, the researcher experienced that staying close the ideal states required personal abilities related to creativity, such as ingenuity, persistence, unlearning, willingness for external knowledge gathering and risk-taking, etc. The workshop conducted in the case study was a way of facilitating one’s creativity, but there can be many more ways. Utilization of the knowledge in the creativity and innovation research should be beneficial in the effort of approaching to the ideal states.
Conclusions

This paper has introduced a unique approach to improving manufacturing processes referred to as the Value Adding Process Point approach. The VAPP approach has been applied at several Japanese manufacturing companies, but it has been rarely known internationally. Presenting the approach to a broader audience is one of the contributions of this paper. In the literature on the approach there is a limited amount of practical information on how the approach can be applied in practice. This paper contributes to the literature by describing a case study in which the VAPP approach was applied at a Swedish manufacturing company. This paper has described how the approach was applied at the company, what outcomes were emerged by the application, and how the approach contributed to the improvement activities. The results of the case study show that the approach was useful in creating simple manufacturing lines, cells, and pieces of equipment. This paper can be one of the few papers reporting application of the approach at companies located outside of Japan. Although it has to be careful to generalize from the single case study, it seems that the approach can be useful at many manufacturing companies regardless of the countries that they are located in. For the companies desiring to apply the approach, it can be recommended to apply it in a manner of experiential learning as it was applied at the case company, because the literature on the approach written in English is still lacking. Finally, studies on how to utilize the approach are far from the completion. More studies on this subject can be conducted in the future.

References


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