IAMOT 2015

8-11 June 2015
24th Annual IAMOT Conference

IAMOT 2015

24th INTERNATIONAL ASSOCIATION FOR MANAGEMENT OF TECHNOLOGY CONFERENCE

PROCEEDINGS

Technology, Innovation and Management for Sustainable Growth

8-11 June 2015
The Westin, Cape Town
South Africa

Editor
Dr Leon Pretorius

Co-Editor
Dr George Alex Thopil

IAMOT ISBN USB: **978-1-77592-111-0**

Additional copies can be ordered from:
Graduate School of Technology Management
University of Pretoria
Private Bag x20
Hatfield
South Africa
0038

e-mail: iamot2015@up.ac.za
www.iamot2015.com

Published June 2015, by the Graduate School of Technology Management, University of Pretoria & Media Chef CC

OPERATIONS STRATEGY FOR MAINTAINING COMPETITIVENESS IN A EUROPEAN AUTOMOTIVE COMPANY

CHRISTIAN KOCH
Chalmers University of Technology, Civil and Environmental Engineering, Sweden
kochch@chalmers.se

DAVID BENNETT
Chalmers University of Technology, Operations Management, Sweden
david.bennett@chalmers.se

THOMAS MARKUSSEN
Aarhus University, AU Herning, Denmark
thomas@ibelieve.dk

ABSTRACT

The automotive industry is mostly known for its large concentration on a few global players. However the industry also encompasses a series of small and medium-sized enterprises, either as suppliers or as value adders, focused on smaller submarkets.

This paper focuses on the specific situation in the automotive industry of a medium-sized manufacturer of tankers for trucks in the road transport industry. The company delivers design, manufacturing and service of high quality products to its customers within an engineer-to-order and manufacture-to-order market. The company faces a range of conflicting demands.

The company operates in Northern Europe and benefits from proximity to its customers, yet experiences pressure from low cost, volume manufacturer competitors. Its operations strategy focuses on improving efficiency while maintaining the high value adding element to meet the needs of its identified market.

The paper provides a case analysis aimed at evaluating the company's operation strategy, and more specifically its efforts to improve layout, and synchronizing material flows and bills of materials, where the use of kits, bundles of materials and location of stocks, are prominent aspects of production. An operations management theoretical framework is adopted including material handling and layout concepts. The contribution builds on interviews with key informants within the company as well as document analysis and the presence of one author within the company over a longer period.

The paper evaluates the development of the company's operations strategy. It describes the analysis made of internal logistics and the bills of material as well as the role of business strategy, market and fluctuations in personnel numbers, together with the operations strategy steps taken subsequently.

Key words: operations strategy; shop floor layout; kitting; automotive industry.

P346

INTRODUCTION

The supply chain networks involved in the design, production and operation of trucks are intensive, global and, at the same time, experiencing growth in turnover despite the economic crisis and fall in production of many players (ACEA 2014, Rubesch and Banomyong, 2005).

The supply network for trucks involves a range of specialised players producing, for example trailers, bodies, etc. as well as the OEM truck manufacturers (Lim et al, 2014).

For truck manufacturers in Europe, realising quality for a customer has historically been viewed as a question of governing the supply chain (Lim et al, 2014, Tay 2003, Xia and Tang 2011), putting pressure on manufacturing, and choosing also to operate close to their European customers. About 8% of the world production of trucks is carried out in Europe (ACEA 2014). On the other hand providing operations services and repair also requires this closeness to the customer. Another factor is that environmental concerns in the automotive industry are gaining momentum (21CTP, 2008; ACEA 2014, Nunes and Bennett, 2010; EU, 2014, Xia and Tang 2011). This amounts to a set of complex, and often contradictory, demands.

The focus of the study described in this paper is TruckCo (a pseudonym), a small manufacturer of road tankers located in Northern Europe. TruckCo has a business strategy of continual quantitative and/or qualitative growth, and therefore forecasts an increase in manufacturing capacity. Against this background the main aims of this contribution are to analyse:

- how the materials handling system at TruckCo can tackle contradictory demands of limited resources, customer quality, customer dependency, time and cost.
- how the material handling system at TruckCo be improved

The paper opens by positioning its methodology combining theory and mixed methods used on a company case. The framework of understanding outlines the theoretical basis and builds on an operations strategy approach, but focuses on material handling. As a frame for the analysis of materials handling, the initial investigation is into how the company has tackled its growth and strived at establishing the required manufacturing capacity. Then further analysis is carried out using "from to" methods. The paper then discusses these findings and suggests improvements. The paper concludes with some salient observations concerning the company's operations strategy and how this translates into solutions for materials supply and assembly.

METHOD

This paper adopts an overall interpretivist approach to operations strategy, but within this it uses a set of mixed methods (Bryman and Bell, 2006; Singhal *et al*, 2008). A review of the literature has been carried out on previous research into operations strategy approaches and contributions (Bennett and Forrester, 1993; Hill and Hill, 2009; Slack and Lewis, 2008). A single case study is used as the core empirical approach.

The case company was chosen for quite simple reasons as good contacts were available providing access to data. Certain aspects of the company have been changed in the description to maintain anonymity. One author has insights of the company from long term employment.

The case analysis builds on a master thesis carried out by one author and supervised by a co-author. The thesis evidence was supplemented by subsequent follow-up qualitative interviews carried out with key company personnel, including the CEO, CFO and COO as well as a warehouse manager, a production planner, a purchaser and a foreman. Quantitative data have been collected from a range of company sources, including internal performance measurements, but also accounting reports covering a decade of the company development. More specifically the analysis of the materials flow and material handling was covered using two main method elements, qualitative interviews with shopfloor employees and self-registration by two truck drivers during their involvement in the moving of material. Their movements constitute the vast majority of the flow. This data collection leads to the results presented in the "from-to" analysis and "most intensive moves" analysis.

The research presented here had certain limitations. First the longitudinal perspective builds on information from just a few persons in the company. Second the quantitative material used is just one snapshot of the material flow. The paper does not consider the Human Resource aspects of the analysed changes and excludes discussion concerning the personnel carrying out a specific task created by the recommended actions. Moreover, the paper focuses only on internal logistics and therefore disregards options related to external logistics such as involving component suppliers in kitting operations and/or parts supermarkets.

FRAMEWORK OF UNDERSTANDING

The framework consists of two main parts. The first is a more overall positioning of how we understand of operations strategy and the second part focuses on material handling in manual assembly.

Operations Strategy

The operations-, manufacturing-, and technology management literature encompasses concepts of operations strategy and manufacturing strategy. Below, both strands are taken into account using operations strategy (OS) as common term as OS can be understood as covering a set of operations in a business, apart from production, such as sales, services etc, which provides an instrumental and broader look at the challenges of the strategy. Here we adopt the Slack and Lewis (2008) definition of operations strategy (OS), i.e.

"The total pattern of decisions which shape the long-term capabilities of any type of operations and their contribution to overall strategy, through the reconciliation of market requirements with operations resources" (Slack and Lewis, 2008, p. 18).

Strategy content approaches in OS (as opposed to strategy process approaches of Rytter *et al,* 2007) deal with how operations can create competitive advantage by providing normative guidelines on what to include when formulating an OS or manufacturing strategy (Anderson *et al*, 1991; Hill and Hill, 2009; Slack and Lewis, 2008). Slack and Lewis (2008, p 19) point to the following strategic decisions given a required performance vis a vis the market:

- Capacity
- Supply networks
- Process Technology

- Development and organisation

The required performance areas are quality, speed, dependability, flexibility and cost (Slack and Lewis, 2008, p 19). The manufacturing organisation might be exposed to quite complex combinations of required and desired performances as well as needed decisions. For example capacity might be closely linked to a need for speedy delivery at high quality and lead to certain process technology concerns and decision on material flow. It is indeed the materials supply for the assembly that is the focus in the following.

Materials supply for manual assembly

To choose to carry out a manual assembly represents one decision within the operations strategy of manufacturing companies. The assembly of complex, large products is often done manually in house, thus temporally ruling out other operations strategy options, such as outsourcing or automation (Rajput and Bennett, 1989).

In this context, different shop floor logistics can be used, pushing (feeding) or pulling (picking) components into the assembly and other production process. Importantly it should be noted that shop floor logistics are not always sufficiently governed merely by applying lean production principles (Cooney 2002, Marx et al 1997). Types of handling include such as manual ad hoc, continuous supply/line stocking (Medbo, 2003), kitting (Hanson and Medbo, 2012), and the supermarket concept (Shingo, 1989).

Manual ad hoc pick up, would imply assembly operators referring to a stock function in order to pick up needed components and are often associated with non-time critical, high value assembly, yet it implies interruptions in assembly work.

Continuous supply/Line stocking means that each part number is usually supplied by a logistics operator, supporting the assembly operators. The operator in charge of components would then need to support the assembly shop with some sort of container (often moveable), with each part necessary for the assembly and/or station/sub-process in the assembly.

“Minomi” is a more simplistic way of providing the components required for the assembly line. It can have various forms but basically provides the components for assembly as stacks of pieces, for example on a Europe-pallet (Hanson, 2014). But can also involve hanging components on hooks or similar carriers. This approach therefore involves both ways of presenting and handling parts at an assembly station. Hanson (2014) finds that minomi can lead to man-hour reductions in assembly but also increased man-hour consumption, depending on the characteristics of the components, the assembly station and the storage.

Kitting means that parts are delivered and presented to the assembly operations in pre-sorted kits, with each kit containing parts for one assembly object (Medbo and Hanson, 2012, pp. 1115). According to Hanson and Medbo (2012) the advantages of kitting are space efficient parts presentation, improved quality of assembled products, shorter learning times, a more holistic understanding of the assembly work by operators and less time spent by the assembler fetching parts. Kitting also implies additional resource allocation (Hanson and Medbo, 2012). Kits need to be prepared in advance, requiring a supporting organisation of work, space and additional handling. If the kits need to be prepared in a separate dedicated area, not linked to either storage or assembly, this implies additional transport and need for space.

Parts supermarkets are locally placed storage areas where the assembly worker can draw required parts for the production process (e.g. assembly) from the 'shelves' of the supermarket when needed. This can in turn be monitored by the supplier who then can initiate replenishment of items as stock is withdrawn (Shingo, 1989). The parts supermarket therefore represents a direct link from supplier to assembly.

Mixing of these principles according to product and process characteristics is a frequent strategy. Medbo (2014) for example provides an automotive example at Fiat Serbia, where three main material feeding flows are mixed; sequence assembly of large parts, kit assembly of medium sized parts and unit supply of component of low value.

Fetching of material is often seen as “non-value adding”. Studies claim 40-50% of the assembly operators’ work time is used for non-value adding activities i.e. fetching (Medbo 2014). It is in the same vein claimed that this can be reduced to 20% through kitting (Medbo 2014.

Summarising our framework, it posits an interpretive approach to decisions in operations strategy, combining qualitative and quantitative contributions. The elements of the operations strategy are often mixed in a complex manner and the companies will often approach strategy development in an emergent manner. When it comes to the sub area of manual assembly of complex high value production, several principles as solutions for providing components for the assembly were presented. It was noted that these forms were likely to be mixed in a concrete setting.

CASE STUDY

Throughout the 22 years since it was established TruckCo has, step-by-step, grown to its current size with a turnover well over 14 million Euro per year. Currently there are approximately 100 employees and the annual production is around 150 trucks. The strategy for the future is to maintain a steady organic growth in both turnover and profitability and this is enabled by a stronger focus on larger customers and more standardized products, or said reversely; by denying a few customers very special products. Moreover a future separation of repair and service and manufacturing of new products will significantly improve the flow and the space in the assembly and other workshops. The qualitative and quantitative growth requires the company to continuously increase its manufacturing capacity to enable it to fulfil the strategic goals.

Because of the difference between the processes carried out at different steps of the manufacturing process four workshops have been set up with different kinds of layout. It has therefore adopted what is referred to as a mixed layout. The layout of the four main manufacturing departments is described as follows.

Components workshop

The components workshop is arranged using a process layout, which supports a simple and direct flow of materials. Compared with the rest of the factory it is capital intensive, with many of the machines in the components department being unique. As most of the manufactured components must pass through more than one machine following varying paths it has not been found possible to use any other layout type. It is therefore not possible to arrange them in cells – at least not with a component department of the current size.

Welding Workshop

Like the components workshop the welding workshop is arranged using a process layout. However, the layout is to some degree approximated to the most common route of materials movement through the workshop. The welding workshop would probably be able to improve its efficiency dramatically by changing to a product layout. Although the products manufactured in the welding department include a lot of details that vary from truck to truck, the processes they undergo, and the machines on which they are made, are similar for all trucks. It will therefore be possible to create a flow through the department even though the number of items passing through the workshop is limited.

Undercarriage Workshop

The undercarriage workshop is arranged using a cell layout. This does not entirely fit with a usual definition of the processes as the jobbing operations used would normally lead to a fixed-position layout or a process layout.

However, the undercarriage workshop is set up as a cell layout with three cells. The first cell carries out the welding of the frame. The second cell assembles the frame with all mechanical parts. Finally the third cell carries out all wiring, and assembly of controls, electrics and pneumatics.

Final Assembly Workshop.

The final assembly workshop layout is by fixed position. This basically means that initially the tank is placed at the work space and then materials, equipment and employees are moved to the tank instead of moving the tank to the facilities. In practice this is an idealization as the tanks are occasionally moved if the need occurs. The most common reasons for moving the tanks inside the assembly are if they have to be pickled again (this is needed if a lot of welding is carried out at the final assembly workshop) or if it needs to be painted (required for most aluminium tanks). Alternatively there is a case for keeping the tankers installed onto trucks near the ends of the workshop. (The workshop is just called "assembly" below)

Stock and warehouse

The supporting stock is organised in three warehouses. A warehouse for large components, a second warehouse for medium sized and small components, where the high bay automatic warehouse is now operating, and a third warehouse for unique components for the single product (called the specific product warehouse, or SPW).

Materials supply to manual assembly

A few critical components for the tankers are purchased immediately upon obtaining an order. About one week before the assembly of a tanker is initiated, the required components are gathered on a cart and one or more pallets, and then moved to the specific product warehouse (SPW) so they are ready when the assembly is initiated.. When this process is carried out it is checked whether all components are in stock. And at this time the critical components need to be on the premises. When all the available components have been gathered, the cart and the pallets are moved to the SPW by the truck driver. Should any components not be in stock, the components are manually registered and the storage department follows-up with the supplier or the components workshop.

Once in the warehouse they await the time where the foreman from the assembly workshop calls the truck driver to have the materials delivered so that assembly can begin. This most often occurs about the same time as the tank used in the assembly is delivered to the assembly workshop.

When the employee at the storage department has finished packing the cart, the warehouse keeps the list of components to be able to track missing components. There is therefore no information passed on to the assembly workshop about what components are to be found on the cart and pallets. Also no information is provided to the assembly department if parts are missing. The employees at the assembly workshop will therefore not be aware that parts are missing until the assembly work has to be stopped because component is not available. Furthermore the assembly operators have no overview of the components which are kept at the warehouse.

ANALYSIS

The “from-to” analysis of assembly presented in Table 1 is a summing up of 35 destinations in 10, and hence simplifying a more complex situation. One central result of this analysis is the importance of transporting parts from warehouses/stock to the assembly shop (56 per week from warehouse to assembly and 20 from outdoor storage to assembly).

Table 1 “From-to” analysis

		To									
		Outdoor storage	Electricians	Washing	Pickle	Warehouses	Assembly	Welding	Undercarriage	Parts storage	Components
From	Components	13	0	1	0	26	6	9	0	3	2
	Parts storage	4	4	1	0	17	3	0	1	6	10
	Undercarriage	8	0	0	0	2	1	0	0	1	1
	Welding	6	0	0	1	5	0	9	0	0	2
	Assembly	26	1	0	4	18	8	2	1	0	2
	Warehouses	3	0	1	0	19	56	12	6	10	25
	Pickle	1	0	0	0	0	1	0	0	0	0
	Washing	0	0	1	0	0	0	1	0	0	0
	Electricians	1	1	0	1	1	1	0	0	1	0
	Outdoor storage	5	2	0	0	1	20	13	6	1	8

(Note: Pickle is a surface treatment)

Moreover several flows of parts go from one warehouse to another (19 from warehouse to warehouse, 10 from warehouse to parts storage, three from warehouse to outdoor storage)

To further improve the usability of the analysis the most intensive transportation routes are listed in Figure 1 according to the number of trips travelled by the truck drivers. The list includes all routes travelled 4 times or more within the time span of the registration

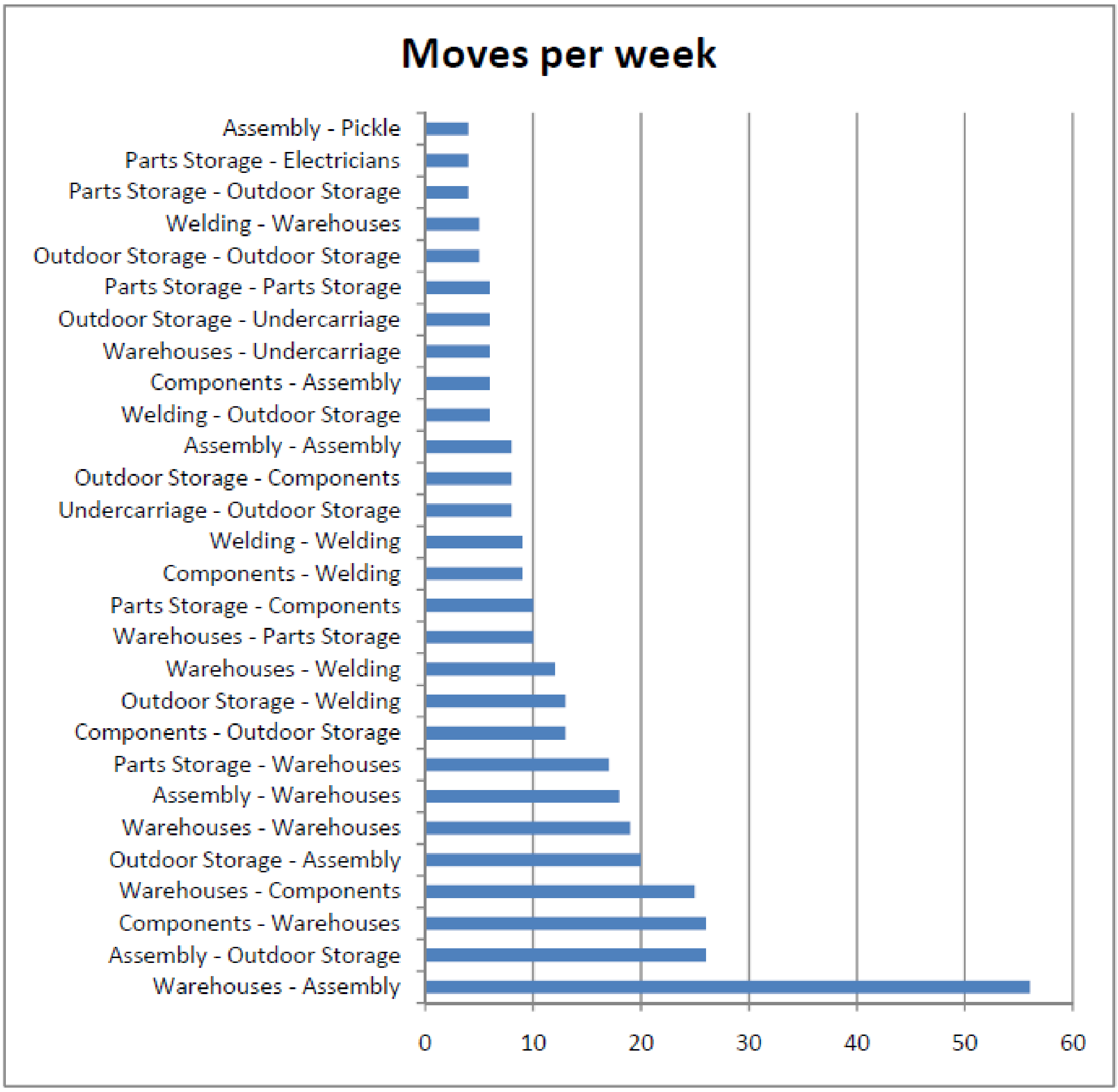

Figure 1 Most intensive moves per week

It should be noted that this analysis was carried before the automated high bay warehouse was implemented. The high bay warehouse has decreased the material handling time around the midsize components, and has concentrated more components in the central warehouse. It is likely that this has reduced the number of moves from warehouse to assembly, because each move contains more components, also because of the use of trolleys.

DISCUSSION

Before focusing on the assembly it should be noted that a range of operation strategy decisions and investments that has been carried out that preconditions and frames the possibilities of the material handling for assembly. This includes changed costing of engineering discouraging expensive variants, investments in IT for production planning and more, investment in machines for the components workshop, and purchasing of real estate providing more space. Most of them give rather direct improvements of the overall flow, although it should be mentioned that purchasing of neighbouring facilities (halls) have created a somewhat windy flow.

Focusing in on the assembly of tankers, the main product, this is basically structured by the tank being relatively difficult to move. Once placed in the workshop the remainder of the assembly is physically organised around it. Currently the final assembly takes roughly one month.

The current material handling practice can be said to be a general type of kitting. The high bay warehouse has increased the use of trolleys where related components are picked from the high bay storage, gathered on a three story trolley and transported by the truck to the assembly work shop and presented to assembly workers at the various work stations. As mentioned, the procedure has decreased the material handling time for the midsize components, and has concentrated more components in the central warehouse. It has also triggered a more accurate IT-based material management system; a system which was part of the purchased high bay storage system and once purchased triggered a stronger ordering of the midsize component storage, but also got integrated with an invested new enterprise resource planning (ERP) system. It is likely that the increased role of the high bay system compared to previous mid-size component storage has reduced the number of moves from warehouse to assembly, because each move contains more components, the bulks of components are more accurate and also because of the use of trolleys that makes the moving simpler.

However there is little obligation for the assemblers of the kit to assure that it is complete and does not lead to interruptions in the assembly. It is usually valued higher to provide assembly with swift supply of components rather than to ensure supply is complete. Previously incomplete supply of components for assembly was everyday routine and both storage and assembly employees developed competences handling the discrepancy. But these replenishment practices also involve increased use of time.

On a more general flow level, the separation of service and reparation and manufacturing will constitute a significant improvement of the flow in the manual assembly, first of all through creating a clearer focus on the new built units. This will create space for future improvements of the use of trolleys, kits or the like.

Suggestions for the improved operations.

Kitting organised with a substantial part of the components will imply additional advantages through an improved overview over components ready and present for assembly, which is a finding that adds to the advantages mentioned by Hanson and Medbo (2012). At TruckCo this would involve commencing the use of kitting for more components than at present and possibly changing the boundaries between the three storage places used, putting more emphasis on high bay storage. It appears instrumental to continue enlarging the scope of the high bay storage because of its central placement and its support for kitting. Done an iterative manner, searching for the right sizes, focus and scope of the kits it will continue to contribute to improvements. Further, it can be noted that, at TruckCo the set-up of kitting, triggers the development of a stronger bill of material facility on the ERP system, an additional ordering impact that creates a further positive feature to those of kitting, that Hanson and Medbo (2012) can take for granted in their large manufacturer context.

It is recommended to approach the more detailed design of the kitting in an iterative manner, experimenting with the number of components involved and starting with a small number before increasing the scope and number of components to find an appropriate level.

More in general the application of lean production principles on the material flow might for example create focus on the use of space for intermediate "parking" of Europa pallets of materials and sub production in many spaces in the production flow, where they at present are allowed to be stacked according to first in, last out ordering. Similarly a closer collaboration with some selected component supplier might enable cost cutting in the amount of storage on site.

CONCLUSION

The focus of this study is a small manufacturer of trucks located in Northern Europe. The company has a business strategy of continual quantitative and/or qualitative growth and therefore forecasts increasing manufacturing capacity. The main aim of the paper was therefore, first to analyse how the materials handling can tackle contradictory performance demands, and second to investigate how the material handling, especially for assembly, may be improved.

As a frame for the analysis of the operations strategy and materials handling processes, a framework of understanding was developed, which took an interpretive approach to operations strategy content development, but also adopted a mixed method. Theoretically it can be expected that the elements of the operations strategy are mixed in a complex pattern and the companies approach strategy development in an emergent stepwise manner. When it comes to the sub area of manual assembly of complex high value production, several principles for solutions for providing components for the assembly, including "kitting" and "minomi" were presented. These forms are likely to be mixed in a concrete setting.

The major result of the case study is that the combination of business strategy and operations strategy at the company has enabled its quantitative and qualitative growth. Focusing on material flow the "from-to" analysis shows a large number of weekly moves. Therefore a major step forward was obtained when investing in a high bay warehouse. This warehouse substituted the previous medium size component storage, and triggered ordering and storing the components in a more systematic and better controlled manner, improving the bill of materials, than before. This automatic storage has "attracted" more components and their handling and moreover has enabled using trolleys with components kitted for each assembly station. It is suggested to continue enlarging the scope of the high bay storage because of its central placement and its support for kitting, but to do it in an iterative manner, searching for the right sizes, focus and scope of the kits.

REFERENCES

21CTP (2008), Summary. The 21st Century Truck Partnership. Washington, DC, USA: National Academies Press.

ACEA (2014), website of European Automobile Manufacturers Association.

http://www.acea.be/automobile-industry/trucks-vans-buses Accessed december 2014.

Anderson, J.C., Schroeder, R. G. and Cleveland, G. (1991), The Process of Manufacturing Strategy: Some Empirical Observations and Conclusions. International Journal of Operations and Production Management, 11(3) 86 - 11.

Bennett, D. and Forrester, P. (1993), Market Focused Production Systems. Hemel Hempstead, UK: Prentice Hall.Bryman, A. and Bell, E. (2006), Business Research Methods. Oxford, UK: Oxford University Press.

Cooney, R. (2002), Is “Lean” a Universal Production System?: Batch Production in The Automotive Industry, International Journal of Operations & Production Management, 22(10),1130 – 1147.

EU (2014), Impact Assessment. Strategy for Reducing Heavy-Duty Vehicles Fuel Consumption and CO2 Emissions. COM(2014) 285 final. Bruxelles, Belgium: European Commission.

Hanson, R. (2014), In Plant Materials Supply: Supporting the Choice Between Kitting and Continuous Supply. Gothenburg, Sweden: Chalmers University of Technology.

Hanson, R. and Medbo, L. (2012), Kitting and Time Efficiency in Manual Assembly. International Journal of Production Research. 50(4) 1115-1125.

Hill, A. and Hill, T. (2009), Manufacturing Operations Strategy: Texts and Cases. London, UK: Palgrave Macmillan.

Lim, L.L. Alpan, G. and Penz, B. (2014), Reconciling Sales and Operations Management with Distant Suppliers in the Automotive Industry: A Simulation Approach. International Journal of Production Economics 151, 20–36

Marx, R., Zilbovicius, M. and Salerno M. S. (1997), The Modular Consortium in a New VW Truck Plant in Brazil: New Forms of Assembler and Supplier Relationship. Integrated Manufacturing Systems, 8(5), 292 - 298.

Medbo, L. (2003), Assembly Work Execution and Materials Kit Functionality in Parallel Flow Assembly Systems. International Journal of Industrial Ergonomics, 31(4), 263-281.

Medbo, L. (2014), Personal communication with the researcher Lars Medbo at Chalmers University of Technology, Sweden.

Nunes, B. T. S. and Bennett, D. J. (2010), Green Operations Initiatives in the Automotive Industry: An Environmental Reports Analysis and Benchmarking Study. Benchmarking: An International Journal, 17 (3), 396-420.

Rajput, S. and Bennett, D. J. (1989), Modular System Design and Control for Flexible Assembly. International Journal of Operations & Production Management, 9(7), 17 – 29.

Rubesch, E. and Banomyong, R. (2005), Selecting Suppliers in the Automotive Industry: Comparing International Logistics Costs. Asia Pacific Journal of Marketing and Logistics, 17(1) 61 – 69.

Rytter N.G., Boer H. and Koch C. (2007), Conceptualizing Operations Strategy Processes. International Journal of Operations & Production Management, 27(10) 1093-1114.

Shingo, S. (1989), A Study of the Toyota Production System from an Industrial Engineering Viewpoint. Portland, OR, USA: Productivity Press.

Singhal, V., Flynn, B. B., Ward, P.T., Roth, A. and Gaur, V. (2008), Editorial: Empirical Elephants -Why Multiple Methods are Essential to Quality Research in Operations and Supply Chain Management. Journal of Operations Management 26 (3), 337–348.

Slack, N. and Lewis, M. (2008), Operations Strategy, 2nd Ed. Harlow, UK: Prentice-Hall.

Tay, H. K. (2003), Achieving competitive differentiation: the challenge for automakers. Strategy & Leadership, 31(4), 23-30.

Xia Y. and Tang T.L., (2011), Sustainability in supply chain management: suggestions for the auto industry, Management Decision, 49 (4) 495 – 512.