Appropriate Work Design in Lean Production Systems

Uwe Dombrowski, Eva-Maria Hellmich and Tim Mielke

Abstract The demographic change has a substantial impact on the age structure of manufacturing enterprises. The specific needs of older employees have to be considered thoroughly in the design of future work systems. Today, many enterprises organize their processes according to the principles of lean production systems. In order to achieve a sustainable implementation of age and aging appropriate work design, the existing lean production systems need an appropriate modification. The paper presents an analysis of today's work design concerning age and aging. Furthermore, it introduces four approaches for age and aging appropriate work in lean production systems.

Keywords Lean production system · Demographic change · Age and aging appropriate · Ergonomics · Occupational health and safety

1 Introduction

The demographic change is one of the key challenges that the European Union needs to overcome. Indicators for a demographic change are found in all EU-27 countries but some of them are affected more severely. For example, compared to the other EU-27 countries Germany shows one of the lowest fertility rates, one of the highest life expectancies and the oldest population which is already declining [8].

At the moment, about 50 million people in Germany are in an employable age. In 2060, it might be only 33 million. [2] A second important development in this context is the rising labor participation of older workers. In 2000, 38 % of employees

U. Dombrowski (✉) · E.-M. Hellmich · T. Mielke
Institute for Advanced Industrial Management, Technische Universität Braunschweig, Langer Kamp 19, 38106 Braunschweig, Germany
e-mail: u.dombrowski@tu-bs.de

E.-M. Hellmich
e-mail: e-m.hellmich@tu-bs.de

T. Mielke
e-mail: tim.mielke@tu-bs.de

C. Hernández et al. (eds.), *Managing Complexity*, Lecture Notes in Management and Industrial Engineering, DOI 10.1007/978-3-319-04705-8_15,

aged 55–64 were in gainful employment. Only ten years later, this share rose to 58 %. [1] Therefore, enterprises have to cope with these unprecedented challenges. In this context, health and especially occupational health and safety will gain in importance. Enterprises have to assure the achievement potential during the whole working life. In order to cope with the changing abilities of older workers, especially manufacturing enterprises have to improve the age and aging appropriate (A^3) work design.

Today's manufacturing industry designs its processes according to lean production systems (LPS), which represent state of the art manufacturing [14]. LPS are also called holistic production systems, which aim at the comprehensive and sustainable design of production [6]. However, practical experience shows that these systems focus on the improvement of quality, time and costs. The demographic change and the thereby rising importance of A^3 work design have not been regarded so far. For a sustainable consideration of the changes due to an older workforce, A^3 work design should be integrated in the widely spread lean production systems. Therefore, the principles, methods and tools of existing LPS have been analyzed to assess the actual significance of A^3 work design in LPS. Based on the results, four strategies were derived that show possibilities for further development of LPS towards A^3 work design.

2 Work Design in Lean Production Systems

In modern manufacturing enterprises, lean production systems specify the details of each and every work process. LPS claim to consider the three aspects technology, organization and people [13].

A lean production system (LPS) is "an enterprise-specific compilation of rules, standards, methods and tools, as well as the appropriate underlying philosophy and culture for the comprehensive and sustainable design of production. An LPS enables an enterprise to meet the requirements of today's business environment, taking into account technological, organizational, work-force-related and economic aspects" [4].

The superior goal of all LPS is the sustainable elimination of waste in all processes. [12, 14] In this context, waste is determined from a customer's point of view and includes all activities that do not add value to the product. As waste elimination is a basic approach in LPS, many descriptions exist. The most common are the following seven types of waste [10, 12, 14, 15]: Overproduction, Waiting, Transporting, Over-processing, Inventories, Unnecessary motion and Defects. Some authors name an eighth type, the waste of unused employee creativity [10].

Several methods and tools support the avoidance and elimination of waste. These methods and tools are embedded in a superior structure that links the enterprise's strategy to the principles, methods and tools of the LPS. Despite the enterprise-specific compilation of LPS, a general structure was identified, which is shown

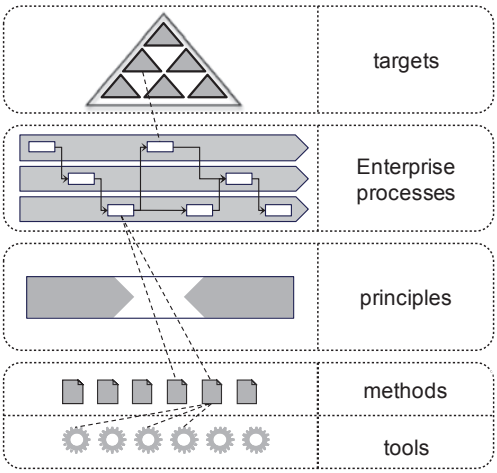

Fig. 1 Organization and structure of a lean production system

in Fig. 1. The fundamental elements of LPS are the enterprise's targets, processes, principles, methods and tools [14].

One of the main differences between LPS and traditional mass production systems is the improvement process. In contrast to mass production, LPS use the continuous improvement of all processes in small but frequent steps. This improvement needs various decentralized steps that contribute to the superior goal of zero waste [14].

The LPS principles are based on an enterprise-specific collection, which causes a variety of principles. Most of them can be traced back to the same eight basic principles that have been described in the LPS guideline of the German association of engineers [14]. These basic principles will be described in the following.

The **elimination of waste** is a fundamental principle that has already been mentioned above. Since waste is everything that does not contribute to customer value. The second principle is the **continuous improvement process** (CIP). Its aim is to question all current practices all the time and to improve them frequently. **Standardization** of processes is an important condition for the waste elimination and continuous improvement process. Standards help to sustain the improved state and show deviations from the desired process. The fourth principle, **zero defects**, contains methods and tools to prevent the appearance and identification of defects. The **flow principle** helps to avoid excess inventory, which results in shorter lead times. In ideal state, the lead time equals the processing time. The **pull principle** focuses on the material flow as well. According to this principle, every product has to be linked to customer demand. **Visual management** is used to illustrate the actual state and the current standards. Thereby, deviations from standards can be recognized at a glance. The principle of **employee orientation and management by objectives** includes methods and tools for leadership in LPS.

3 Age and Aging Appropriate Work

Due to the demographic change, enterprises have to adapt their future work design to an older workforce. One response to the increasing age of the workforce is the age and aging appropriate (A^3) work design. The A^3 work design should ensure that the processes in enterprises are designed for assuring the achievement potential during the whole working life. Therefore the A^3 work design contributes positively to health, motivation and qualification of the employees across their entire working life [3].

The age appropriate work design is aimed at adopting special measures for the group of older employees, whose performance has already changed in the course of their working lives. In comparison, the aging appropriate work design regards preventive measures. These preventive measures are supposed to maintain the achievement potential over the whole working live. Thereby false strains are avoided directly [9].

A lot of different measures can be attributed to the A^3 work design. In particular, these measures can be allcoated to six different aspects [3]: Ergonomic work design, Promotion of occupational health and safety, Job enrichment, Reduction of time pressure at work, Implementation of exculpatory working time models and Job rotation

4 Analysis of A^3 Work Design in Lean Production Systems

A recent study of the German Federal Ministry of Labour and Social Affairs shows that only 5.1 % of the examined enterprises design their processes under age and aging appropriate work aspects. Thereby enterprises have to focus on an A^3 work design to cope with changing conditions [1]. Based on these findings, the Institute for Advanced Industrial Management conducted a further analysis regarding A^3 work design. Since LPS represent state of the art manufacturing, it was investigated how A^3 work design is integrated in LPS.

The LPS were analyzed in terms of their direct impact on age and aging appropriate work design. Furthermore, it was of interest whether the different LPS could at least positively influence the A^3 work design if they do not have a direct impact.

The analysis was based on the LPS guideline of the German association of engineers (VDI 2870) and the LPS of 22 enterprises. The considered enterprises operate in ten different industry sectors. Thus, it was a heterogeneous group. Most frequently represented were the automotive original equipment manufacturers (OEM) (four enterprises) and suppliers (OES) (seven enterprises). Each of the 22 enterprises have a specific LPS considering their individual requirements. So, the LPS did not only vary in their number of levels of detail, design principles and methods. They also differed in terms of content.

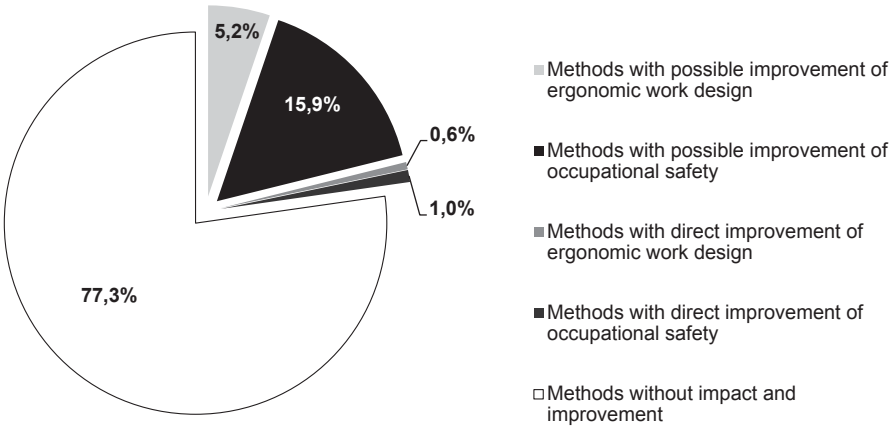

Fig. 2 A^3 Analysis of LPS

For comparability, all of the LPS examined were normalized to the structure of the VDI 2870. Based on this standardization, the targets, principles and methods of the various LPS were analyzed concerning their consideration of A^3 work design. As shown before, the A^3 work design can be divided into six aspects. In this analysis, only the aspects of ergonomic work design and promotion of occupational health and safety were examined. As regards the promotion of occupational health and safety, the focus was on the consideration of occupational safety.

At the target level, no direct consideration of ergonomic work design and occupational safety could be identified. The enterprise targets rather aim at involving the employees in the enterprise processes. They focus on increasing the employees' satisfaction, identification with the enterprise, motivation and longterm employment. These aspects, however, do not lead directly to an improvement of A^3 work design in terms of ergonomic work design and occupational safety. At least, they increase the motivation of employees and thus have a positive impact on the aging appropiate work design.

Furthermore, it was found that ergonomic work design is not considered in any of the analyzed LPS on the principle-level. However, occupational safety is fixed in five enterprises on this level.

In the next step, the LPS methods have been regarded. The analysis of the methods has shown that overall 21.1 % of the 805 considered methods could have a positive impact on ergonomic work design and occupational safety if they were applied with this aim. Therefore, they are improving the A^3 work design potentially or directly. As shown in Fig 2, 5.2 % of the methods may improve the ergonomic work design. An exemplary method is the job rotation. Job rotation means that employees change their jobs in regular intervals, which avoids a one-sided strain. Direct improvement of the ergonomic work design is included in only 0.6 % of the methods. One exemplary method for direct improvement in terms of the LPS is "ergonomic work analysis tools". The further analysis showed that 15.9 % of the methods could

have a positive impact on occupational safety, such as the method 5S. Result of 5S is a well-organized workplace based on standardization. This leads to an improvement in occupational safety because of avoiding accidents due to misplaced items. Only 1% of the 805 methods directly affect occupational safety. An exemplary method for this is "Visualized Safety".

Corresponding results have come out in a second analysis. Thereby, workshops and projects of a German automotive manufacturer were evaluated. It was checked whether aspects for improving the ergonomic work design were part of the projects and workshops or not. The analysis of a total of 52 workshops and nine projects showed that only 5.7% of the workshops and 22.2% of the projects have focused on an improvement in ergonomics.

In summary, it can be said that especially ergonomic work design is still not well enough considered in the examined LPS. In particular, it should be noted that no principle of the observed LPS directly improves the ergonomic work design. Also the consideration of ergonomic work design at the method level is very low. Only 0.6% of the examined methods take aim at direct improvement of ergonomic work design. At the moment, occupational safety is considered in five out of 23 LPS at the principle level. Just 1% of the methods have a direct impact on occupational safety. But the analysis has also shown, that many LPS methods could have a positive impact on A^3 work design.

5 Strategies for A^3 Work Design in LPS

The previous analysis of present LPS has shown that A^3 work design has not been considered consistently. As the results indicate, several methods already existing offer possibilities to improve A^3 work design. Many methods just have to be refocused on the specific topic and do not need much adaption. In summary, enterprises could use the potential of LPS for A^3 work design in order to cope with the new requirements due to the demographic change. Four strategies will be described in the following, which show four different ways to integrate A^3 work design into existing LPS. The strategies consider the causalities in the above described LPS structure and the findings from recent analyses of existing LPS. This is necessary to achieve the desired effects and to change the LPS sustainably. The four strategies are shown in Fig 3.

The **structural integration** describes an additional principle that regards A^3 work design. The principle has to refer to a strategic goal of the enterprise in order to ensure a consistent structure. This strategy allows clustering of particular methods and tools and assures their systematic use. If the LPS follows an A^3 principle, it will most likely be part of the visual LPS depiction. These depictions often serve as a logo or symbol of the LPS and are widely used in slideshows, brochures and other marketing material. Thereby, the structural integration supports the degree of awareness for A^3 work design. The most common depictions of LPS are a house, a circle and the enterprise's product [5].

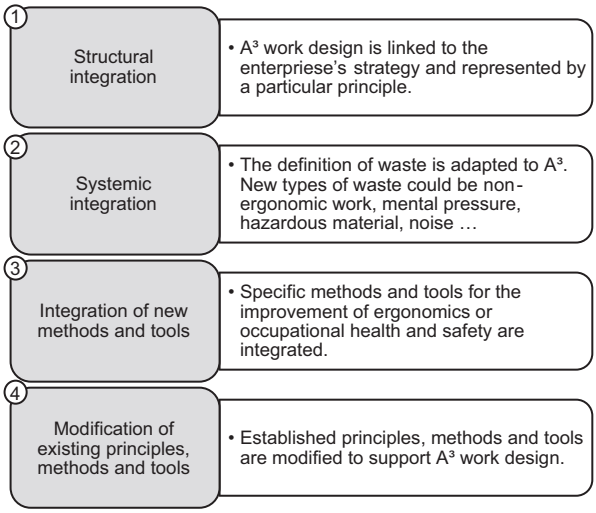

Fig. 3 Strategies for A^3 work design in LPS [7]

The second strategy is based on a **systemic integration** of A^3 work design. Therefore, the principle of waste elimination can be adapted. This principle represents the foundation for other principles and is a key element of every LPS. In general, this principle has the goal to eliminate activities that do not increase customer value [14]. Waste elimination could also contribute to eliminating activities that compromise the employee's health and safety. Waste would then be defined from the customer's and employee's point of view. Consequently, the description of waste should be improved by adding non-ergonomic work, mental pressure, hazardous material, noise or other unsafe working conditions.

The shop floor implementation of A^3 work design requires the **integration of A^3 methods and tools** in the existing LPS. This allows to continuously integrate A^3 work design into daily routines. The previously introduced analysis has shown a lack of methods that support A^3 work design in LPS. Especially methods and tools for the assessment and improvement of ergonomic work conditions should be integrated. Such methods are already widely known but are not part of the LPS and due to that, not part of work design. Many enterprises already use the ergonomic assembly worksheet (EAWS) [11]. If the EAWS would be integrated in LPS, a comprehensive application could be achieved. Another benefit would be the early ergonomic assessment during the design of the process. Besides EAWS, other methods have to be integrated. Especially the so called screening methods should be used. Their results are less detailed but easy to use and no special training is necessary.

The fourth strategy uses a **modification of existing principles, methods and tools**. Therefore, the systemic integration should have been applied. With the new understanding of waste, several basic LPS methods can contribute to A^3 work design. For example, PDCA, five whys or benchmarking are easily deployable on the improvement of ergonomic work conditions or occupational health and safety. Other methods might need a little adjustment. Poka yoke could not only be used to

achieve failure-proof processes, it could also provide malposition-proof processes. The well known 5S method could be extended to a 6S method: sorting, set in order, sweep, **secure**, standardize and sustain. Besides individual methods, also principles could be modified. The principle of standardization would be very suitable for A^3 work design. Thereby, not only quality, time and costs would be regarded, the best processes in terms of occupational health and safety would be standardized as well. Another possibility is the implementation of a zero disease principle, derived from the zero defects principle. It could cluster methods and tools that reduce absenteeism due to employee illness.

6 Conclusions

Many industrial countries already show significant symptoms of a demographic change. The low fertility rate and high life expectancy result in a higher average age of workforces. Enterprises have to adapt their processes to the age specific requirements of their employees. The age and aging appropriate (A^3) work design combines approaches of occupational health and safety, ergonomics and age specific solutions like better lighting. The A^3 work design should be integrated in already existing and well established lean production systems (LPS) in order to achieve a sustainable application. An analysis has shown that A^3 work design is not suficiently regarded in presently existing LPS. Some LPS have implemented individual methods for ergonomics or safety but lack a comprehensive integration. Therefore, four strategies were introduced that show solutions to integrate A^3 work design in future LPS.

References

1. BMAS (2012) Fortschrittsreport “Altersgerechte Arbeitswelt”. Federal Ministry of Labour and Social Affairs, Berlin
2. BMI (2011) Demography report. Federal Ministry of the Interior, Berlin
3. Buck H, Kistler E, Mendius H-G (2002) Demographischer Wandel in der Arbeitswelt. Broschürenreihe, Demograpghie und Erwerbsarbeit, Stuttgart
4. Dombrowski U, Schmidt S (2008) Framework for the planning and control of lean production system implementation. Int J Agile Manuf
5. Dombrowski U, Palluck M, Schmidt S (2006) Strukturelle Analyse Ganzheitlicher Produktionssysteme. ZWF Z wirtsch Fabrikbetrieb 10:553–556
6. Dombrowski U, Mielke T, Schulze S (2010) Impact of lean production systems implementation on labor conditions. APMS, Cernobbio
7. Dombrowski U, Mielke T (2012) Entwicklungspfade zur Lösung des Demografieproblems in Deutschland. GITO-Verlag, Berlin
8. European Commission (2011) Demography report 2010: older, more numerous and diverse Europeans. Publications Office of the European Union, Luxembourg
9. Kistler E et al (2006) Altersgerechte Arbeitsbedingungen. BAuA, Dortmund

10. Liker JK (2004) The Toyota way. McGraw-Hill, New York
11. MTMaktuell (2011) Instruktoren aus fünf Ländern. EAWS. MTMaktuell 1:24–25
12. Ohno T (1988) Toyota production system. Productivity Press, New York
13. Spath D, Braun M (2003) Menschengerechte Arbeitsgestaltung als Führungsaufgabe. wt Werkstattstech online (1/2):75–79
14. VDI (2012) VDI 2870—Lean production systems. VDI, Beuth, Berlin
15. Womack JP, Jones DT (2003) Lean thinking. Free Press, New York