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Workplace design in Indonesian manufacturing small and medium-sized enterprises: Review and further research

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Abstract
Workplace design is an essential process for the manufacturing industry to realize a low manufacturing cost with high productivity and competitive advantage, as well as high employee performance and well-being. Although research on workplace design in the Indonesian manufacturing industry began more than 20 years ago, workplace conditions in the manufacturing industry, especially in small and medium-sized enterprises (SMEs) in Indonesia, have remained subpar, with high material handling costs. This review article aims to evaluate recent research on workplace design in the Indonesian manufacturing SMEs and explore possible directions for further research. The results of this review indicate that the research on workplace design in Indonesian manufacturing SMEs is mostly focused on the department area (micro-level), using systematic layout planning methods to improve material handling activities. Even though environmental conditions are unfavorable with low levels of occupational safety and health, research that consider these two in the process of designing workplace in Indonesian manufacturing SMEs is still limited. This review also shows the possibility of developing an integrated workplace design by involving environmental ergonomics and occupational safety and health in manufacturing SMEs.

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1. Introduction

The design of workplaces in many countries, particularly developing ones like Indonesia, is often substandard, contributing to various work environment problems (Abeid, 2015; Shamusideen and Ukpomwan, 2014). According to Abeid (2015), these work environment issues are a major contributor to poor employee performance and health problems. Improper workplace design in developing countries is one of the factors that cause workplace hazards, poor worker's health, injuries, and disabilities, reduce worker productivity, and increase costs (Shamusideen and Ukpomwan, 2014).

Over the past few decades, extensive research has been conducted on the design of industrial manufacturing workplaces. This research has yielded a variety of theories, methods, and tools for creating effective and efficient workplaces.

Workplace design influences job satisfaction and motivation (Baleshzar and Tabbodi, 2019). The workplace can have a direct and measurable impact on overall organizational performance and productivity if properly configured and designed (Teicholz, 2004). Improper workplace design can result in physical fatigue and discomfort, thus reducing work quality and extending task completion times (Abdous et al., 2018).

Workplace design encompasses the arrangement, dimensions, and positioning of various physical components within a workspace that surrounds one or more individuals (Marmaras and Nathanael, 2012). Mufti et al. (2019) stated that the design of a safe and comfortable workplace is related to the regulation of all matters related to the workstation, including equipment, the environment, and the layout of facilities, to avoid injuries and other adverse effects due to work to increase productivity.

The primary objective of workplace design is to establish a conducive and comfortable working environment by eliminating physical impediments that hinder employee mobility and comfort (Akbilek, 2018). According to Czaja and Nair (2006), the main concern of designing a workplace is to ensure that the work environment can support workers' performance and

activities and enable workers to carry out their work in an efficient, comfortable and safe manner.

In reality, the practical experience of designing workplaces in industries in several countries shows contradicting results (Launis et al., 1996). According to Santos' (2012) findings, over one-third of workplace designs require significant modifications within the first year of implementation.

Research on workplace design in the Indonesian manufacturing industry was first published online by San and Wahjudi (2000) who investigated the design of the layout of production facilities in the bag-producing industry to minimize material handling distance. Although research on workplace design has been performed for the past twenty years, Indonesia's manufacturing industry, especially small and medium-sized enterprises (SMEs), still faces high costs of material handling due to poor facility design (Setiyawan et al., 2017). Workplace conditions in Indonesia's manufacturing SMEs are also far from optimal (Hermawati et al., 2014). Moreover, occupational safety and health in Indonesian SMEs are in poor condition, incurring high rates of occupational accidents and diseases (ILO, 2014).

In this study, the term "industrial manufacturing workplace" refers to all types of workplaces used to perform production process activities in the manufacturing industry, including the processes at sub-micro-level (workstation area), micro-level (department area), and macro-level (factory area) according to Lee et al. (1997). Industrial manufacturing places have been described not only as "workplaces," but also as "workstations" (Ben-Gal and Bukchin, 2002), "workspaces" (Corlett and Clark, 2009), "assembly lines" (Deros et al., 2011), "production lines" (Castellone et al., 2017), "production rooms" (Mufti et al., 2019), or "shop floors" (Sanjog et al., 2019).

SMEs in Indonesia face the challenge of increasing productivity while improving occupational safety and health and working conditions (ILO, 2014). A safe and healthy workplace is one of the prerequisites for increasing company productivity (ILO, 2013), obtained through workplace design (Fulder et al., 2005).

The remaining problems mentioned above suggest that workplace design in Indonesia's manufacturing SMEs has not been sufficiently addressed. Therefore, workplace design that has been carried out in Indonesia's manufacturing SMEs needs to be explored and analyzed to determine actions that can be taken to improve the workplace design process in the future.

This paper is intended to review workplace design research in the Indonesian manufacturing SMEs over the past two decades (2000–2022) and explore possible developments for future research. Ultimately, it will assist the development of an appropriate framework and standards for the workplace design process of manufacturing SMEs in Indonesia.

To the best of the authors' knowledge, this is the first review of workplace design for the manufacturing SMEs, particularly in developing countries. Although there have been several previous reviews like those conducted by Ben-Gal and Bukchin (2002) and Muralidaran et al. (2017), they only looked at workplace design in the workstation area.

In this review article, the methods and approaches for identifying and analyzing study results from the literature are first explained. Subsequently, the results of the review and analysis are detailed. In the final section, a discussion is presented on the problems and phenomena observed in the reviewed studies, with a prospective outlook on future developments to enhance workplace design within small and medium manufacturing enterprises. This is aimed at achieving a safer, more comfortable, and more productive workplace. While the scope of this article is confined to research articles pertinent to workplaces in Indonesia, the findings are posited to have applicability to other developing countries.

2. Materials and methods

This study is intended to review and analyze the development of research on workplace design in the Indonesian manufacturing SMEs based on previous research results. For this purpose, considering that research on workplace design in Indonesia was first published in 2000, identification was made of previous articles that have been published online from 2000 to December 2022 using ScienceDirect, Scopus, and Google Scholar. Following the stated objectives, the search for articles was not limited to only those written in the English language but also included articles in Indonesian. Keywords used in the article search include "workplace," "workspace," "workstation," "layout," and "design" by combining these keywords with the "AND" Boolean operator. Moreover, the keywords used in the search for articles published in Indonesia were "tempat kerja (workplace)," "stasiun kerja (workstation)," "tata letak (layout)," and "perancangan (design)."

The research results involved in this study are the research results that have been published as articles in not only scientific journals but also proceedings of scientific seminars or conferences, as well as master's theses and Ph.D. dissertations.

The articles that have been obtained from the database were then filtered and screened and only the articles that discuss workplace design in Indonesia were selected. Next, the articles on workplace design were sorted specifically to discuss workplace design in the manufacturing industry. Henceforth, the articles used in this study include only the articles that discuss the design of workplaces in the Indonesian manufacturing SMEs.

Articles were analyzed based on the following criteria:

- *The coverage area of workplace design*. This term refers to the size of the designed work area. In this study, the coverage area of workplace design is grouped into three areas according to Lee et al. (1997), namely the workstation area (sub-micro-level), department area (micro-level), and factory area (macro-level).
- *Workplace design method(s) used*. Workplace design methods were used in each of the reviewed studies.
- *The purpose of designing the workplace*. The purpose of workplace design was carried out in each study reviewed.

VOSviewer also used to visualize the relationship between the keywords and terms used in the literature so that the focus of the articles on workplace design in the Indonesian manufacturing SMEs can be identified and interpreted.

Based on these considerations, the possibility of developing research on the design of workplaces in the manufacturing SMEs is discussed.

3. Results and discussion

Following the methodology previously designed, articles were then searched using predetermined keywords and screened them to obtain the articles that are truly oriented toward the study objectives. The process of searching and screening articles resulted in the selection of 84 papers that met the specified criteria. Table 1 (Appendix A) provides summaries of all the papers reviewed. Henceforth, 84 papers were further analyzed and reviewed based on the objectives of this study.

In the next section, a review of workplace design studies over the past two decades in Indonesian manufacturing SMEs is presented. A more specific analysis of the research results at SMEs related to the design of their workplaces was conducted to find problems that cause the conditions in SMEs to be less than good, and if possible, to find solutions to improve them.

Figure 1 shows the keywords and terms used in workplace design research in the Indonesian manufacturing SMEs in the past two decades along with the relationships between these keywords.

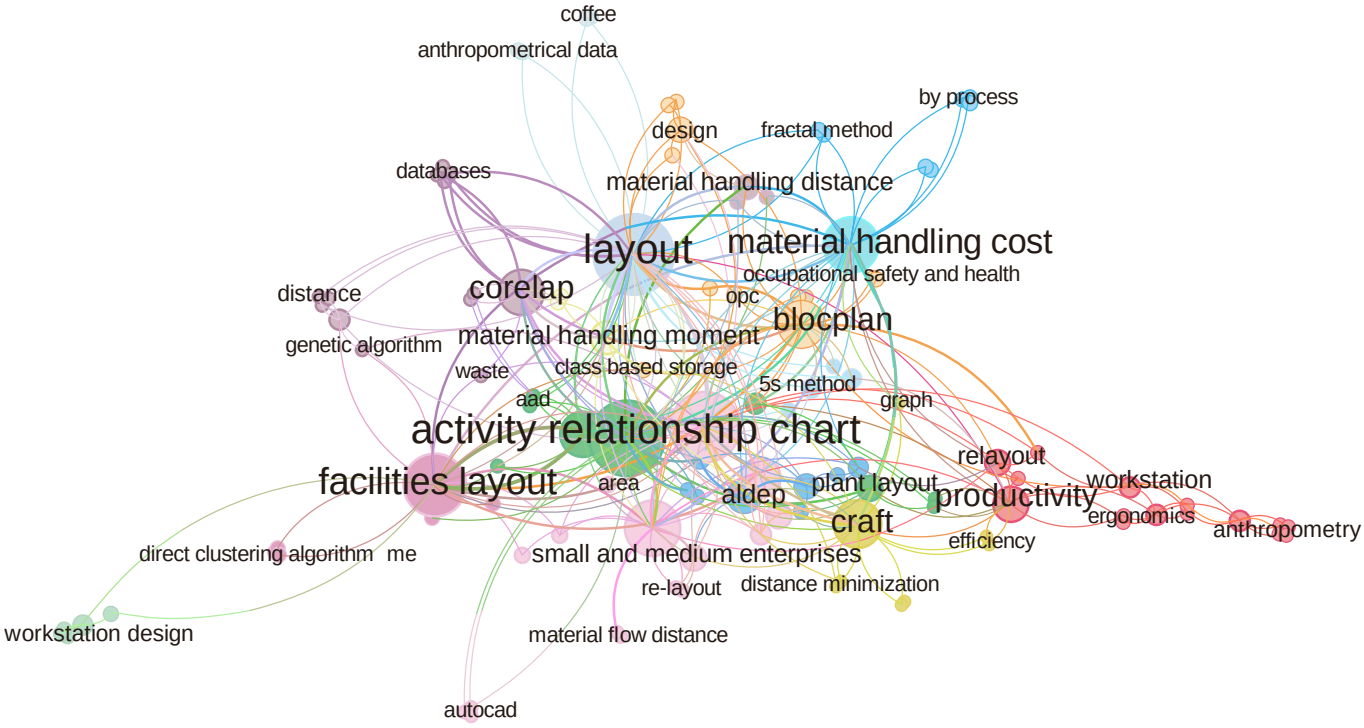

Fig. 1. Terms in workplace design research in the Indonesian manufacturing SMEs (2000–2022)

The six keywords most widely used include "layout" (28 times, 8.67%), "activity relationship chart" (24 times, 7.43%), "material handling" (21 times, 6.50%), "facilities layout" (18 times, 5.57%), "material handling cost" (14 times, 4.33%), and "systematic layout planning" (14 times, 4.33%). These keywords suggest that the researchers are primarily interested in minimizing material handling expenses by designing production facility layouts using systematic layout planning (SLP) and activity relationship chart (ARC) methods.

Although the occupational safety and health in Indonesia's manufacturing SMEs are not good, it turns out that there are only two keywords related to this, namely "work safety and health" and "safety and health analysis" with each occurring once. Besides, there are no occurrences of keywords related to environmental ergonomics, such as noise, lighting, and temperature. These indicate that the researchers pay little attention to aspects of occupational safety and health as well as aspects of environmental conditions in designing workplaces in Indonesian manufacturing SMEs.

Research on the design of workplaces in Indonesia's manufacturing SMEs in the past two decades, based on the coverage area, has largely focused on the department area (59 papers, 70.24%), as shown in Figure 2. Next is the coverage of the factory area (17 papers, 20.24%), and the workstation area (8 papers, 9.52%).

Almost all research on workplace design in SMEs, both at the workstation, department, and factory area, unfortunately, discussed workplace design partially. Interestingly, Kurniawan et al. (2020) designed the factory layout, which was started by the workstation design. However, the workstation that is designed is only one of all existing workstations, and

there is no detailed explanation of how to integrate the design of the workplace at the workstation area with the factory area.

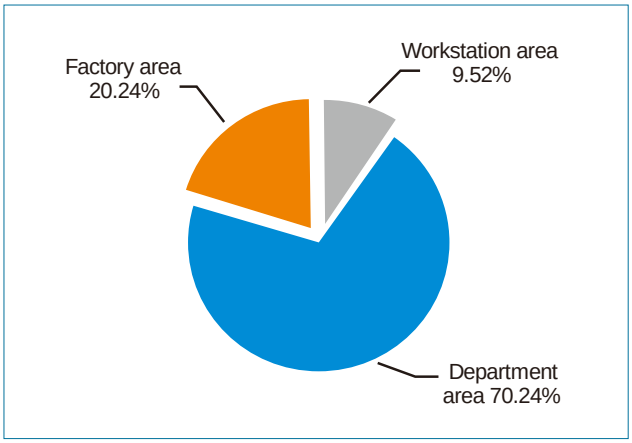

Fig. 2. The scope of workplace design for manufacturing SMEs in Indonesia

The following subsections will describe a more detailed review of the objectives and methods used in research on workplace design in each coverage area.

3.1. Workplace design in the sub-micro-level (workstation area)

Based on eight papers, workplace design during the past two decades has had three main objectives: increasing productivity, improving working comfort, and reducing the physical disorders (see Figure 3). Increasing productivity, which is the most dominant goal, is achieved through reducing the processing time, improving working time efficiency, and reducing energy consumption (Dewi et al., 2015; Sari, 2012; Trisusanto et al., 2020; Wibawa, 2010; Wicaksana and Nugroho, 2017).

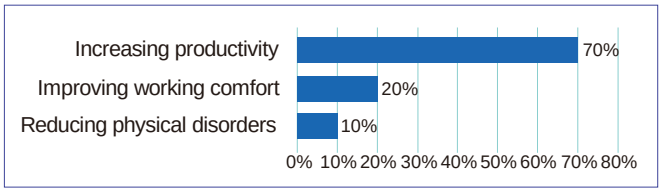

Fig. 3. The objective of workplace design in the workstation area

The improvement of working comfort was obtained by designing workstation according to the worker's body size and providing safer and more comfort workplace (Mulyati et al., 2004; Sutalaksana and Widyanti, 2016). Meanwhile, reducing physical disorder was obtained through improving the working posture of employees while carrying out their work (Ariyanti et al., 2019).

Figure 3 shows that previous researchers were less concerned with the application of ergonomics in workplace design, as evidenced by the limited research that included aspects of physical disorders to design workplace in the workstation area. This is one of the causes of the many occupational safety and health risks in Indonesian manufacturing SMEs.

Anthropometry is the most famous method and most widely used by researchers to design workplaces in the workstation area. Researchers such as Ariyanti et al. (2019) and Sari (2012) used anthropometry methods to design work facilities and workstation layouts that are appropriate for workers' body sizes to provide a comfortable working environment. The use of the anthropometry method based on the fact that most of the work facilities and their layout in the workstations at the SMEs do not match the worker's body size; thus the workers show unnatural work postures while working which causes physical disorders (e.g. Mulyati et al., 2004; Sutalaksana and Widyanti, 2016; Trisusanto et al., 2020).

Unfortunately, of the eight papers that discuss workplace design in the workstation area in manufacturing SMEs, no paper considered occupational safety and health and the improvement of environmental conditions as the purpose of workplace design.

3.2. Workplace design in the micro-level (department area)

The objectives of research on workplace design in the department area of Indonesian manufacturing SMEs over the last two decades are shown in Figure 4. Improving material handling activities is the most dominant purpose of designing workplaces in the department area, even in the entire workplace design coverage area. Researchers such as Adiyanto and Clistia (2020) and Gunanti et al. (2021) improved the material handling activities to minimize the material handling costs by reducing the distance and time of material handling by rearranging the layout of production facilities.

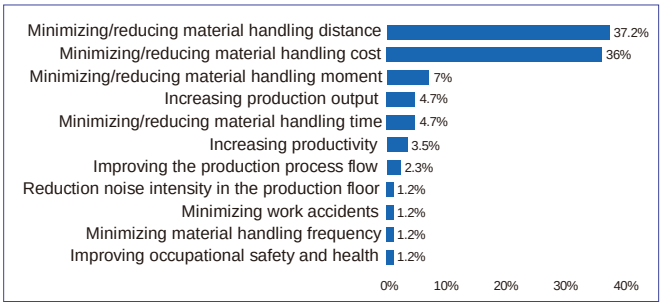

Fig. 4. The objective of workplace design in the department area

Improving productivity is the next purpose of workplace design in the department area. The productivity can be improved by redesigning the layout of production facilities to enhance the process flow and increase production outputs (e.g. Faishal and Pratama, 2019; Jaya et al., 2017).

Workplace design in the department area is usually accomplished through SLP and parts of SLP such as ARC, activity relationship diagram (ARD) and from-to chart (e.g. Irmanto et al., 2021; Saputra et al., 2020). Designers of workplace layouts in Indonesia have favored these methods for their systematic and organized approach.

Other popular workplace design methods are the computerized relative allocation of facilities technique (CRAFT) (e.g. Lubis et al., 2022; Patra and Ramadhan, 2020), the computerized relationship layout technique (CORELAP) (e.g. Adiyanto and Clistia, 2020; Hendrawan and Mulyati, 2021), BLOCPLAN (e.g. Gunanti et al., 2021; Pramesti et al., 2019), and the automated layout design program (ALDEP) (e.g. Adiyanto and Paldo, 2019; Husen et al., 2020). These well-known computer-assisted layout design methods are widely used for the workplace layout designs of manufacturing industries in Indonesia, particularly those of SMEs. Researchers usually select two of the four methods to provide an alternative design layout of the facility. The best design layout is then decided after running a simulation method.

Systematic layout planning (SLP), activity relationship chart (ARC), activity relationship diagram (ARD), computerized relative allocation of facilities technique (CRAFT), block layout overview with layout planning (BLOCPLAN), computerized relationship layout technique (CORELAP), and automated layout design program (ALDEP) are methods commonly used in designing the facility layout in the production room aimed at improving the material handling activity.

Of the 59 papers that discuss workplace design in departmental areas, only two papers paid attention to occupational safety and health aspects (Pramesti et al., 2019; Wati and Singgih, 2019). Besides, only two papers paid attention to environmental ergonomic aspects in designing workplaces in departmental areas, especially noise (Ramaditya et al., 2017) and temperature (Wati and Singgih, 2019). Ramaditya et al. (2017) conducted workplace design considering the noise level of machines in the production room, where machines with high noise levels are clustered in one area. Meanwhile, Wati and Singgih (2019) place machines or production facilities that generate heat or high temperatures close to the ventilation.

3.3. Workplace design in the macro-level (factory area)

The objective of workplace design in the factory area is to improve the material handling activities by reducing material handling distance, moment,, and cost (Kurniawan et al., 2020; Oktarini et al., 2019), increasing productivity (Martha and Ardiansah, 2020), and improving the process flow (Kumalasari et al., 2019) as shown at Figure 5. In general, these objectives are the same as the workplace design objectives in the department area, considering that the department area or production room is the most part of the entire factory area in SMEs, so previous researchers considered these two areas to be the same.

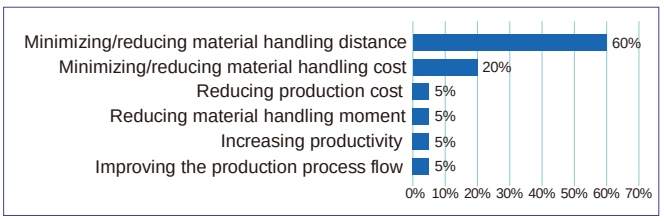

Fig. 5. The objective of workplace design in the factory area

Factory areas are usually designed by SLP (Kurniawan et al., 2020; Martha and Ardiansah, 2020). Other methods were used to design the workplace in the factory area are BLOCPLAN (Daya et al., 2018; Syarif and Bedros, 2017) and CRAFT (Sembiring et al., 2019; Siska and Risman, 2017).

Unfortunately, none of the workplace design papers in this factory area consider occupational safety and health and environmental ergonomic aspects in the workplace design process.

3.4. Discussion

This review and analysis showed that designers of workplaces in the manufacturing SMEs in Indonesia predominantly focus on setting the layout of facilities in the department area (micro-level) or production room, usually using the SLP method. Most workplace designs aim to reduce the distance, time, moment, and cost of material handling. Meanwhile, the material handling activity in the production room is far from perfect. Material handling activities in the production room are hampered mainly by poor machine and material management by SME managers. In particular, many workplace designers consider only the availability of free space (Setiyawan et al., 2017), ignoring the layout of machinery and other production facilities (Mufti et al., 2019).

Most of the work in manufacturing SMEs in Indonesia is done manually, thereby increasing occupational safety and health risks for workers. However, the results of this study show that the application of ergonomic aspects in workplace design, especially in the workstation area, is still very lacking. If this is not improved, workers will experience negative impacts due to the work they do and reduce their work productivity.

Despite the pressing need to improve workplace conditions in most Indonesian SMEs (Hermawati et al., 2014; Herwanto and Suzianti, 2020), this crucial aspect has been largely overlooked by workplace design researchers. Among the 84 papers reviewed, only two addressed environmental factors such as noise (Ramaditya et al., 2017) and temperature (Wati and Singgih, 2019). This suggests a lack of awareness among researchers regarding the need to incorporate environmental variables into workplace design for Indonesian manufacturing SMEs. This oversight has contributed to the subpar environmental conditions in these workplaces. In fact, considering the prevalent environmental issues in the manufacturing industry, Dianat et al. (2016) emphasize the importance of incorporating environmental factors (noise, lighting, and temperature) into the design of manufacturing industry workplaces. Furthermore, Regulation Number 5 of 2018, issued by Indonesia's Minister of Manpower, mandates companies to implement workplace environment controls to ensure that environmental conditions meet established standards.

Several studies have shown the poor condition of occupational safety and health in SMEs in developing countries (e.g. Wang et al., 2018) and Indonesian SMEs. Like the workplace environment conditions, occupational safety and health issues are largely neglected in workplace design research. Among the 84 papers reviewed, only Pramesti et al. (2019) and Wati and Singgih (2019) considered the safety and health aspects of

workplace design at the micro-level (department area). Unfortunately, these studies do not explain how occupational safety and health aspects should be involved in workplace design.

The findings of this study indicate that the consideration of the manufacturing SMEs workplace area in Indonesia has remained insufficient. The design of workplaces in each coverage area is still carried out separately, where each study is focused only on the design of a workplace for one work area, such as one workstation. During the paper search process in this study, no publications were found that show the research results that integrate the three areas in the design of workplaces in the manufacturing SMEs. Only one paper (Kurniawan et al., 2020) discussed workplace design in the workstation area and continues to design workplaces in the factory area. However, there is no clear explanation for the integration process. Considering the relatively small size of the production space, workplace design in SMEs should be carried out comprehensively and integrated at all levels of the workplace area, not only in one or some areas.

One of the problems faced by SMEs in developing countries is poor workplace design, which results in poor employee performance (Abeid, 2015). This problem also happens in most SMEs in Indonesia. The findings of Mufti et al. (2019) and Setiyawan et al. (2017) show that the layout of production facilities has been overlooked in the design of workplaces in Indonesian manufacturing SMEs. The setting of production facilities layout is based on only the availability of space, which has caused many problems for manufacturing SMEs in Indonesia, especially in terms of material handling.

Workplace design is vital to consider in the initial planning of the company. Given the importance of workplace design, several countries, including Canada, New Zealand, and Australia, published guidelines on workplace design to get an efficient and effective office. Launis et al. (1996) proposed guidance for designing workplaces with workstation coverage. During the paper search in this study, no research has been found that discusses workplace design guidelines in the Indonesian manufacturing industry. This guide needs to be prepared to assist industry managers, especially SME managers when designing their workplaces.

The results of this review lead to several shortcomings of existing workplace design studies in the manufacturing SME in Indonesia as shown in Figure 6.

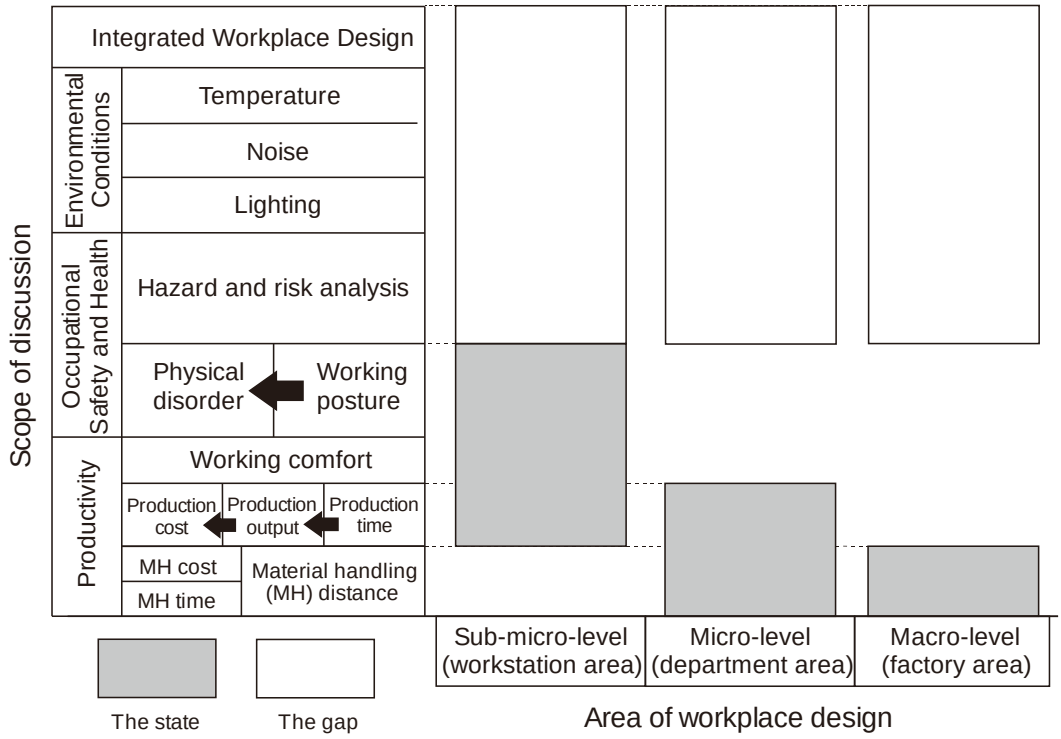

Fig. 6. The shortcomings of workplace design studies in the Indonesian SMEs

Figure 6 shows the scope of discussion of each existing study that is represented by the length of the shaded rectangle. The research on workplace design at the workstation area only discussed productivity concerning production costs and working comfort, as well as occupational safety and health concerning physical disorders due to work postures. The discussion in workplace design research at the department area focused on productivity, particularly concerning material handling distance, cost, and time, and production costs. Meanwhile, research on workplace design at the factory area focused on productivity, particularly concerning material handling distance and production costs. None of the existing studies have addressed occupational safety and health issues related to hazard and risk assessment, nor have they considered physical environmental factors such as noise, lighting, and temperature. Furthermore, the workplace design in all areas (workstation, department, and factory area) has not been integrated and is separate from one another.

Some future research can be proposed to improve the existing study shortcomings, which can also be applied to other developing countries, namely,

- *Involving environmental aspects in workplace design*. Judging from the results of previous studies, the conditions of the workplace environment in most manufacturing SMEs in developing countries, are far from satisfactory (e.g. Hermawati et al., 2014). Meanwhile, most workplace design research ignores or only rudimentarily considers the environmental conditions of the workplace in the manufacturing SMEs. Among the 84 papers reviewed in this study, only two studies considered the environment conditions (noise and temperature) in the workplace design of manufacturing SMEs (Ramaditya et al., 2017; Wati and Singgih, 2019), but without detailing the involvement of these environmental conditions in workplace design. Involving environmental conditions such as noise, lighting, and temperature in workplace design is necessary for realizing a comfortable workplace.
- *Involving occupational safety and health consideration in the workplace design*. More attention to occupational safety and health would reduce the high rate of work accidents in Indonesian SMEs (Pramesti et al., 2019), although occupational safety and health are regulated in the Indonesian industry. Involving occupational safety and health aspects in workplace design is among the targets of occupational safety in SMEs. After establishing an SME, creating a safe and healthy workplace is a prerequisite to maximizing the productivity of the firm (ILO, 2013). However, this requirement has been overlooked in the workplace design of Indonesia's manufacturing SMEs. Among the 84 papers reviewed, only two papers considered occupational safety and health aspects in workplace design (Pramesti et al., 2019; Wati and Singgih, 2019), and the discussion was unclear. Therefore, workplace designs involving occupational safety and health aspects must be further researched to obtain safe and secure workplaces.
- *Integrated workplace design*. Research on workplace design in the Indonesian manufacturing SMEs in the last two decades revealed a lack of continuity among the results of workplace design research at the sub-micro (workstation), micro (department area), and macro (factory area) levels. Thus far, studies at these different levels have been conducted separately and are unrelated to each other. For instance, research results at the sub-micro level have not been applied at the micro and macro levels. Likewise, micro-level workplace designs have not applied the results of workplace designs in smaller areas such as workstations. During the literature search for this review, no research publications was found in Indonesia that integrated all work areas (workstation, department, and factory area) in the manufacturing SME into a single workplace design. Besides the need to integrate all work areas into a single workplace design, the workplace design in SME also needs to involve aspects of ergonomics, physical environmental conditions, and occupational safety and health. To realize an integrated workplace design, it necessary to develop a workplace design framework that can integrate all work areas in SME which also involves aspects of ergonomics, physical environmental conditions, and occupational safety and health, while still considering material handling activities and productivity.
- *Develop the guidelines of workplace design for manufacturing SMEs*. Workplace design guidelines help SME managers to design their workplaces. However, the workplace-design guidelines for the manufacturing industry are still minimal, particularly in Indonesia. The literature search afforded only two papers discussing workplace design guidelines in the textile industry (Dragcevic et al., 2019), and the guidelines in both papers were limited to the designing of sewing workstations in a workplace. As previously mentioned, the design of workplaces in Indonesian SMEs considers only the free space availability without accounting for the variables related to good workplace design. Based on the limitation, ample opportunity exists for designing guidelines suitable for manufacturing SMEs in Indonesia.

  The guidelines must consider aspects of ergonomics, material handling, and physical environmental conditions, as well as other variables appropriate to the characteristics of manufacturing SMEs in Indonesia, such as products, processes, and workers. The stages of the workplace design process in the guidelines must integrate workplace design in all SME areas, including workstation design, facilities layout design, and setting of environmental conditions, especially noise, lighting and temperature. The guidelines must also include hazard evaluation in workplace design in each area and productivity evaluation. Apart from that, considering the limited quality of human resources in SMEs, this guide must be simply so that it is easy for SME managers to apply.

Although this research was conducted on Indonesian manufacturing SMEs, these results can be applied to other countries manufacturing SMEs, especially in developing countries, with similar characteristics to manufacturing SMEs in Indonesia. Nevertheless, the application of the results of this study needs to consider the conditions and regulations related to SMEs in each country.

The implementation of the results of this review can begin with structuring a framework for the workplace design process that considers the conditions of the work environment and occupational safety and health, as well as work productivity. This framework must also integrate the design of workplaces in all work areas of manufacturing SMEs, from the smallest area (workstation) to the largest, both at the departmental and factory levels. The results of applying this framework can then be the basis to form a guide for manufacturing SME managers in designing their workplaces.

4. Summary and conclusion

The study findings indicate that workplace design research in Indonesian manufacturing SMEs in the last two decades has been more dominant in the department area by using the SLP method to improve material handling. That also indicates that

previous researchers paid more attention to the problem of productivity improvement in the department area (through improving material handling) than the other two areas (workstation and factory area). No research has been found that integrates workplace design at all three workplace area (workstation, department, and factory area) in the Indonesian manufacturing SMEs. Besides, the researchers have not paid serious attention to involving environmental conditions and occupational safety and health in the Indonesian manufacturing SME's workplace design.

The results of this study indicate opportunities for future direction to develop a suitable workplace design framework for manufacturing SMEs in Indonesia that integrates workplace design at three levels (workstation, department, and factory area) by considering productivity and involving environmental conditions and occupational safety and health. Given the limited human resources in manufacturing SMEs in Indonesia and other developing countries, it is necessary to prepare guidelines for designing suitable workplaces for manufacturing SMEs to assist manufacturing SME managers in designing their workplaces.

Although previous studies have revealed shortcomings in the workplace design in the Indonesian manufacturing SMEs, this study has its own limitation. This study used only three databases for reference search, namely, Scopus, ScienceDirect, and Google Scholar. Most of the research on workplace design in the Indonesian manufacturing SMEs may not be indexed in one or more of these databases, and may therefore have been missed.

This study shows the need for managers of manufacturing SMEs in Indonesia to involve aspects of occupational safety and health and the work environment from the start of the workplace design process while still paying attention to productivity. In addition, the design of workplaces in manufacturing SMEs should also be integrated from the smallest area (workstation) to the larger area (department or factory area). Thus, the challenges faced by manufacturing SMEs regarding occupational safety and health, work environment, and productivity can be overcome.

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Reference

Abdous, M. A., Finco, S., Visentin, V., 2018. Workload evaluation of industrial work: Existing methods and practical applications, Proceedings of the Summer School Francesco Turco, 395–401.

Abeid, A. H., 2015. Investigation of workplace environment: The case of selected micro and small manufacturing enterprises in Tanzania, International Journal of Engineering Research & Technology (IJERT), 4(6), 827–832.

Adiasa, I., Suarantalla, R., Rafi, M. S., Hermanto, K., 2020. Perancangan ulang tata letak fasilitas pabrik di CV. Apindo Brother Sukses menggunakan metode systematic layout planning (SLP), Performa: Media Ilmiah Teknik Industri, 19(2), 151–158, DOI: 10.20961/performa.19.2.43467 (in Indonesian)

Adiyanto, O., Clistia, A. F., 2020. Perancangan ulang tata letak fasilitas produksi UKM Eko Bubut dengan metode computerized relationship layout planning (CORELAP), Jurnal Integrasi Sistem Industri, 7(1), 49–56. (in Indonesian)

Adiyanto, O., Paldo, K. M. R., 2019. Perancangan tata letak fasilitas produksi UKM Eko Bubut menggunakan metode automated layout design program (ALDEP), Teknoin, 25(2), 66–79, DOI: 10.20885/teknoin.vol25.iss2.art1 (in Indonesian)

Akbilek, N., 2018. Ergonomic assessment and workplace design in dairy processing industry, Advances in Social & Occupational Ergonomics, AHFE 2017, Springer, Cham, 295–306, DOI: 10.1007/978-3-319-60828-0_30

Al-Haq, Z., Antara, N. S., Hartiati, A., 2015. Perancangan tata letak ulang (relayout) pabrik terhadap tingkat produksi produk bakso ayam (studi kasus pada pabrik bakso UD. Supra Dinasty Denpasar), Jurnal Rekayasa dan Manajemen Agroindustri, 3(2), 80–91. (in Indonesian)

Amalia, R. R., Ariyani, L., Noor, M., 2018. Perancangan ulang tata letak fasilitas industri tahu untuk meminimalkan material handling dengan algoritma blocplan di UD. Pintu Air, Jurnal Teknologi Agro-Industri, 4(2), 89–100, DOI: 10.34128/jtai.v4i2.54 (in Indonesian)

Amri, Meutia, S., Syuaib, M., 2015. Perancangan ulang tata letak pabrik menggunakan metode systematic layout planning (SLP) pada UD. Indaco Bireun, Prosiding SNTI 2015, Lhokseumawe, Aceh, Indonesia, 195–203. (in Indonesian)

Anggraini, F., Sunarni, T., 2019. Usulan perbaikan tata letak dengan menggunakan metode fraktal (studi kasus di perusahaan mebel X), Jurnal Metris, 20, 89–102. (in Indonesian)

Anisa, N., 2014. Alternatif tata letak fasilitas (mesin) menggunakan cellular manufacturing system di UD. Tri Rejeki Madiun, Jurnal Agri-Tek, 15(2), 1–8. (in Indonesian)

Anthara, I. M. A., 2010. Usulan perbaikan tata letak lantai produksi dengan metode CRAFT untuk meminimasi ongkos material handling (studi kasus CV. Karya Mekar Bandung), Majalah Ilmiah UNIKOM, 8(1), 107–118. (in Indonesian)

Anwar, A., Bakhtiar, B., Nanda, R., 2015. Usulan perbaikan tata letak pabrik dengan menggunakan systematic layout planning (SLP) di CV. Arasco Bireuen, Malikussaleh Industrial Engineering Journal, 4(2), 4–10. (in Indonesian)

Arif, M., Sulastri., 2017. Perancangan ulang lay out pabrik tahu Makmur Jaya di Dumai, Prosiding Semnas Teknik 2017, Dumai, Indonesia, 106–116. (in Indonesian)

Arios, A. L., 2020. Usulan perbaikan layout produksi garam di CV. X sebagai upaya meningkatkan efisiensi, efektifitas dan penerapan SNI garam, Majalah Teknologi Agro Industri (Tegi), 12(2), 53–57. (in Indonesian)

Ariyanti, S., Widodo, L., Zulkarnain, M., Timotius, K., 2019. Design work station of pipe welding with ergonomic approach, Sinergi, 23(2), 107–114, DOI: 10.22441/sinergi.2019.2.003

Astuti, M., Poerwanto, E., Trianingsih, A., 2017. Analisis tata letak fasilitas dengan menggunakan metode activity relationship chart pada industri mebel bambu Karya Manunggal Yogyakarta, Prosiding SENATIK 2017, Yogyakarta, Indonesia, DOI: 10.28989/senatik.v3i0.137 (in Indonesian)

Baleshzar, A., Tabbodi, M., 2019. The relationship of environmental architecture with the level of job satisfaction and productivity among the employees of Islamic Azad University, Shiraz Branch, Journal of Health Managament & Informatics, 6(1), 22–27.

Ben-Gal, I., Bukchin, J., 2002. The ergonomic design of workstations using virtual manufacturing and response surface methodology, IIE Transactions (Institute of Industrial Engineers), 34(4), 375–391, DOI:/10.1080/07408170208928877

Cahyono, B. D., Simanjuntak, R. A., Oesman, T. I., 2018. Usulan perancangan tata letak parik dengan metode systematic layout planning pada WL Alumunium, Prosiding IENACO 2018, Surakarta, Indonesia, 233–240. (in Indonesian)

Castellone, R., Spada, S., Sessa, F., Cavatorta, M. P., 2017. A simple multibody 2d-model for early postural checks in workplace design, International Journal of Applied Engineering Research, 12(23), 13451–13461.

Corlett, E. N., Clark, T. S., 2009. The Ergonomics of Workspaces and Machines: A Design Manual, Taylor & Francis Ltd., London.

Czaja, S. J., Nair, S. N., 2006. Human Factors Engineering and Systems Design, Handbook of Human Factors and Ergonomics, John Wiley & Sons, Inc., 32–49, DOI: 10.1002/0470048204.ch2

Daya, M. A., Sitania, F. D., Profita, A., 2018. Perancangan ulang tata letak fasilitas produksi dengan metode blocplan (Studi kasus: UKM Roti Rizki, Bontang), Performa: Media Ilmiah Teknik Industri, 17(2), 140–145, DOI: 10.20961/performa.17.2.29664 (in Indonesian)

Deros, B. M., Khamis, N. K., Ismail, A. R., Jamaluddin, H., Adam, A. M., Rosli, S., 2011. An ergonomics study on assembly line workstation design, American Journal of Applied Sciences, 8(11), 1195–1201, DOI: 10.3844/ajassp.2011.1195.1201

Dewa, K. B., Mulia, A., Yunitasari, D. P., 2018. Perancangan tata letak dan fasilitas menggunakan metode simulasi untuk meminimasi biaya material handling, Prosiding IENACO 2018, Surakarta 295–300. (in Indonesian)

Dewi, L. T., Sari, M. H. R. S. R., Dewi, C., Ariyono, V., 2015. Implementasi prinsip ekonomi gerakan untuk pengaturan tata letak fasilitas kerja pada pemrosesan batu alam, Performa, 14(2), 149–156, DOI: 10.20961/performa.14.2.11488 (in Indonesian)

Dianat, I., Vahedi, A., Dehnavi, S., (2016). Association between objective and subjective assessments of environmental ergonomic factors in manufacturing plants, International Journal of Industrial Ergonomics, 54, 26–31, DOI: 10.1016/j.ergon.2015.12.004

Djunaidi, M., Nugroho, M. T., Anton, J., 2006. Simulasi group technology system untuk meminimalkan biaya material handling dengan metode heuristic, Jurnal Ilmiah Teknik Industri, 4(3), 129–138. (in Indonesian)

Dragcevic, Z., Kirin, S., Saravanja, B., 2011. A method of workplace design for sewing operations, Proceedings of the 22nd International DAAAM Symposium, DAAAM International, Vienna, Austria, 379–380.

Faishal, M., Pratama, M. A., 2019. Perancangan ulang tata letak fasilitas perusahaan sandal hotel dengan metode ARC untuk mengurangi waste, Jurnal Teknologi, 12(2), 116–122. (in Indonesian)

Faishal, M., Putra, M. K., 2019. Perancangan ulang tata letak fasilitas industri sandal dengan metode CORELAP, Jurnal Material dan Proses Manufaktur, 3(2), 116–125, DOI: 10.18196/jmpm.3245 (in Indonesian)

Faiz, A. H., Fadhlurrohman, N., Salsabila, Z. F., 2019. Perancangan tata letak fasilitas pada UKM Tajusa Drumband menggunakan pendekatan simulasi guna menurunkan ongkos material handling, Prosiding IENACO 2019, Surakarta, Indonesia, 53–60. (in Indonesian)

Fatoni, R., Mayasari, H. D., Sholaika, A. M., Susanto, Y., 2013. Perancangan ulang tata letak pabrik dan analisa keselamatan dan kesehatan kerja (studi kasus CV Okabawes Karya Logam), Prosiding Simposium Nasional RAPI XII, Surakarta, Indonesia, 52–59. (in Indonesian)

Febianti, E., Herlina, L., Khoiriah, F., 2011. Relayout fasilitas produksi dengan menggunakan algoritma blocplan, Teknika: Jurnal Sains dan Teknologi, 7(2), 125–133. (in Indonesian)

Fulder, T., Pizmoht, P., Polajnar, A., Leber, M., 2005. Ergonomically designed workstation based on simulation of worker's movements, International Journal of Simulation & Modelling, 4(1), 27–34, DOI: 10.2507/IJSIMM04(1)3.038

Gunanti, N. A., Subagyo, A. M., Herwanto, D., Arifin, J., 2021. Optimasi tata letak fasilitas menggunakan algoritma blocplan dan corelap. Journal of Industrial and Manufacture Engineering, 5(2), 107–120, DOI: 10.31289/jime.v5i2.5555 (in Indonesian)

Hamzah, A., 2020. Perancangan ulang tata letak fasilitas produksi dengan metode systematic layout planning (SLP) dan 5S di CV. Seken Living, IEJST (Industrial Engineering Journal of The University of Sarjanawiyata Tamansiswa), 4(1), 10–21. (in Indonesian)

Hendrawan, D., Mulyati, D. S., 2021. Usulan perancangan ulang tata letak fasilitas dengan metode algoritma corelap di CV. X, Industrial Engineering Science, 1(1), 31–38. (in Indonesian)

Hermawati, S., Lawson, G., Sutarto, A. P., 2014. Mapping ergonomics application to improve SMEs working condition in industrially developing countries: a critical review, Ergonomics, 57(12), 1771–1794, DOI: 10.1080/00140139.2014.953213

Herwanto, D., Suzianti, A., 2020. An Environmental Ergonomics Review of Small Medium Enterprises Workplace Condition in Indonesia, Proceedings of the 3rd Asia Pacific Conference on Research in Industrial and Systems Engineering 2020, ACM, New York, 213–218, DOI: 10.1145/3400934.3400974

Hidayat, N. P. A., 2012. Perancangan tata letak departemen finishing pabrik CV. SG-Bandung, Jurnal Teknik Industri, 2(2), 137–146. (in Indonesian)

Husen, T. A., Suryadhini, P. P., Astuti, M. D., 2020. Perancangan tata letak fasilitas untuk meminimasi jarak material handling pada UKM XYZ menggunakan metode ALDEP, Prosiding IDEC 2020, Surakarta, Indonesia, A08.1-A08.12. (in Indonesian)

ILO, 2013. Keselamatan dan Kesehatan Kerja: Sarana untuk Produktivitas. International Labour Office, Jakarta. (in Indonesian)

ILO, 2014. Hari Keselamatan dan Kesehatan se-Dunia 2014: Mempromosikan budaya keselamatan di usaha kecil menengah di Indonesia. https://www.ilo.org/jakarta/info/public/pr/WCMS_241780/lang--en/index.htm (in Indonesian)

Irmanto, I. N., Darmawan, M. I., Ningsih, Y., 2021. Perancangan ulang tata letak fasilitas pabrik dalam upaya efisiensi material handling di UD. Donesi, Jurnal Teknologi Pertanian Andalas, 25(1), 16–24, DOI: 10.25077/jtpa.25.1.16-24.2021 (in Indonesian)

Jaya, J. D., Nuryati, Audinawati, S. A. N., 2017. Perancangan ulang tata letak fasilitas produksi UD. Usaha Berkah berdasarkan activity relationship chart (ARC) dengan aplikasi blocplan-90, Jurnal Teknologi Agro-Industri, 4(2), 111–123, DOI: 10.34128/jtai.v4i2.56 (in Indonesian)

Kalijaga, M. A., Restiana, R., Fadhlurrohman, N., 2018. Perancangan tata letak fasilitas pada UKM A3 aluminium Yogyakarta menggunakan software Flexsim 6.0, Prosiding IENACO 2018, Surakarta, Indonesia, 178–184. (in Indonesian)

Kartika, I. M., 2014. Perancangan tata letak area produksi dengan menggunakan ARC pada CV Gading Putih di Semarang, CALYPTRA, 3(1), 1–18. (in Indonesian)

Kumalasari, E., Puspitorini, P. S., Putra, A. C., Ernes, A., 2019. Activity relationship chart sebagai perancangan tata letak fasilitas miniplant pada produksi chips porang di Desa Jembul, Prosiding SNP2M UNIM 2018, Mojokerto, Indonesia, 83–88. (in Indonesian)

Kurniawan, I. D., Susetyo, J., Simanjuntak, R. A., 2020. Perancangan ulang tata letak fasilitas produksi dengan metode systematic layout planning (SLP) dan peta tangan kanan tangan kiri proses perakitan, Jurnal Rekavasi, 8(2), 13–22. (in Indonesian)

Kuswanto, Junius, J., Sembiring, A. C., 2020. Perbaikan tata letak lantai produksi industri mebel menggunakan metode grafik dan algoritma craft, Jurnal Rekayasa Sistem Industri, 6(1), 2–6. (in Indonesian)

Launis, M., Vuori, M., Lehtelä, J., 1996. Who is the workplace designer? — Towards a collaborative mode of action, International Journal of Industrial Ergonomics, 17(4), 331–341, DOI: 10.1016/0169-8141(95)00058-5

Lee, Q., Amundsen, A. E., Nelson, W., Tuttle, H., 1997. Facilities and Workplace Design: An Illustrated Guide, first ed.. Engineering & Management Press, Norcross, Georgia.

Linauliyamara, R. R., Nurcahyati, Muqaffi, M. S., 2018. Perancangan tata letak fasilitas produksi wajan TS Putra Yogyakarta, Prosiding IENACO 2018, Surakarta, Indonesia, 322–329. (in Indonesian)

Lubis, P. S., Dewi, H. A. R. N., Selvi, E., 2022. Redesain tata letak pabrik gula dalam meningkatkan efesiensi dan produktivitas CV. Rizki Abadi, J-MAS (Jurnal Manajemen dan Sains), 7(1), 120–132, DOI: 10.33087/jmas.v7i1.342 (in Indonesian)

Marmaras, N., Nathanael, D., 2012. Workplace Design. Handbook of Human Factors and Ergonomics, fourth ed. John Wiley & Sons, Inc., Hoboken, New Jersey.

Martha, N. S., Ardiansah, I., 2020. Usulan perbaikan tata letak fasilitas produksi industri kopi studi kasus CV. Tri Anom Agrotektur, Jurnal Rekayasa Sistem Industri, 5(2), 125–133. (in Indonesian)

Morena, Y., Siska, M., 2011. Perancangan ulang tata letak fasilitas pabrik pembuatan batu bata (Studi kasus: Kulim, Pekanbaru). Prosiding Seminar Nasional Teknologi Informasi Komunikasi dan Industri (SNTIKI) III 2011, Pekanbaru, Indonesia, 405–413. (in Indonesian)

Mubarok, H., Lukmandono., 2017. Perancangan ulang tata letak fasilitas dengan pendekatan metode systematic layout planning guna meningkatkan produktivitas di CV. Putra Perkasa, Prosiding Sntekpan Itats V 2017, Surabaya, Indonesia, 129–134. (in Indonesian)

Mufti, D., Ikhsan, A., Putri, T. M., 2019. Workplace Ergonomic Risk Assessment Toward Small-Scale Household Business, IOP Conference Series: Materials Science and Engineering, 528(1), 012013. DOI: 10.1088/1757-899X/528/1/012013

Mulyati, G. T., Wagiman, Madyana, A. M., 2004. Perancangan tata letak vertikal pembuatan emping melinjo, Agritech, 24(2), 59–64. (in Indonesian)

Muralidaran, V. M., Arun, V., Siddarth, R. S., Krishna, S. A., 2017. Ergonomic considerations for design of industrial workstation: A review, International Research Journal of Engineering and Technology (IRJET), 04(10), 276–281.

Nelfiyanti, Rani, A. M., Ramadhan, A. I., 2016. Perancangan sistem informasi dan tata letak fasilitas produksi tas CV. Banua dengan menggunakan algoritma corelap, Prosiding Semnastek 2016, Jakarta, Indonesia, 1–6. (in Indonesian)

Nugeroho, A. A. U., 2021. Usulan perbaikan tata letak fasilitas pabrik tahu dengan metode systematic layout planning, Jurnal Optimasi Teknik Industri (JOTI), 3(2), 65–69, DOI: 10.30998/joti.v3i2.10452 (in Indonesian)

Nurhasanah, N., Simawang, B. P., 2013. Perbaikan rancangan tata letak lantai produksi di CV. XYZ, Jurnal Al-Azhar Indonesia Seri Sains dan Teknologi, 2(2), 81–90, DOI: 10.36722/sst.v2i2.128 (in Indonesian)

Oktarini, D., Suryani, F., Madagaskar, Rosyidah, M., 2019. Modernization of facility layout design in earthenware craft industry with green productivity approach, IOP Conference Series: Materials Science and Engineering, 620(1), 012114, DOI: 10.1088/1757-899X/620/1/012114

Pambudi, Y. D. S., Sari, I. A., 2019. Alternatif perancangan tata letak mesin produksi di CV. Anugerah Sukses Sejahtera, JISO: Journal of Industrial and Systems Optimization, 2(2), 49–54. (in Indonesian)

Patra, O., Ramadhan, R., 2020. Usulan perbaikan tata letak fasilitas departemen produksi dengan algoritma craft (Studi kasus di CV. Grand Manufacturing Indonesia), Sistemik (Jurnal Ilmiah Nasional Bidang Ilmu Teknik), 08(02), 34–41. (in Indonesian)

Pramesti, M., Subagyo, H. S. H., Aprilia, A., 2019. Perencanaan ulang tata letak fasilitas produksi keripik nangka dan usulan keselamatan kesehatan kerja di UMKM Duta Fruit Chips, Kabupaten Malang, Agrisocionomics: Jurnal Sosial Ekonomi dan Kebijakan Pertanian, 3(2), 150–164. (in Indonesian)

Prasetya, Y. Y., Runtuk, J. K., Hartanti, L. P. S., 2015. Analisis tata letak fasilitas dalam meminimasi material handling (Studi kasus: perusahaan roti Matahari), Jurnal Gema Aktualita, 4(1), 1–10. (in Indonesian)

Pratiwi, I., Muslimah, E., Aqil, A. W., 2012. Perancangan tata letak fasilitas di industri tahu menggunakan blocplan, Jurnal Ilmiah Teknik Industri, 11(2), 102–112. (in Indonesian)

Putra, Y. P., 2018. Merancang tata letak fasilitas pabrik dengan metode algoritma corelap di CV. Robbani Singosari, Jurnal Valtech, 1(1), 65–70. (in Indonesian)

Qisthani, N. N., Sitorus, I. A., Lusianti, H. A., 2021. Perancangan dan simulasi tata letak pabrik untuk mengoptimalkan biaya material handling dengan menggunakan algoritma craft dan activity relationship chart pada industri kerajinan bambu, Journal of Industrial Engineering: Scientific Journal on Research and Application of Industrial System, 6(1), 35–41, DOI: 10.33021/jie.v6i1.1433 (in Indonesian)

Rajak, S., 2018. Optimasi Tata Letak Fasilitas Produksi Menggunakan Algoritma Genetika. Universitas Islam Indonesia. (in Indonesian)

Ramaditya, A. R., Sunardi, Santoso, B., 2017. Analisis kebisingan suara mesin untuk perancangan tata letak mesin pada CV Mitra Baru Teknik, Tekmapro: Journal of Industrial Engineering and Management, 12(02), 56–66. (in Indonesian)

Rengganis, E., Mauidzoh, U., 2021. Re-layout penempatan fasilitas produksi dengan menggunakan metode systematic layout planning dan metode 5 S guna meminimalkan biaya material handling, Jurnal Rekayasa Industri (JRI), 3(1), 31–40, DOI: 10.37631/jri.v3i1.289 (in Indonesian)

Rokhmani, E. W., Desiyanto, F., Harsadi, D. I., 2021. Perencanaan tata letak fasilitas mesin produksi menggunakan metode activity relationship chart (ARC) di CV. Yasri Cipta Mandiri, Jurnal Pendidikan dan Aplikasi Industri (UNISTEK), 8(2), 107–112. (in Indonesian)

Rozak, A., Kristanto, A. D., Raharjo, G. S., Saleh, N. A., 2021. Penerapan ARC dan ARD untuk membuat rancangan layout fasilitas pada pabrik kerupuk menggunakan blocplan di CV Arto Moro, Bulletin of Applied Industrial Engineering Theory, 2(2), 145–149. (in Indonesian)

Samsudin, L. M., Afma, V. M., Purbasari, A., 2014. Perancangan ulang tata letak pabrik jamur tiram menggunakan metode activity relationship chart untuk meningkatkan produktivitas (Studi kasus CV. Mandiri Tiban III), Profesiensi, 2(1), 19–27. (in Indonesian)

San, G. S., Wahjudi, D., 2000. Analisa tata letak pabrik untuk meminimalisasi material handling pada pabrik koper, Jurnal Teknik Mesin, 2(1), 41–49. (in Indonesian)

Sanjog, J., Patel, T., Karmakar, S., 2019. Occupational ergonomics research and applied contextual design implementation for an industrial shop-floor workstation, International Journal of Industrial Ergonomics, 72, 188–198. DOI: 10.1016/j.ergon.2019.05.009

Santos, M. S. e., 2012. The PhOCoe Model - ergonomic pattern mapping in participatory design processes, Work, 41, 2643–2650. DOI: 10.3233/WOR-2012-0507-2643

Santoso, Halim, C., 2012. Usulan tata letak fraktal untuk pabrik baru dari CV Prima Bangun Nusantara, INASEA, 13(2), 100–108. (in Indonesian)

Saputra, B., Arifin, Z., Merjani, A., 2020. Improvement of facility layout using systematic layout planning (slp) method to reduce material movement distance (Case study at UKM Kerupuk Karomah), Profisiensi, 8(1), 71–82. (in Indonesian)

Sari, S. A., 2012. Desain stasiun kerja proses pelunakkan dan pembengkokkan rotan untuk peningkatan produktivitas di UD. Rukun Rotan-Balearjosari Malang, Industri Inovatif, 2(2), 42–46. (in Indonesian)

Sembiring, A. C., Sitanggang, D., Budiman, I., Aloina, G., 2019. Redesign layout of production floor facilities using algorithm CRAFT, IOP Conference Series: Materials Science and Engineering, 505(1), 012016. DOI: 10.1088/1757-899X/505/1/012016

Setiyawan, D. T., Qudsiyyah, D. H., Mustaniroh, S. A., 2017. Usulan perbaikan tata letak fasilitas produksi kedelai goreng dengan metode blocplan dan corelap (Studi kasus pada UKM MMM di Gading Kulon, Malang), Industria: Jurnal Teknologi dan Manajemen Agroindustri, 6(1), 51–60. DOI: 10.21776/ub.industria.2017.006.01.7 (in Indonesian)

Shamusideen, K., Ukpomwan, N., 2014. Industrial Workplace Design and Physiological Consideration of Work in Developing Countries, Les Actes de La Deuxième Conférence Internationale Sur : L'application de l'ergonomie Dans Les Pays En Voie de Développement, Alger, 37–51.

Siahaan, R. C., Oktiarso, T., 2018. Perancangan tata letak lantai produksi baru dengan metode systematic layout planning, Journal of Integrated System, 1(2), 161–179. (in Indonesian)

Siska, M., Henriadi., 2012. Perancangan fasilitas pabrik tahu untuk meminimalisasi material handling, Jurnal Teknik Industri, 13(2), 133–141. DOI: 10.22219/JTIUMM.Vol13.No2.133-141 (in Indonesian)

Siska, M., Retno, D., Sari, M., Hartati, M., Nur, M., 2019. Rancang ulang tata letak fasilitas pabrik dengan metode systematic layout planning dan simulasi arena di industri pallet kayu, Prosiding SNTIKI 11, Pekanbaru, Indonesia, 656–667. (in Indonesian)

Siska, M., Risman, F., 2017. Rancang ulang tata letak CV. Sumber Vulkanisir Super menggunakan metode konvensional dan craft, Jurnal Sains dan Teknologi Industri, 14(2), 225–233. (in Indonesian)

Siska, M., Sabri, F., 2016. Perancangan ulang tata letak pabrik vulkanisir ban, Prosiding SNTIKI 8 - 2016, Pekanbaru, Indonesia, 341–352. (in Indonesian)

Sitohang, R. B., Anthara, I. M. A., 2017. Usulan perbaikan layout lantai produksi produk spare part saringan oli motor di CV. Grand Manufacturing Indonesia, INAQUE: Journal of Industrial & Quality Engineering, 6(1), 57–66. (in Indonesian)

Suhardini, D., Rahmawati, S. D., 2019. Design and improvement layout of a production floor using automated layout design program (ALDEP) and CRAFT algorithm at CV. Aji Jaya Mandiri, IOP Conference Series: Materials Science and Engineering, 528(1), 1–8. DOI: 10.1088/1757-899X/528/1/012062

Sutalaksana, I. Z., Widyanti, A., 2016. Anthropometry approach in workplace redesign in Indonesian Sundanese roof tile industries, International Journal of Industrial Ergonomics, 53, 299–305. DOI: 10.1016/j.ergon.2016.03.002

Syaichu, A., Nurhuda, W., 2021. Perencanaan ulang stasiun kerja untuk meminimalkan biaya material handling menggunakan metode ARC (activity relationship chart) dan FTC (from to chart) CV Karsa Galih Kusuma, Jurnal Ilmu-Ilmu Teknik - Sistem, 17(3), 9–19. (in Indonesian)

Syarif, A. A., Bedros, R. O., 2017. Rancangan ulang tata letak pabrik dengan menggunakan blocplan (studi kasus di UD. Roti Jamal), Juitech, 01(02), 103–113. (in Indonesian)

Tahir, S., Syukriah, Baidhawi, S., 2015. Usulan perbaikan tata letak fasilitas dengan menggunakan algoritma CRAFT, Malikussaleh Industrial Engineering Journal, 4(2), 36–41. (in Indonesian)

Tanjung, W. N., Harimansyah, F. H., 2014. Usulan perbaikan tata letak fasilitas lantai produksi produk sepatu perlengkapan dinas harian (Studi kasus pada CV. Mulia), JIEMS: Journal of Industrial Engineering & Management Systems, 7(1), 39–53. (in Indonesian)

Teicholz, E., 2004. Facility Design and Management Handbook. McGraw-Hill, New York.

Trisusanto, D., Bariyah, C., Kristanto, A., 2020. Design of ergonomic work facilities on assembly station of mozaic stone for increasing work productivity, Asia-Pacific Journal of Science and Technology, 25(1), 1–11.

Wahyuni, R. S., Safitri, A. A., 2014. Metode CRAFT berbantuan perangkat lunak WinQsb untuk usulan perbaikan tata letak fasilitas V2.0 pada industri dompet CV. X, Jurnal Teknologi dan Rekayasa, 19(3), 15–23. (in Indonesian)

Wang, Q., Mei, Q., Liu, S., Zhang, J., 2018. Analysis of managing safety in small enterprises: Dual-effects of employee prosocial safety behavior and government inspection, BioMed Research International, 2018, 1–12, DOI: 10.1155/2018/6482507

Wati, P. E. D. K., Singgih, M., 2019. Perancangan ulang tata letak fasilitas dengan memperhatikan aspek ergonomi lingkungan, Jurnal Teknologi dan Terapan Bisnis (JTTB), 2(2), 33–41. (in Indonesian)

Wiati, N. M., Zaman, M. Z., Kautsar, F., 2021. Analisis dan perancangan ulang tata letak fasilitas produksi dengan metode systematic layout planning, Journal of Industrial View, 3(2), 55–63. DOI: 10.26905/jiv.v3i2.6678 (in Indonesian)

Wibawa, T., 2010. Perancangan stasiun kerja dengan pendekatan human centered design (studi kasus pada industri kecil emping melinjo), Jurnal Optimasi Sistem Industri, 3(1), 30–38. (in Indonesian)

Wicaksana, B. I. A., Nugroho, Y. J. D., 2017. Pendekatan antropometri dalam perancangan ulang stasiun kerja penyoletan guna mengurangi kelelahan fisik dan psikis karyawan akibat kerja, Tekinfo: Jurnal Ilmiah Teknik Industri dan Informasi, 6(1), 1689–1699. DOI: 10.31001/tekinfo.v6i1.387 (in Indonesian)

Wijayanti, A. T., Nova, T. S., Suroso, H. C., 2021. Perancangan ulang tata letak fasilitas (re-layout) pada produksi kerupuk di UD. Sekar, Prosiding Seminar Nasional Teknologi Industri Berkelanjutan I (SENASTITAN I), Surabaya, Indonesia, 159–169. (in Indonesian)

Yunanto, T. B. C., Donoriyanto, D. S., Tranggono, 2020. Rancangan tata letak fasilitas produksi menggunakan automated layout design program di perusahaan makanan, Juminten: Jurnal Manajemen Industri dan Teknologi, 1(3), 25–36. DOI: 10.33005/juminten.v1i3.79 (in Indonesian)

Appendix

Appendix A

Table 1. Summary of articles that were included in the review

#	Author(s)	Workplace design area	Method(s)	Purpose(s) of the workplace design
1	Adiasa et al. (2020)	Factory	SLP	Reducing material handling distance
2	Adiyanto and Clistia (2020)	Department	CORELAP	Reducing material handling cost
3	Adiyanto and Paldo (2019)	Department	ALDEP	Reducing material handling distance and cost
4	Al-Haq et al. (2015)	Department	UA-FLP modeling	Reducing material handling distance and increasing productivity
5	Amalia et al. (2018)	Department	BLOCPLAN	Reducing material handling distance
6	Amri et al. (2015)	Department	SLP	Reducing material handling moment
7	Anggraini and Sunarni (2019)	Department	Fractal method	Reducing material handling distance and cost
8	Anisa (2014)	Department	Cellular manufacturing	Reducing material handling distance and cost
9	Anthara (2010)	Department	CRAFT	Minimizing material handling cost
10	Anwar et al. (2015)	Department	SLP	Reducing material handling moment
11	Arif and Sulastri (2017)	Factory	SLP	Reducing material handling distance and cost
12	Arios (2020)	Factory	ARC, ARD	Reducing material handling distance
13	Ariyanti et al. (2019)	Workstation	Anthropometry	Reducing bad work postures and reducing processing time
14	Astuti et al. (2017)	Department	ARC	Reducing material handling distance and cost
15	Cahyono et al. (2018)	Department	SLP	Reducing material handling distance and time
16	Daya et al. (2018)	Factory	BLOCPLAN	Reducing material handling distance
17	Dewa et al. (2018)	Department	ARC, ARD	Reducing material handling cost
18	Dewi et al. (2015)	Workstation	Motion economy	Improving working time efficiency
19	Djunaidi et al. (2006)	Department	Group technology	Reducing material handling distance and cost, and increasing production output
20	Faishal and Pratama (2019)	Department	ARC, simulation	Reducing material handling distance and time, and increasing production output
21	Faishal and Putra (2019)	Department	CORELAP	Reducing material handling distance
22	Faiz et al. (2019)	Department	ARC, ARD, simulation	Reducing material handling cost
23	Fatoni et al. (2013)	Department	BLOCPLAN	Reducing material handling distance
24	Febianti et al. (2011)	Department	BLOCPLAN	Minimizing material handling cost
25	Gunanti et al. (2021)	Department	BLOCPLAN, CRAFT	Reducing material handling moment and cost
26	Hamzah (2020)	Department	SLP	Reducing material handling distance and cost
27	Hendrawan and Mulyati (2021)	Department	CORELAP	Reducing material handling distance
28	Hidayat (2012)	Department	CRAFT	Minimizing material handling moment
29	Husen et al. (2020)	Department	ALDEP	Minimizing material handling distance
30	Irmanto et al. (2021)	Department	ARC	Reducing material handling distance, cost, and time
31	Jaya et al. (2017)	Department	BLOCPLAN	Improving the production process flow
32	Kalijaga et al. (2018)	Department	ARC, ARD	Reducing material handling cost and increasing production output
33	Kartika (2014)	Department	ARC	Reducing material handling distance and cost
34	Kumalasari et al. (2019)	Factory	ARC	Improving the production process flow
35	Kurniawan et al. (2020)	Factory	SLP	Minimizing material handling distance
36	Kuswanto et al. (2020)	Department	Graph method, CRAFT	Reducing material handling cost and moment
37	Linauliyamara et al. (2018)	Department	CORELAP	Minimizing material handling cost
38	Lubis et al. (2022)	Department	CRAFT	Reducing material handling cost and increasing productivity
39	Martha and Ardiansah (2020)	Factory	SLP	Increasing productivity and reducing production cost
40	Morena and Siska (2011)	Factory	SLP	Reducing material handling distance
41	Mubarok and Lukmandono (2017)	Department	SLP	Reducing material handling cost and increasing productivity
43	Mulyati et al. (2004)	Workstation	Anthropometry	Improving working comfort

#	Author(s)	Workplace design area	Method(s)	Purpose(s) of the workplace design
44	Nelfiyanti et al. (2016)	Department	CORELAP	Improving the production process flow
45	Nugeroho (2021)	Department	SLP	Reducing material handling distance and cost
46	Nurhasanah and Simawang (2013)	Department	RDM, hollier 1, hollier 2	Reducing material handling distance
47	Oktarini et al. (2019)	Factory	ARC	Reducing material handling distance
48	Pambudi and Sari (2019)	Department	CORELAP	Minimizing material handling frequency
49	Patra and Ramadhan (2020)	Department	CRAFT	Reducing material handling cost
49	Pramesti et al. (2019)	Department	BLOCPLAN	Minimizing material handling distance and time, and minimizing work accidents
50	Prasetya et al. (2015)	Department	SLP	Reducing material handling cost
51	Pratiwi et al. (2012)	Factory	SLP	Reducing material handling distance
52	Putra (2018)	Department	CORELAP	Reducing material handling distance
53	Qisthani et al. (2021)	Department	CRAFT	Reducing material handling cost
54	Rajak (2018)	Department	Genetic algorithm	Reducing material handling distance
55	Ramaditya et al. (2017)	Department	N/A	Reducing noise intensity in the production floor
56	Rengganis and Mauidzoh (2021)	Department	CRAFT	Reducing material handling cost
57	Rokhmani et al. (2021)	Factory	ARC, ARD	Reducing material handling distance
58	Rozak et al. (2021)	Department	BLOCPLAN	Reducing material handling distance
59	Samsudin et al. (2014)	Department	ARC	Increasing production output and reducing material handling distance
60	Santoso and Halim (2012)	Department	Fractal method	Minimizing material handling cost
61	Saputra et al. (2020)	Department	SLP	Reducing material handling distance
62	Sari (2012)	Workstation	Anthropometry	Increasing productivity
63	Sembiring et al. (2019)	Factory	CRAFT	Minimizing material handling cost
64	Setiyawan et al. (2017)	Department	BLOCPLAN, CORELAP	Reducing material handling distance and cost
65	Siahaan and Oktiarso (2018)	Factory	SLP	Reducing material handling distance
66	Siska and Henriadi (2012)	Department	SLP	Minimizing material handling distance
67	Siska and Risman (2017)	Factory	CRAFT, simulation	Reducing material handling distance
68	Siska and Sabri (2016)	Department	SLP, ALDEP	Reducing material handling distance and cost
69	Siska et al. (2019)	Department	SLP, simulation	Reducing material handling distance
70	Sitohang and Anthara (2017)	Department	SLP, simulation	Reducing material handling cost
71	Suhardini and Rahmawati (2019)	Department	CRAFT, ALDEP	Reducing material handling cost
72	Sutalaksana and Widyanti (2016)	Workstation	Anthropometry	Providing safer and more comfort workplace
73	Syaichu and Nurhuda (2021)	Factory	ARC, ARD	Reducing material handling distance and cost
74	Syarif and Bedros (2017)	Factory	BLOCPLAN	Reducing material handling moment
75	Tahir et al. (2015)	Department	CRAFT	Reducing material handling distance
76	Tanjung and Harimansyah (2014)	Department	RDM, hollier 2, direct clustering algorithm	Reducing material handling distance
77	Trisusanto et al. (2020)	Workstation	Anthropometry	Increasing productivity
78	Wahyuni and Safitri (2014)	Department	CRAFT	Minimizing material handling cost
79	Wati and Singgih (2019)	Department	From-to-chart	Reducing material handling moment and improving occupational safety and health
80	Wiati et al. (2021)	Department	SLP	Reducing material handling distance and cost
81	Wibawa (2010)	Workstation	Anthropometry	Increasing productivity and reducing energy consumption
82	Wicaksana and Nugroho (2017)	Workstation	Anthropometry	Reducing processing time
83	Wijayanti et al. (2021)	Factory	SLP	Reducing material handling cost
84	Yunanto et al. (2020)	Department	ALDEP	Reducing material handling distance