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A NEW REDESIGN IDEA FOR DUST FILTER TOOL USED IN GERANDONG CRACKERS MANUFACTURING PROCESS BASED ON ROOT CAUSE ANALYSIS (RCA) AND DESIGN FOR ASSEMBLY (DFA) APPROACH

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Abstract

The purpose of this research is to redesign the dust filter tool in Gerandong cracker making process. This research used qualitative method based on Root Cause Analysis (RCA) concept approach and Design for Assembly (DFA). Root Cause Analysis (RCA) is a process of identifying factors that cause variations in performance or predisposition to undesirable outcomes. DFA is a method for assembling components and subcomponents to form a product to optimize cost efficiency. The results of the study stated that the initial efficiency value of dust filter tool is 21%, while the efficiency after the redesign is 31%, so productivity has increased 10%. The total time before redesigning the device is 1376.25 seconds and after the redesign becomes 1156.34 seconds. The part of a component before the redesign is 38 pcs, and after the redesign is 33 pcs, and cost to make dust filter tool before the redesign is IDR 762,000 and after redesign is amount IDR 528,500. Based on these results, it can be concluded that redesigning the dust filter tool can improve the efficiency and produce better products.

Keywords: Gerandong cracker, Design for assembly, Root cause analysis, Redesign.

1. Introduction

Cracker is one of the most popular snacks favored by Indonesian people. This product is widely produced by Small Medium Enterprises (SMEs). SMEs in Indonesia has an important role for its great contribution to the Indonesian economy. Gerandong crackers are different types of crackers than other crackers, due to the raw materials and production process. The primary raw material of gerandong crackers are not from flour but derived from the production of crackers that are not perfect in shape and less have economic value to be sold. So that, the production process also has different stages with the manufacture of other crackers, such as sorting of raw materials, milling, filter dust, boiling, forming the model and size of cracker, drying and the last stage of packaging crackers.

Stages of dust filter consist of steps to remove dust on raw materials after the milling process. However, the SMEs that produce Gerandong crackers still use simple dust filter tool. It affects the productivity of the enterprise. The dust filter used have some disadvantages, these are: 1) The dust from the screening process is still flying around the production area, which can disrupt the health of the operator, 2) Many parts of the tool have no function value, 3) The tool used has a large dimension that takes up the production room and the effect on the quality of the resulting product. Hence, it is a need to redesign the dust filter tool to increase the effectiveness of the devices. Quality of a standard of correspondence between the actual performance of the service with the customers' expectations or the difference between the customers' expectation and their realization of the service's actual performance needs to be taken into consideration [1]. Quality has become the prototype for positioning and differentiation; according to which, business is expected to deliver and will deliver a unique need-satisfying offering that will enhance organizational performance and success in the global market space [2]. Quality of product is a collection of features and sharp brand product characteristic, which have contribution to the ability to fulfilling specific demand [3].

Therefore, the objective of this research is to redesign the dust filter tool with the existence of a design improvement done from the existing dust filter tool, from the existing tools it will be made design improvement design, in order to increase the effectiveness of dust filter tool. Prior to carrying out design improvements, we first identify the problems using root cause analysis (RCA). Then, the result of the identification of problem is done by designing for Assembly. Based on the problem of dust filter tool for Gerandong Cracker, thus the purpose of this paper is to discuss a new redesign idea for dust filter tool used in Gerandong Crackers manufacturing process based on root cause analysis (RCA) and design for assembly (DFA) approach.

2. Method

The method used is a quantitative method with the root cause analysis (RCA) and design for assembly (DFA) approaches. RCA is a process to identify factors that underlie variation in performance or that predispose an even toward undesired outcomes [4]. RCA is a problem solving process for conducting an investigation into an identified incident, problem, concern or non-conformity [5]. Root Cause Analysis (RCA) is one the elements of effective auditing and risk management strategies [6]. RCA is a retrospective approach used to get to the root cause of problem, which when identified and resolved prevents recurrence of the problem [7]. RCA is most effective when equipped with adequate resources and carried out by trained personnel [8]. RCA is designed to help identify not only what and how an event occurred but, more importantly, also why it happened [9].

Assembly is one of the most effective approaches to high product variety [10-16]. Furthermore, Assembly is the one capstone process for product realization where component parts and subassemblies are integrated together to form the final products [10]. Design for Assembly (DFA) as a process for improving product design for easy and low-cost assembly [11]. The process of manual assembly can be divided into two separate areas, handling (acquiring, orienting and moving the part or group of parts) and insertion/fastening (mating a part to another past or group of parts) [12]. These two areas for evaluating of DFA, complexity of assembly, Functional Analysis, Error Proofing Secondary Operations, Time plays an important role [13]. In addition, DFA complexity factor (DCF) is used for assessing complexity of a product design, it includes following two parameters, these are Number of parts (Np) and Number of Interface (Ni) [13]. Then, functional analysis evaluates functional aspects of all components in assembly, it includes three parameters, these are theoretical minimum parts, standardization of parts, and cost [13].

Design for assembly (DFA) is a method to assembly component and sub component to form a product in order to optimize the cost efficiency [14]. Design for Assembly (DFA) is the process by which a product is designed to be easily assembled [15, 16]. For example, such design simplifications are accomplished through reducing the number of operations required to assemble the product, improving the handling of each component, and/or modifying the assimilability of a design through an analysis of these three aspects [15]. DFA is the method to design the products in order to facilitate assembly [17]. In addition, DFA concerned with reducing product assembly cost, there are: minimizes number of assembly operations and individual parts tend to be more complex in design [17]. DFA can support the reduction of product manufacturing costs and it provides much greater benefit than a simply reduction in assembly time [18]. Furthermore, the DFA technique can be applied during the conceptual design phase when decision greatly affects production cost [19].

There are several steps of this method, namely: (1) identification of problems by using root cause analysis; (2) data collection stage; at this stage, the structure of the old dust filtering tool is formulated; (3) Determining Parameter Repair; and (4). Process Design for Assembly (DFA). At this stage, the design for assembly calculation (DFA) before redesign and design for assembly calculations after redesign is done.

2.1. Identification of problems using Root Cause Analysis (RCA)

Analysis using RCA is shown in Fig. 1. Based on the figure, there are three components that can cause low effectiveness of the dust filter tool: 1) the dust filtering tool used, in that the tool dimension is too large and requires a lot of space. To move the production stage from one place to another takes a long time, because the tools used are still simple. 2) dust collection on dust filters that are not functioning optimally, affecting the health of operators who operate the equipment will decrease due to inhalation of continuous dust. 3) The current process is less effective, because too many screening processes in one production and time-consuming. In the production of Gerandong crackers require the process of filtering dust twice before and after grinding. Based on the three causes of the low effectiveness of the tool, it can be analyzed that the root of the problem is the absence of definitive tool design. During this time, the entrepreneurs make simple tools according to their skills and knowledge.

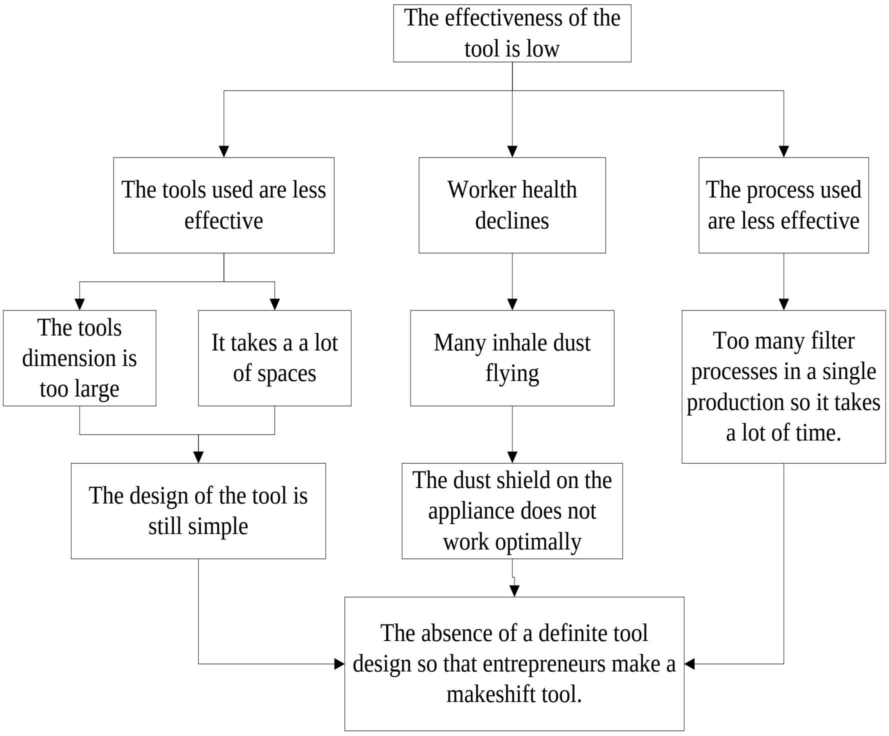

Fig. 1. Identification problem with root cause analysis.

2.2. Breakdown structure

The structure of dust filter devices used in one of the small and medium-sized "Barokah" industries. This tool consists of two separate parts A and part B, which are used in series (Fig. 2). Based on the results of structure formulation in Fig. 3, the researchers draw up the design of material (BOM) of Dust Filter Design Tool currently used in Fig. 3.

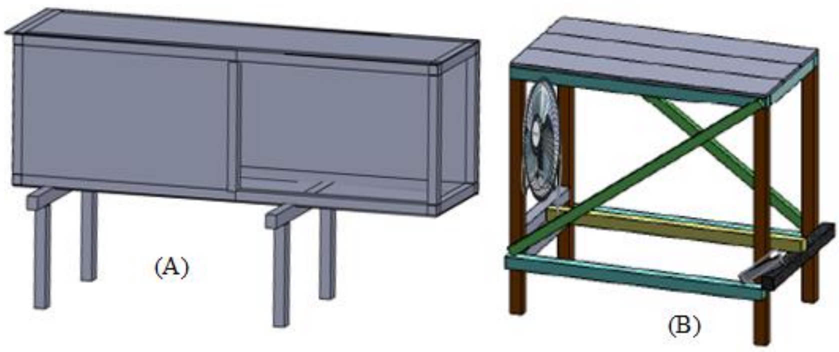

Fig. 2. Part A and Part B on the old design of the dust filter tool.

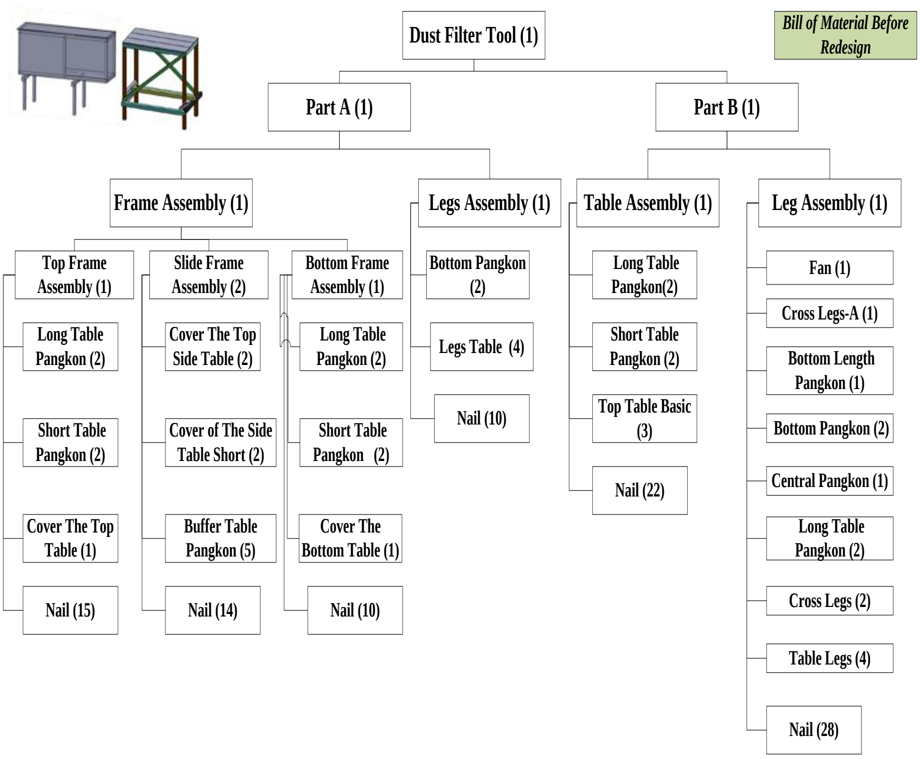

Fig. 3. Bill of material of old design of the dust filter tool.

2.3. Determining the improvement parameters

In determining the design improvement of dust filtering equipment, the first point to do is to determine the equipment specification. Determination of specifications based on increasing dimensions and function of old dust filtering tools that do not consider the aspects of the tools and feature of each part to:

a. Change the dimensions of the tool to be more concise, practical, and efficient so it is easy to move.

b. Minimize air pollution because of dust filter process.

c. The availability of tools convenient for users.

The development stage of the design concept takes into account the condition of the existing dust filtering tool and creates a new concept as follows:

d. The dust filter tool is built and adapted to other device dimensions in order not to take up much space.

e. To minimize the volume of a movement of the appliance, from the previous tool that must undergo movement of the tool before and after the dust filter process, in the presence of the new design is expected no movement of the equipment at the time of production.

f. The new dust filter tool is equipped with a filter at the bottom, to minimize the likelihood of mixing the dust again with the filtered material.

g. Table design for pouring made slopes to facilitate the operator in pouring materials to be processed.

h. The upper part of the table is given a hinge to ease the process, when not used the table can be folded and closed the other table.

i. There are several doors to pick up the process dust on the back and facilitate the installation of the fan in the center of the appliance.

The calculation of the efficiency of the dust filter before the device redesign based on the DFA calculation results in Table 1 is explained by the following formula [20]:

$$E_{ma} = N_{min}\, t_a / T_{ma} \qquad (1)$$

where N_{min} is the minimum number of theoretical part, t_a is the basic assembly time for one part (3 s), and t_{ma} is the estimated time to complete

2.4. Design for assembly process

2.4.1. Design for assembly improvement (DFA) before redesign

Before to the calculation, the initial design of the dust filter tool can be seen in Fig. 2, whereas for details of Part A components can be seen in Fig. 4 and Part B in Fig. 5.

Based on information on Figs. 4 and 5, it is known that the old dust filtering tool consists of two parts A and B. Part A consists of 10 components and part B consists of 11 components so that if calculated as a whole the number of compiler components of dust filter equipment, there are 21 components. In details, the number of components and the initial design calculation of the DFA dust filter can be seen in Table 1.

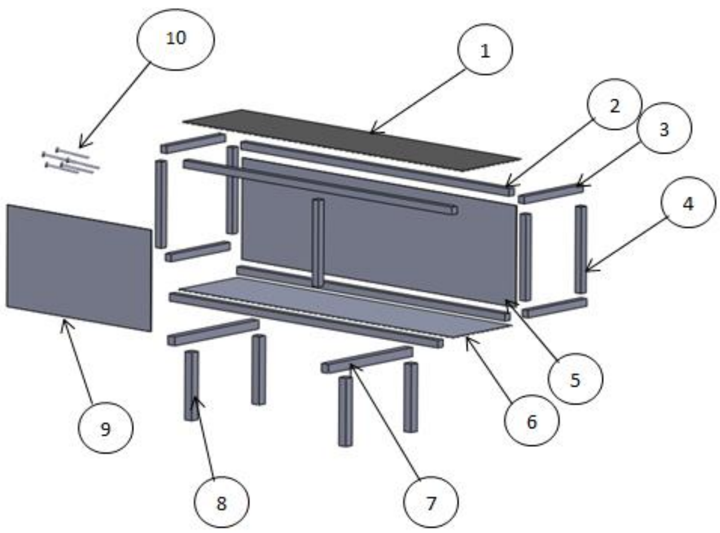

Fig. 4. Part A component. This figure contains: 1. Cover the top table, 2. Long table pangkon, 3. Short table pangkon, 4. Buffer table pangkon, 5. Cover the long side table, 6. Cover the bottom table, 7. Bottom pangkon, 8. Legs table, 9. Cover the side table short, and 10. Nail.

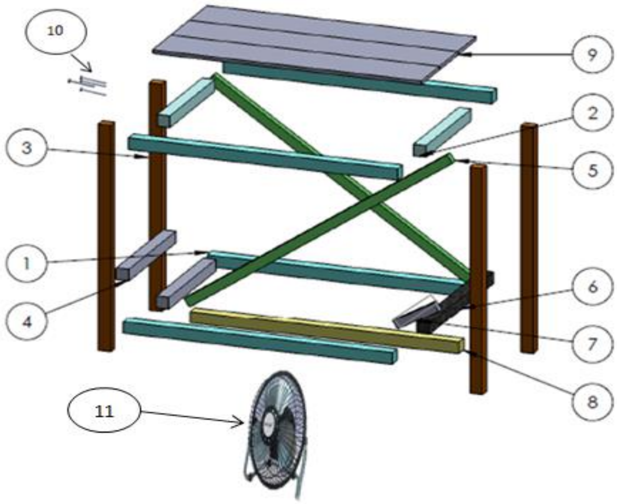

Fig. 5. Part B component. This part component contains: 1. Long table pangkon, 2. Short table Pangkon, 3. Foot table, 4. Bottom Pangkon, 5. Cross legs, 6. Bottom length Pangkon, 7. Cross legs A, 8. Central Pangkon, 9. Top table basic, 10. Nails, and 11. Fans.

The calculation of the efficiency of the dust filter before the device redesign based on the DFA calculation results in Table 1 is explained by the following formula:

$$E_{ma} = N_{min}\, t_a / T_{ma} \tag{2}$$

Based on formula 1, calculation of the efficiency of the dust filter tool before redesign uses N_{min} = 97; t_a = 3; and T_{ma} = 1376.25

So, $E_{ma} = N_{min}\, t_a / T_{ma}$
$= 97 \times 3 / 1376.25$
$= 291 / 1376,25$
$= 0.21$
$E_{ma} = 21\%$

2.4.2. Design for assembly improvement (DFA) after redesign

After knowing the efficiency, the obtained score on the dust filter before the redesign is 21%, then the efficiency calculation on the dust filtering tool that has undergone the process of redesigning the tool can be seen in Fig. 6, while for the compiler component can be seen in Fig. 7. Related to the bill, the calculation is shown in Fig. 8. Based on Fig. 8, calculation of the efficiency of the dust filter tool after redesign uses N_{min} = 120; t_a = 3; T_{ma} = 1156.34. Thus,

$E_{ma} = N_{min}\, t_a / T_{ma}$

$= 120 \times 3 / 1156.34 = 360 / 1156.34$

$= 0.31$

$E_{ma} = 31\%$

Based on the constituent components of the existing equipment it can be calculated efficiency of the new tool.

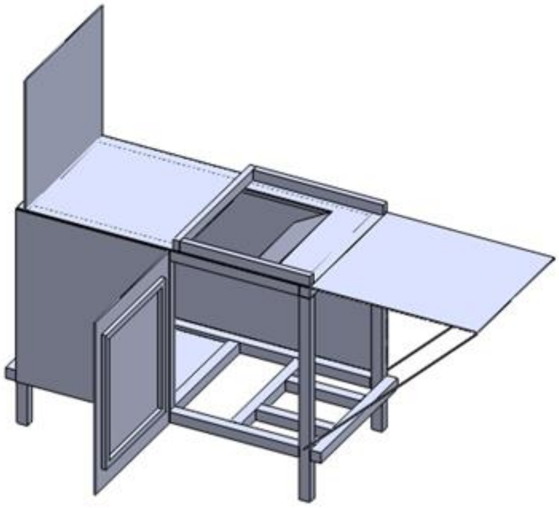

Fig. 6. Redesign dust filter tool.

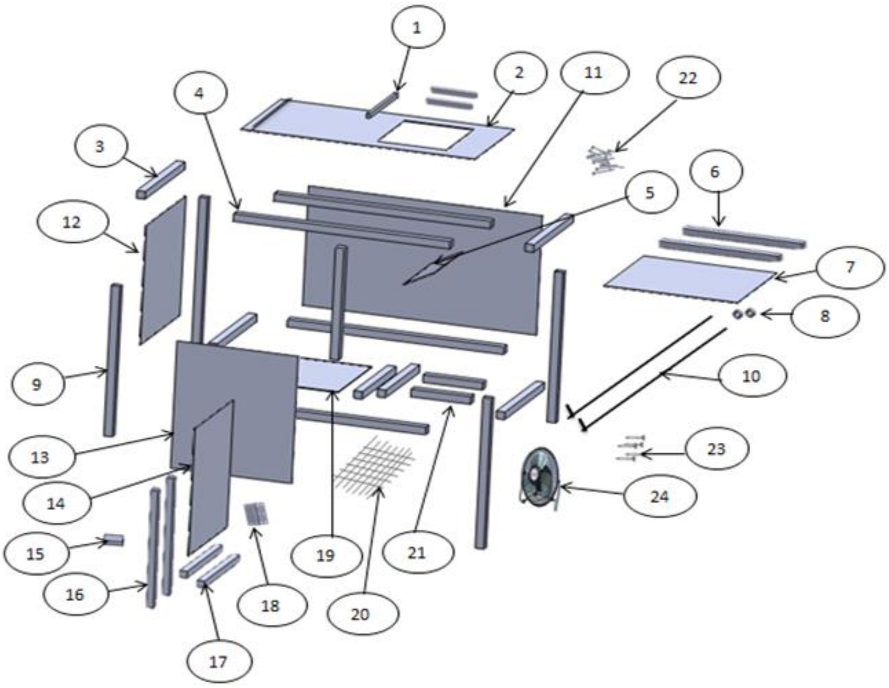

Fig. 7. Part of redesign of dust filter tool. The Explanation of Fig. 7 the component are 1. Barring table, 2. Cover the top table, 3. Pangkon top short, 4. Pangkon top length, 5. Hypotenuse, 6. Pangkon cover helper, 7. Hook the table right, 8. Legs table, 10. Right table, 11. Cover the side table long, 12. Cover the back, 13. Cover the side table short, 14. Side door cover, 15. Door handle, 16. Pangkon buffer door, 17. Pangkon door, 18. Hinges, 19. Cover the bottom of the table, 20. Dust filter down, 21. Bottom middle pangkon, 22. Nails, and 23. Threaded nails.

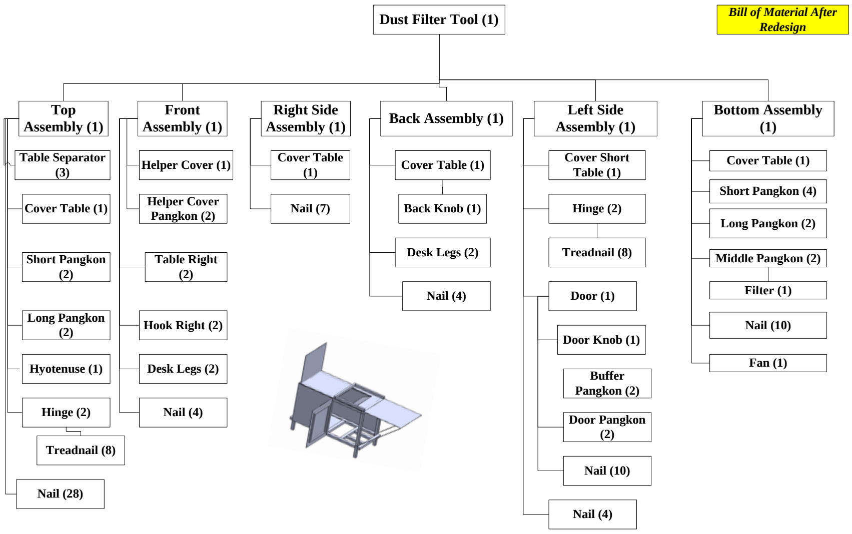

Fig. 8. Bill of material of redesign of the dust filter tool.

3. Results and Discussion

Gerandong cracker which is the focus of research is produced in Sidoarjo, Indonesia. Currently, there are 14 SMEs in Sidoarjo that produce Gerandong cracker. Figure 9 shows the production process of Gerandong cracker.

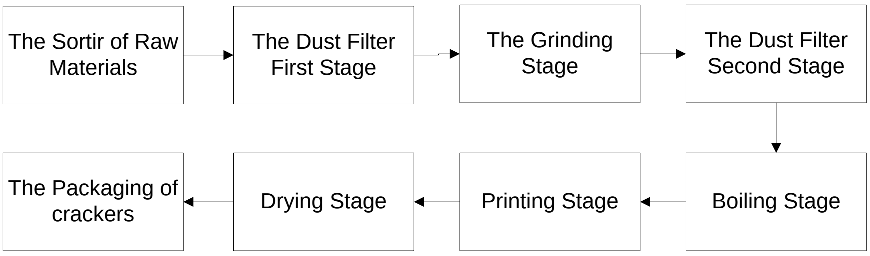

Fig. 9. The stage of gerandong crackers production process.

Based on observation in the process of production Gerandong Crackers, most of the producers faced the same problems in the dust filter tool. The equipment used is still simple, and the productivity of the tool is still not effective.

Based on the calculation using Design For Assembly (DFA) in Table 1, it can be seen that the efficiency value obtained before the redesign was as much as 21%, while the efficiency after the redesign was as much as 31%. The process of redesign tool filter dust has increased the compound efficiency by 10%, with decreasing the time from 1376.25 to 1156.34 seconds.

Besides, to improve the efficiency of the dust filter assembly, the materials used in new dust filters can be extracted from the old dust filter components. Thus, it can save costs and get a good quality tool. Entrepreneurs also need to compare with existing components in material stores, such as plywood boards that can be replaced with aluminium sheets. Regarding price and component compiler different materials, the effectiveness of the resulting tool will be different. Based on calculation using the design for assembly for before and after the redesign, the results are presented in Table 1.

Table 1. The calculation for the dust filter tools before and after re-design.

Design	Number of Component	Assembly Time	Cost (IDR)
Original Design	38 pcs	1376,25 sec	762.000
After Re-Design	33 pcs	1156,34 sec	528,500

Based on the observations made before and after the redesign of dust filter tool, the following explanation is made.

a. Based on the dimensions of the existing dust filter tool, there is a large dimension difference in the dust filter tool, the dimension of the dust filter tool before the redesign tool of 367 cm whereas after the redesigned tool there is a change in tool dimensions of 212 cm, from the dimensional changes the tool can analyze that the amount of space used space is getting smaller or smaller, this means effort in minimizing the room has been reached.

b. Based on the observed results of the dust level generated during the new tool testing process, there is a decrease in the amount of dust generated before the redesign of the tool.

c. In terms of effectiveness and efficiency of the equipment used, before the dust filter process the operator must move the other part of the tool (part B) first before the dust filter process and re-setting the tool, in the presence of tools that have been redesigned no device switching again, thus saving time and facilitating the operator in doing the process.

The results of this research, design for assembly, can reduce the number of components, cost and assembly time [19]. The research conducted by Favi et al. under the title "Multi-Objective Design Approach to Include Material Cost, Manufacturing, and Assembly at the Initial Design Phase [19]. Results of research showed that the redesign results by using DFA method can reduce the number of components and assembly time, i.e., for original design 325 pcs, and for after redesign as much as 125 pcs. As for the assembly, the time needed for the original design was 88 minutes and that needed for the redesigned model is 33 minutes [19].

The results of this research support those of research by More et al., entitled “Design for Manufacture and Assembly (DFMA) Analysis of Burring Tool Assembly”, which showed that design for assembly can reduce standardization of fastener used in burring tool that can reduce assembly time, cost and part component [16].

The suggestions for further research are expected to perform the calculation of the cost of existing components and type of material in the new dust filter tool that is easy to apply by entrepreneurs and analyzed regarding ergonomic tools.

4. Conclusion

Based on the research conducted, the following conclusions can be drawn: (1). In terms of effectiveness, with new dust filters, operators do not need to move the equipment and rearrange the tool before and after the dust filtering process is complete, so the dimensions of the new tool can minimize space; (2) Based on DFA calculations, the resulting efficiency increased from 21 % to 31%, with decreasing assembly time from 1376.25 seconds to 1156.34 seconds; (3). The new dust filter design can reduce the occurrence of air pollution around the work area because the new designer has provided dust that can reduce air pollution. The suggestions for further research are to perform the calculation of the cost of existing components and type of material in the new dust filter tool that is efficient to apply by entrepreneurs and analyzed regarding of ergonomic tools.

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