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Work Analysis of An Assembly Operation Using Therbligs

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Abstract

This study aims to analyze an assembly operation using work analysis technique. The LED bulb assembly operation is studied because it is labor-intensive manufacturing. This operation requires highly repetitive motions of two hands of worker. Therbligs represent motions when worker assemble the parts. Therefore, Therbligs are used to analyze the movements of worker in this study. The results shown that the ineffective motions such as search, select and hold can be minimized or eliminated by using fixture and rearranging workstation.

Keywords : Work analysis; Methods study; Work measurement

INTRODUCTION

Work analysis is a branch of work study developed by Gilbreth in the twentieth century. Work analysis includes the study of methods and the measurement of work. These techniques are used to study human performance in an industrial context in order to improve efficiency and economy. Methods study is a conventional way to help increase productivity without significant investment in new innovations. In addition, better ways of working also help to improve the health and safety of workers. In the fourth industrial revolution with new technologies invented, work study still remains an important role for industrial engineers to examine and improve operations in manufacturing.

Therbligs are human movements when performing manual tasks. Therbligs were developed by Frank and Lillian Gilbreth to analyze the operations of bricklayers (Freivalds & Niebel, 2014). Then, therbligs is applied to study other manual operations in order to increase productivity and also reduce physical work stress of workers. This paper presents a work analysis of an assembly operation in a LED bulb assembly line. The LED bulb manufacturing process is chosen in this study because it is a labor-intensive manufacturing process. An assembly operation was selected because it involves repetitive motions of two hands of the worker.

The following sections are related works, introduction of the product and process, procedure of work analysis, results and conclusion. The following sections are literature reviews, method, result and conclusion.

LITERATURE REVIEWS

The concept of therbligs is applied to develop the learning system (Yen, 2011). Author devided therbligs to assemble hardware computer into seek position, select object, rotate object, assemble object, press, loosen and fasten object, inspect, etc. The purpose of applying therbligs concepts in learning system is to training operators to follow standard operation procedures.

Other study is applying therbligs to make smart work pieces (Oyekan, Hutabarat, Turner, Arnoult, & Tiwari, 2020). Authors labeled four kinds of table legs in which fitting to four types of holes. These smart workpieces was assisted workers when search and select parts to assemble.

Therbligs concept were also developed to modelling the power supply of manufacturing processes on machines (Jia, Tang, & Lv, 2012). The results shown that Therblig-energy models can be used to predicting energy consumption of machining operations on lathe machine.

Shun Jia, et al. also developed a new method for lean operations by embedding Therbligs into value stream map of machining process (Shun Jia, 2017). This novel method can be applied for determining energy waste of non-cutting activities in machining operation.

METHODS

Procedure of work analysis

The procedure of work analysis is illustrated as Figure 1. The first step is select operation. In this study, the operation in which assembled LED chips, plate, screw on housing is selected. It is because two hands of worker operate simultaneously. Another reason for choosing this operation is the worker familiar with assembly steps and work in normal speed when filming. Further more, this operation produces one type of product. Then the motions of two hands is collected by video recording. After that, motions are analyzed by using Therbligs. Next step is intepreting data and suggesting improvements. Finally, conclusion is shown based on identifying effective and ineffective motions.

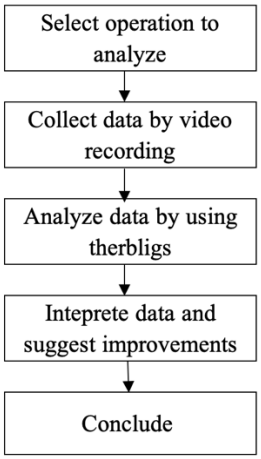


Figure 1. Procedure of work analysis

Therbligs

There are 17 Therbligs which was developed by Gilbreth and refined by Frevails (Freivalds & Niebel, 2014). Table 1 presents therbligs and its descriptions.

Table 1. Effective and Ineffective Therbligs (Freivalds & Niebel, 2014)

No	Therbligs	Symbol	Description
1	Reach	RE	Motion of empty hand to or from object; time depends on distance moved; usually preceded by Release and followed by Grasp.
2	Move	M	Movement of loaded hand; time depends on distance, weight, and type of move; usually preceded by Grasp and followed by Release or Position.
3	Grasp	G	Closing fingers around an object; begins as the fingers contact the object and ends when control has been gained; depends on type of grasp; usually preceded by Reach and followed by Move.
4	Release	RL	Relinquishing control of object, typically the shortest of the therbligs.
5	Preposition	PP	Positioning object in predetermined location for later use; usually occurs in conjunction with Move, as in orienting a pen for writing.
6	Use	U	Manipulating tool for intended use; easily detected, as it advances the progress of work.
7	Assemble	A	Bringing two mating parts together; usually preceded by Position or Move; followed by Release.
8	Disassemble	DA	Opposite of Assemble, separating mating parts; usually preceded by Grasp and followed by Move or Release.
9	Search	S	Eyes or hands groping for object; begins as the eyes move in to locate an object.
10	Select	SE	Choosing one item from several; usually follows Search.
11	Position	P	Orienting object during work, usually preceded by Move and followed by Release (as opposed to prior to work for Preposition).
12	Inspect	I	Comparing object with standard, typically with sight, but could also be with the other senses.
13	Plan	PL	Pausing to determine next action; usually detected as a hesitation preceding Motion.

14	Unavoidable Delay	UD	Beyond the operator's control due to the nature of the operation, e.g., left hand waiting while right hand completes a longer Reach.
15	Avoidable Delay	AD	Operator solely responsible for idle time, e.g., coughing
16	Rest to overcome fatigue	R	Appears periodically, not every cycle, depends on the physical workload.
17	Hold	H	One hand supports object while other does useful work.

The first 8 Therbligs are effective Therbligs contributing to the work. Effective Therbligs may be minimized but they cannot be eliminated. The other 9 Therbligs are ineffective Therbligs in which they should be eliminated if possible.

Manufacturing bill of material of LED bulbs

This section introduces about product. Manufacturing bill of materials shows clearly about components combining into a LED bulb as Figure 2. A LED bulb is divided into three groups which are a plastic cover, a plastic housing and an Edison screw. The plastic housing includes a heat sink with LED, a driver, two plates and four screws. The driver consists of four wires, a capacitor, a coil, a resistor and a board.

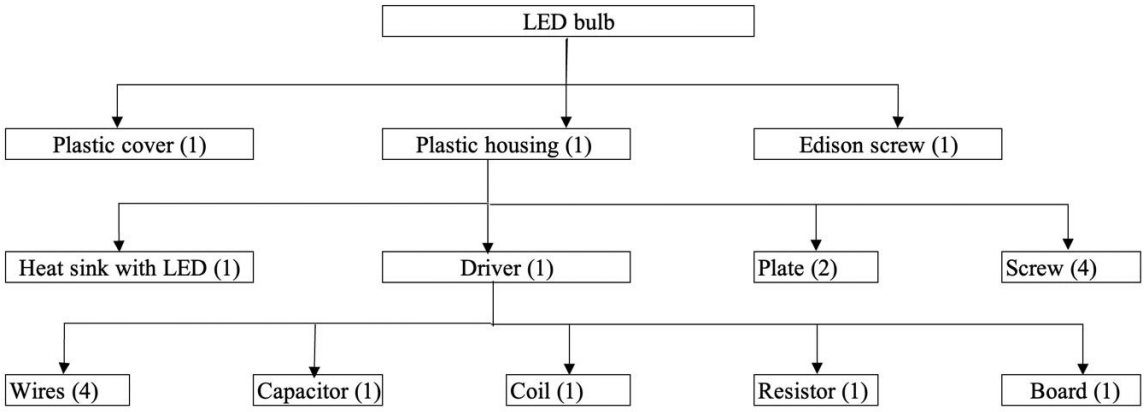


Figure 2. Manufacturing Bill of Materials of a LED bulb

Manufacturing Process of LED bulbs

There are eleven steps in order to making LED bulbs as Figure 3. Driver is assembled and then soldered before tested. The failed ones will be repaired. At the same time, name of the company is printed on housing of LED bulb. LED chips is soldered with tin. Then driver and LED chips are assembled into housing. After that, LED chips are soldered with wires. Then Edison screw is installed before testing semi-product. If any semi-product is not light, it will be reworked. Finally, plastic cover is installed.

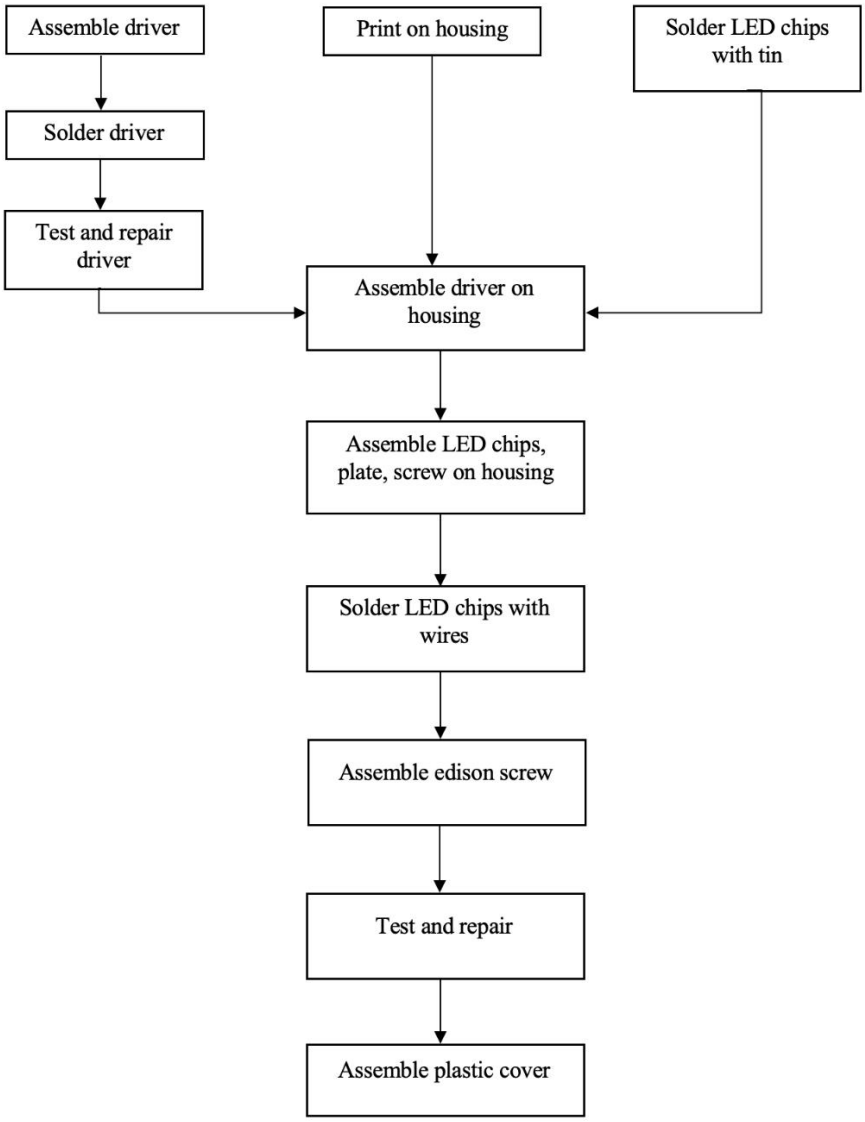


Figure 3. Manufacturing process of LED bulbs

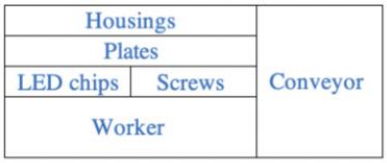
RESULT

This section presents the result of Therbligs analysis of an assembly operation by two-hand process chart. The LED chips, plate and screws are assembled into a plastic housing. Workstation consists of a table and a chair. It is located next to a conveyor. A screwdriver is used for fitting a plate to a housing. This assembly operation is filmed by a smart phone camera. Then the video recording was analyzed to see the effective and ineffective motions of two hand of worker. The result is shown as Figure 4.

Two-Hand Process Chart Page of

Operation: Assemble LED chips, plate and screws into housing	Part: XYZ	**Summary**	Left Hand / Right Hand
Operator Name and No.: Operator 7		Effective Time:	2.5 / 18
Analyst: Analyst 1	Date: 11 July	Ineffective	19 / 3.5
Method (circle choice) (*Present*) *Proposed*		Cycle Time =	21.5 seconds

Sketch:



Left Hand Description	Sym-bol	Time	Time	Sym-bol	Right Hand Description
Search housing Select housing	S SE	1			
Reach housing Grasp housing Move housing Position housing	R G M P	2	3	H	Hold screwdriver
Hold housing	H	2	2	H P RL	Hold screwdriver Position wires in housing Release wires in housing
Hold housing and plate	H	10	6	H S SE R G M P U RL	Hold screwdriver Search plate Select plate Reach plate Grasp plate Move plate Position plate Use screwdriver to push plate into housing Release plate
			4	H S SE G M P RL	Hold screwdriver Search LED chips Select LED chips Grasp LED chips Move LED chips Position LED chips Release LED chips
Hold housing, plate and LED chips	H	6	3	U M P U RL	Use screwdriver to pick screw Move screwdriver and first screw Position first screw Fitting first screw Release first screw
			3	U M P U RL	Use screwdriver to pick screw Move screwdriver and second screw Position second screw Fitting second screw Release second screw
Move part Release part on conveyor	M RL	0.5	0.5	H	Hold screwdriver

Figure 4. Two-hand process chart

Present method of assembly operation is analyzed using Therbligs. Cycle time of operation is 21.5 seconds. The ineffective motions of left hand are search, select and hold the housing in 19 seconds. The ineffective motion of the right hand is holding the screwdriver in all cycle. The position motion is ineffective motion but it is necessary.

Therefore, a suggestion for improve the current method is using fixture to hold the parts. Then the left hand will be available to do other effective motions. The second suggestion is to rearrange the workstation in order to reduce the search and select motions. It is also help to reduce time to reach and move the part.

CONCLUSION

Work analysis using Therbligs is essential for method improvement. Methods studies can help increase productivity and improve worker health and safety in manufacturing industries. This paper presented a work analysis of an assembly operation in a LED bulb assembly line. The results showed that the ineffective movements such as search, select and hold can be reduced by adding fixtures and rearranging the workstation. This study can be further developed to propose new methods. The work analysis procedure can be applied to analyze other operations in the assembly line.

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