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ANALYSIS OF AIR VALVE ASSEMBLY TECHNOLOGY

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Abstract

This article focuses on assembly technology, which is an important part of the production process. When assembling a new product, emphasis is placed on the expected speed of product assembly and the associated development of the training curve. The training curve is an event in which the value of time decreases with the number of increases in repetitions of activity over a period. This is an important indicator for planning production and the number of assembled products over a period of time. The article contains his own design and implementation of an experiment in which an air valve from Bosch. The following is an evaluation of the experiment focused on the assembly speed of one valve, from which the training curve is created. Finally, there is a comparison with the theoretical training curve based on the literature.

Keywords: Assembly technology; training curve; productivity; air valve; Bosch

1. Introduction

Assembly is a set of operations of people, machines and equipment in the assembly system, the execution of which in a specified order creates a finished product from individual components and assembly units. Assembly is an important part of the production process, where individual technical, technological, organizational, but also economic factors from previous preparation and planning meet. The importance of assembly in mechanical engineering can be described by the share in the total laboriousness of engineering products. This share is around 40% for the textile and consumer industries. In the automotive industry, this share is smaller and is around 32%. When assembling electrical equipment, the assembly can reach up to 80% of the total production workload.

The importance of assembly can also be characterized by the percentage of assembly workers to the total number of employees in the company. In the automotive industry, this value is around 40%, in the textile industry it is 30% and the consumer industry has the smallest share of assembly workers in the total number of workers, namely 20%. The values depend on several factors, such as the type and organization of production, the degree of mechanization or the design of the product. For more complex products, the share of assembly workload decreases, which is mainly due to the mechanization of assembly operations due to higher demands on accuracy, which is also related to surface quality. Assembly includes not only connecting and assembling components, but also transport, handling and possible inspection of products. [1] [3] [5] [7]

The assembly is divided into several independent phases, depending on the type of product. These phases are manual handling, coupling, inspection, positioning and disassembly, and associated reassembly. With the increasing series of assembly, the share of manual handling and joining of components increases. On the other hand, the share of position control and adjustment is reduced. This growth and decline in values is mainly influenced by the increasing level and sophistication of the production process. [1] [2] [5] [7]

The assembly activity is composed of several stages. The first stage is preparatory, in which cleaning, shape adjustment, balancing, marking, etc. are performed. The next stage is handling. This stage includes inserting, removing, inserting, setting up and moving. The next stage is the connection. In this part, screwing is performed, which is the most commonly used way of joining components, it also includes pressing, riveting, welding, soldering or gluing. The last in the series is the control stage, during which the functionality of the assembled product is measured and tested. The decisive activities in piece and small series production are preparatory and adaptation work, and adjustment, inspection and disassembly work play a significant role in the actual assembly. In total, these activities cover approximately 80% of the assembly workload. In mass and series assembly, the share of typical assembly activities, such as joining and handling, will increase, as complex assembly activities will be eliminated due to the higher sophistication of production. [1] [5] [10]

The assembly technology is an important part of the production process. When assembling new products, the expected speed of product assembly and the associated development of the training curve is taken into account. Therefore, it is a very important indicator for production planning and the number of assembled products for a given period. The learning curve is an event in which the value of time decreases with the number of increases in repetitions of activity over a period. Previously, this dependency was called the "production function." The theoretical learning curve is mathematically designed as a smooth dependence. Equation (1) is a mathematical notation for a learning curve, where Y is the time at the xth assembly, K is the assembly time of the first piece, and X is the number of assemblies supplemented by the constant A for a specific situation. [6]

$$Y = K \cdot X^{-A} \tag{1}$$

The assembly worker is usually very insecure and nervous during training. For this reason, he uses visual inspection more than a worker who is already trained. This visual inspection decreases with increasing number of repetitions. This is one of the main reasons why the curve decreases with increasing repetition. The motivation of a person is to strive for the shortest possible use of sight and to consciously reduce position control. When observing experienced employees at work, it was found that they use sight to a minimum. An operator who can look around while still working is called skilled. This fact sometimes causes difficulties for a manager who feels that such an operator is not fully focused on the activity being performed. If the operator responds to these warnings, its productivity may even decrease. [8] [9] [10]

However, the actual course of training is not a smooth dependence, see Figure 1. There are small errors that affect the resulting assembly time and thus the smoothness of the curve. Only after interpolating the real curve can we get closer to the shape of the theoretical curve. The Y-axis shows the assembly time of the measured piece or unit and the X-axis shows the number of repetitions. For short periods of time, however, the learning curve is less significant [4] [6]

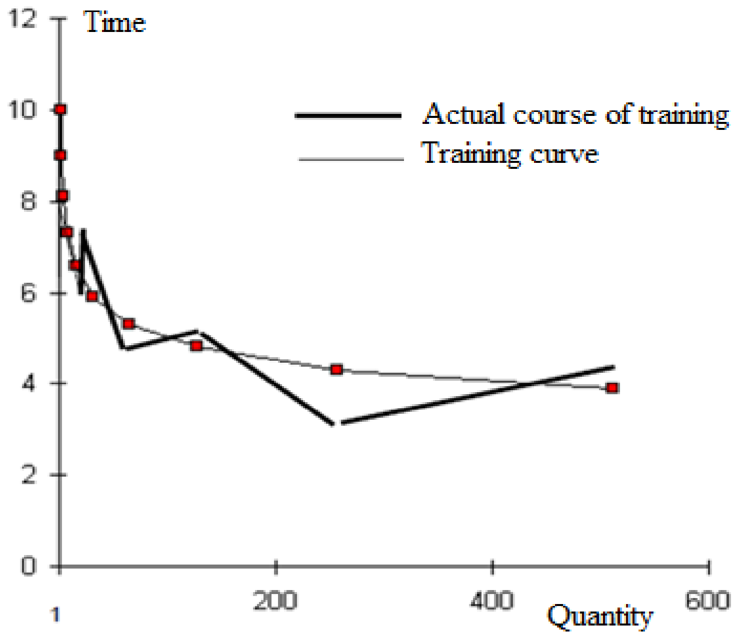

Fig. 1. – The actual process of the training curve [6]

2. Description and preparation of the experiment

The experiment was performed at the Department of Machining Technology at the University of West Bohemia in Pilsen. In the room there is a training workplace for the installation of an air valve from Bosch. An air valve is a device that regulates the air flow. The air valve consists of ten components and requires manual assembly to store them. The workplace consists of several boxes for components and a box with the main valve cover, see figure 2. There is also a hand lever on the table to help hold the valve during final assembly.

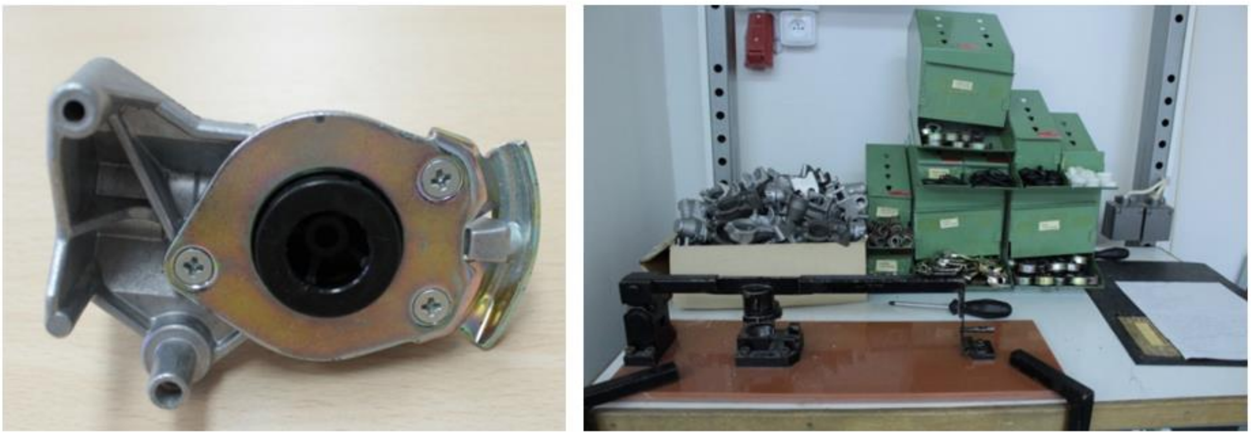

Fig. 2. – Workplace for air valve assembly

When assembling the valves, it is possible to use two assembly instructions. The first instructions are written only in writing in hand. These assembly instructions are very confusing and illegible, and in some cases more detailed descriptions would be needed to better understand the individual steps. The second assembly instructions are pictorial, supplemented by a description of the individual steps. According to the second instruction, the air valve was assembled very quickly and easily, so this procedure would be a more suitable option for employee training. Due to the fact that the labels of the containers were incorrectly marked, so without the pictures in the assembly instructions, it would be very difficult to fold the valve correctly. The workflow was no longer required to further assemble the valves, as the assembly was very easy to remember.

Aids for assembling the valve are a classic screwdriver, a mounting lever, which is already part of the work table. In addition, tools will be needed to measure and record the resulting times. An electric drill is available for faster disassembly of completed valves and a camera for photo documentation. The experiment will be performed on three consecutive days. The experiment will involve two people who will measure the final assembly time of one piece. On the first day, the operators assemble ten pieces, four times in a row with ten-minute breaks. The aim of the observation will be the time of assembling the individual pieces and observing the errors during training. On the second and third day, the operators assemble 35 pieces at once twice, with a thirty minute break. The aim of the observation will again be the individual assembly times, the observation of errors and certain shortcomings in the workplace.

3. Evaluation and result of the experiment

When assembling the first pieces, the operators often forgot about the components, looked confused and were not 100% sure if they had forgotten something during the assembly. However, this is a common practice during training. After training the operators and stabilizing their final valve assembly times, the following errors occurred. Especially on the first day of assembly, the operator forgot about the large seal that was to be put on the roller. This minor error is very fundamental in the function of the valve, which can be considered faulty. If an error is detected, the valve can of course be disassembled, the missing seal can be added and then the valve reassembled. This would be time consuming, which would have a negative effect on production efficiency and employee performance. In addition, the operator did not even notice this error in most cases.

Another error found, which often occurred in both operators, was the handling of small screws. Since half the assembly time of the valve was that the screws had to be grasped, inserted into the hole and screwed in. This offers the possibility of improvements to increase production efficiency. During handling, it sometimes happened that the screws fit into the valve when inserted into the holes. The countersunk screw then most often had to be removed with a screwdriver and re-inserted into the hole, which had a fundamental effect on the final assembly time. This problem can be easily eliminated by replacing the original screwdriver with a screwdriver with a magnetic end, which would make inserting screws much easier and faster. The last significant mistake, which occurred especially with the operator, was the incorrect placement of the face plate on the lever. When the face plate was placed incorrectly, the lever could not be pushed all the way to the table, because it did not fit the shape of the piston body. This error meant an increase of at least 15 seconds in total time.

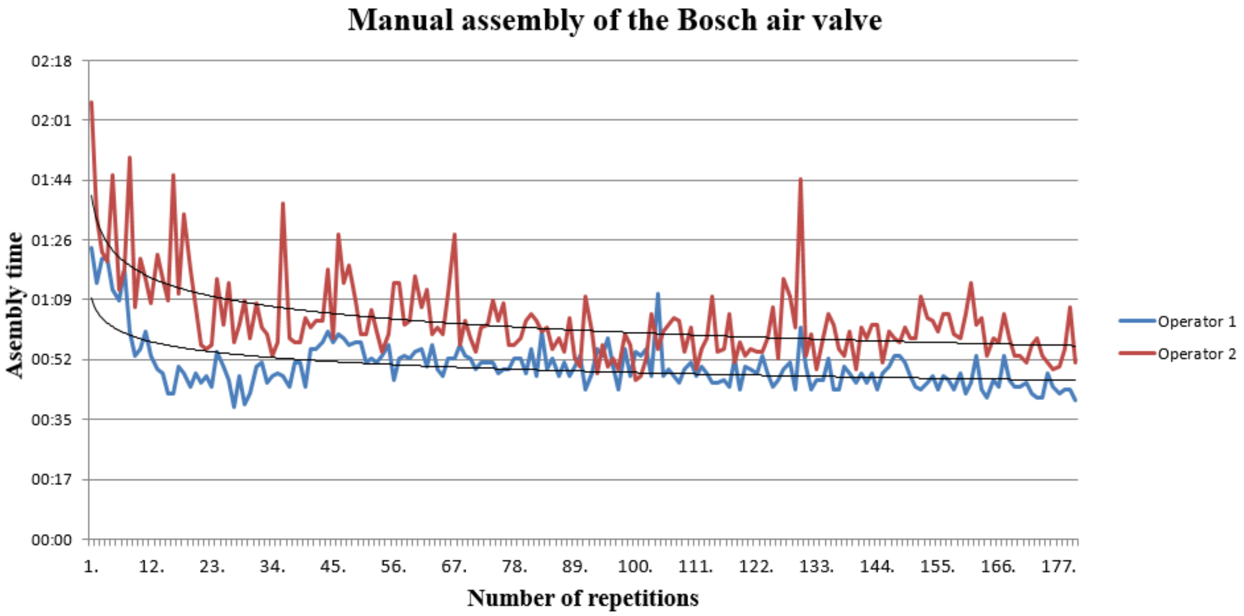

Fig. 3. Manual assembly of the Bosch ai valve

As already mentioned, the training curve is an event in which the time value decreases with the number of increases in the repetition of a certain activity per period. The graph above was compiled from the record sheet, which consists of measured time values for each assembled pieces for both assembly operators. After interleaving, this graph creates a training curve, which with its shape is very close to the theoretical curve, which is shown in Figure 1. The experiment thus confirmed the statement that with increasing number of assembled pieces, the time requirement decreases. Therefore, the training curve is a very important factor in planning the production and cycle time of assembly lines.

4. Conclusion

The paper was focused on assembly technology, which is an important part of the production process. The assembly can be final, at the end of which the product is already finished, but also continuous during the assembly of subassemblies. When assembling new products, the expected speed of product assembly and the associated development of the training curve is taken into account. A training curve is an event in which the value of time decreases with the number of increases in repetition of activity over a period of time. Therefore, it is a very important indicator for production planning and the number of assembled products for a given period.

The experiment consisted of assembling an air valve from Bosch. The workplace is located in one of the teaching laboratories of the Department of Machining Technology. The whole experiment lasted for three consecutive days. Two people took part in the assembly. The main monitored parameters were: the total time required to assemble one air valve, then the number of assembled pieces and the analysis of errors made by operators during assembly. These parameters were written into record sheets, from which graphs were subsequently made.

The aim of the evaluation of the experiment was to determine the errors during assembly, to describe the assembly workplace and to compare the resulting training curve with the theoretical training curve. The most common errors included prolonged handling of the bolts, forgetting about the component called the "big seal" and problems assembling the valve with the auxiliary lever. For operator 1, the assembly time of one valve averaged around 46 seconds after training. For operator 2, this time was higher and was around 56 seconds after training. In my opinion, the main reason for this time difference was the unsatisfactory height of the table for operator 2 with a height of 162 cm. A curve was created from the graph, which was created from the times of the individual assembled valves, which with its shape is very close to the shape of the theoretical training curve. The whole experiment proved the fact that it is important to devote the necessary time and effort when training a new employee.

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