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A NOVEL MECHATRONIC SYSTEM DEVELOPMENT FOR ROBOTIC EYEGLASS FRAMES POLISHING

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ABSTRACT

Developments in robotic systems have created opportunities for use in many different areas and developed solution systems. Especially in labor-intensive studies, with the use of robotic systems, more mass production results were obtained with less errors. Polishing is a work that requires a lot of operator experience in manual applications. It is applied in many fields such as aviation, industrial and health. Although there are advantageous aspects of current manual use due to visual adaptation, the use of robotic systems in polishing applications is increasing day by day, especially after the developments in sensor technology. In this study, a robotic system has been developed to be used in the finishing processes of glasses frames including polishing. By comparing the developed system with the results obtained with the current technology, the benefits to be obtained in the use of the developed system were determined. As a result of the study, it was determined that the developed system has the ability to perform glasses frame polishing processes with high efficiency.

Keywords: Polishing, Mechatronics, Robotics, Eyeglass frame.

I. INTRODUCTION

Polishing process is called polishing until sufficient smoothness is obtained on metal surfaces.It is a method aiming to destroy the parts forming the surface with the principle of etching.It is used in all manufacturing processes, especially mold making.This polishing requirement is sometimes only due to visual expectations. Polishing is applied in hygiene, aerodynamic smoothness, reducing friction and improving light transmission quality. Polishing is one of the last processes, which is constantly repeated especially in mass production and directly affects the market share of the product, reveals the success of all transactions made on the date of product production or, on the contrary, it is damaged. Currently, the method of application commonly used in polishing is done manually (Figure 1). In manual polishing, the process is long, qualified personnel are required and productivity is low. However, it is an important advantage of manual polishing that a problem situation that occurs or is noticed during polishing application can be solved immediately. With its human decision making structure, it can achieve the targeted situation in existing automation technologies in a very short time.

Figure 1. Examples of Polishing Manual Application

This process, which is very frequent, has a quality that depends on operator initiative, especially in manual polishing processes. Many systems have been developed in order to make polishing quality standard independent from the operator, besides special systems on the subject, CNC and robotic solution systems have also been developed. KUKA, RobotWorx, Motoman, Fanuc, ABB and Universal Robots, etc. There are robotic polishing systems developed by commercial robot manufacturers. In addition to the fact that products with a standard quality can be obtained with the use of robots in polishing, another benefit of the subject is at the point of worker health. Very fine grained metal shavings formed in the polishing process are prevented by the employee to be taken into the body by respiratory tract and important health problems (pneumoconiosis formation, etc.) that will occur in time are prevented. In addition, the high level of noise generated in the workplace appears to be another health problem for the employee, while minimizing this problem with the robotic polishing process. The development of a robotic polishing system suitable for mass production also saves energy and the amount of work per unit time increases. Another important achievement is; It is realized with the profit provided by keeping the product recycling to a minimum.

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Mohammad, A.E.K., and his colleagues, who carried out a study on polishing process, gave information about electrochemical mechanic (ECM) polishing processes, explained their application principles and gave information about their active parameters. In addition, the authors proposed different and new configurations about the installation of robotic ECM polishing systems [1].

In their study, Kalt, E., and colleagues identified the needs for automatic polishing processes. In collaboration with industrial partners, a mechatronics-based device has been developed to accurately identify and analyze operational variables such as force, torque, vibration, polishing pattern and feed rates. This article also carried out a series of experiments to define the polishing parameters that a manual operator controls through tactile and visual detection [2]. They determined the effective factors in terms of the worker (1), the workpiece (2) and the system (3) in manual polishing. In the light of these determinations, the visual given in Figure 2 was created.

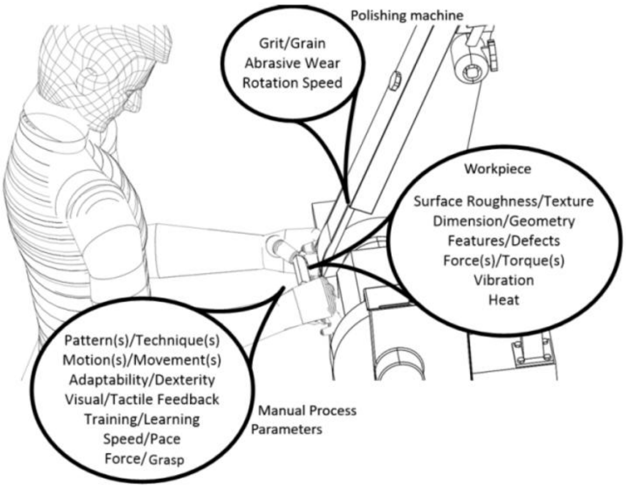

Figure 2. Manual Polishing Application and Factors [2]

The purpose of the polishing process; To make the correction that will make the surface with maximum quality in terms of roughness and aesthetics by taking the least amount of material. In the polishing process that takes place mechanically, a thin layer of material is removed by means of abrasive tools to reduce the surface roughness to the desired level. Smoothing the surfaces; occurs by removing scratches, machining marks, pits and other imperfections to achieve a smooth surface roughness across the part surface [3-5]. Polishing is very important for minimizing friction on mechanical components in areas such as aviation, medicine and precision machinery production. Otherwise, the targets set during the design phase will not be achieved as a result of production.

Surface roughness is vital in ensuring flow smoothness, especially in areas where liquids such as aviation are used. With the surface quality obtained as a result of polishing, friction is reduced, the effects of aerodynamic deterioration are reduced, and therefore the probability of the problem and malfunction in the process is minimized and the life of the products is extended. Studies have been conducted to determine the effects of polishing on turbine blades results [6-7]. The use of industrial robots in polishing is also widely used today. Chotiprayanakul, P. et al. In their work, they conducted research on the use of polishing robots and identified platform requirements [8].

In this study, a mechatronic system that includes a robotic polishing system to be used in eyeglass frame finishing processes has been developed and the solutions and contributions to the process have been examined.

II. MATERIALS AND METHODS

Metal eyeglass frames usually have a labor-intensive production process; after the whole production process; It takes the form of the final product by going through milling, deburring, rounding and polishing processes. The most difficult, time consuming, personalized and pollutant amount of these steps is polishing. This process should be saved from being dependent on workers and high waste rate. When the polishing process is at the discretion of the staff; the worker may not shine the product to the desired level. It may forget to polish some areas, the worker may have vision problems and may prevent them from seeing problems in this polishing process. In this case, it is not possible to obtain the desired quality. Also, depending on the staff, polishing takes a long time and is an important part of the total production process. In addition, regional wear occurs intensely due to the continuous use of the same area of the polishing felts. This result is that the employee uses his choice as easily as possible. This not only shortens the life of polishing felts, but also reduces polishing quality. Due to the use of polishing felts in variable positions and performing this movement independently of the operator, regional wear may occur at a minimum.

In this study, a mechatronic structure, which is formed by combining 5 different system elements, has been developed. 1st system unit; It is an image acquisition and processing unit that detects the current spectacle frame model and modifies the next stage operations according to the differences between the current curve data and what it should be. In the second unit, burrs of the in-frame channels are taken. In the third unit, there is a polishing drum. Unit 4 has a holder attached to the frame model. System element 5 is the robot. Visual system of this system is given in Figure 3, detailed pictures and operation steps of the units of the system are given in Figure 4.

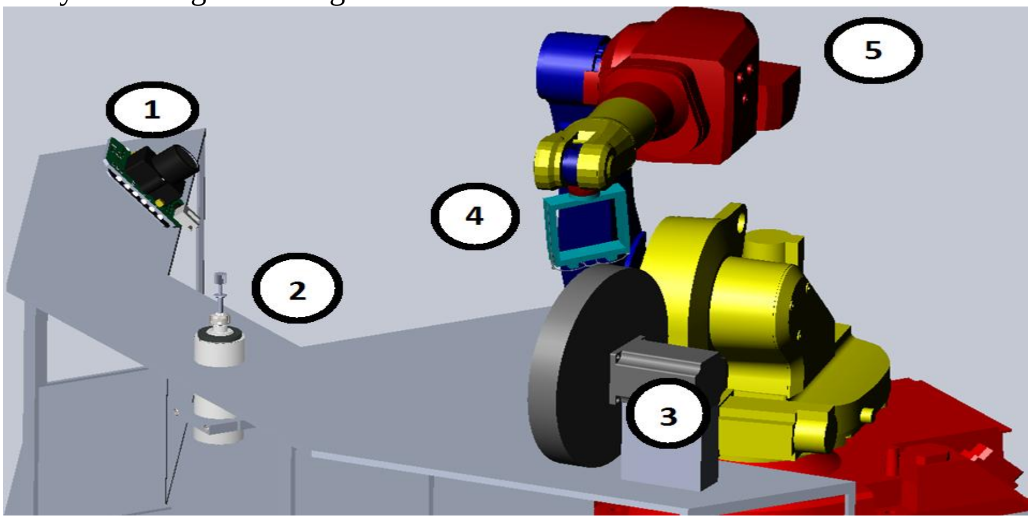

Figure 3. Robotic Finisher Unit (1: Image processing unit, 2: Deburring unit, 3: Polishing unit, 4: Eyeglass frameholding apparatus, 5: Robot)

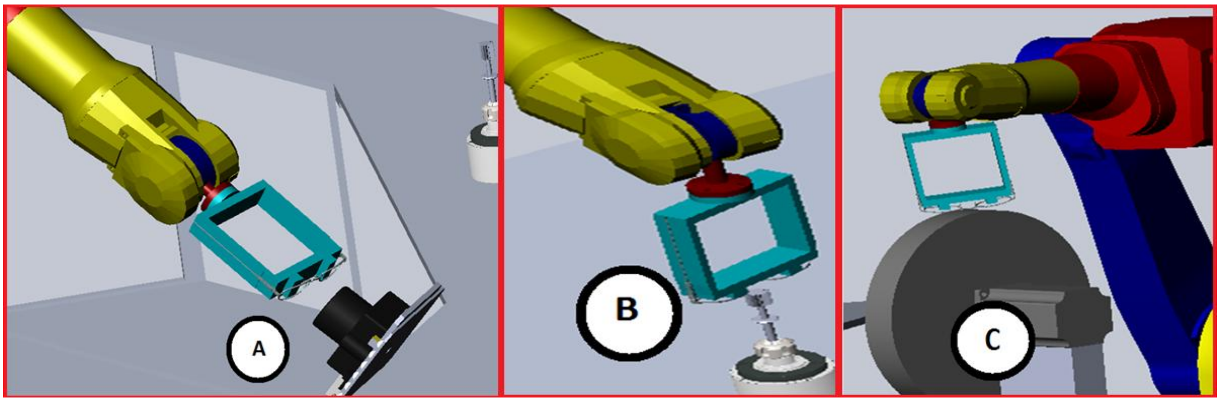

Figure 4. Robotic Finisher Unit Process Steps (A. Image Processing, B: Deburring, C: Polishing)

Within the scope of the study, 3 operations are performed sequentially. The entire process, which takes place in unhealthy conditions for employees, with many employees at many stations, turns into a reliable structure with the developed system.The results of using a robotic system instead of workers who are highly experienced in manual use and whose response times are very short due to their visual advantages are given in Table 1. The average polishing time and current losses realized by the current employee were taken as basis in the creation of these data. As the comparison data, not the robot catalog values, the maximum speeds that can be reached in the polishing process are determined as the experience value. Studies on the experimental phase of the study will be carried out in the following stage.

Table 1. Comparison of Robotic and Manual Polishing

<table>
<tr><th></th><th>Occupational Health</th><th>Problem Detection and Response Speed</th><th>Standard Quality</th><th>Waste Rate</th><th>Reduced Waste Rate in Robotic Polishing</th><th>Production Increase in Robotic Polishing</th></tr>
<tr><td>Manual Polishing</td><td>-</td><td>+</td><td>-</td><td>-</td><td rowspan="2">%20</td><td rowspan="2">%20</td></tr>
<tr><td>Robotic Polishing</td><td>+</td><td>-</td><td>+</td><td>+</td></tr>
</table>

The data used in Table 1. are the values determined as a result of the examinations carried out with the practitioners who have gained a long experience in the field of glasses manufacturing. Catalog values cannot be used directly when comparing robotic polishing with manual polishing. Because there is a difference between the speed that should be applied in the polishing process and the speed of the robots can be reached.The high speed capacity of the robot can not to be applied during the process. Because, a adjusted force must be applied on the frame during the process, the material must not be broken, its geometry must not be distorted, and polishing must be performed with movements suitable for its geometry.For this reason, the earnings that can be obtained are restricted and the value of earnings that we encounter in almost all results is reached. This value is 20%.

III. RESULTS AND DISCUSSIONS

In this study, a robotic application system has been developed for polishing eyeglass frames. This system also includes the image processing module, which determines which of the existing frames will be applied, its geometric data and the differences between what it should be. The deburring milling module that should be done before polishing is located on the system. Polishing takes place as a finishing process. Thanks to the realization of the work with the robotic system, it has been determined that the worker health problems, time, waste and return processes are reduced and contribute to the production of standard quality. In robotic polishing, which is still under development and presented within the scope of this study, it is a clear result that the eyeglass frames from the production will not be exactly the same and the decision making structure must be defined very carefully due to the differences that will occur. In the later stages of the study, it is necessary to provide image processing and analysis infrastructure to detect product differences in order to overcome these problems.

ACKNOWLEDGEMENT

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