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Development of a gripper for handling and assembly of microscrews

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Abstract

This paper presents the development and design of a gripping tool, able to perform both handling and assembly of microscrews. The gripping tool presented here is a vacuum based gripper interacted with an automatic screwdriver. This construction is used in the handling and assembly of microscrews.

1 Introduction

Handling and assembly is facing new problems when entering the micro world. In particular downscaling affects the force equilibrium [1]. Furthermore three-dimensional geometries increase the complexity of handling and assembly processes of micro components [2]. Screws are used in the medical devices production (e.g. hearing aid components) as one of the simplest fastening components. However a microscrew represents a series of challenges connected to its three-dimensional geometry. Today such screwing operations are usually performed in semi-automated production lines requiring the interaction of manual labour. Therefore automation of the handling and assembly process would be economically beneficial. The developed gripping and screwing device allows the creation of a fully automated handling and assembly process which is an issue of the great interest of European industry, as it overcomes most of the problems related to the microscale.

2 Development of the gripping and screwing device

Microscrews need to be handled and assembled in a controlled manner. The microscrews used in this work have a length of 1.2 mm long (figure 1a) and a thread with an inner diameter of 0.35 mm and outer diameter of 0.5 mm. The weight of the screw is about 0.04 g. To establish a secure connection between the gripper and the screw, a vacuum principle was proposed for picking up the screws. The screwing device was driven by a motor mounted inside the screwdriver. In order to select the correct motor, it was necessary to determine the torque of the screwing operation. The torque to be applied is dependent on the application, joint parts and the maximum rating of the screws [3]. The screwdriver was moved up and down by gearings between the motor and the screwdriver, corresponding to the pitch of the screw. Construction of the screwdriver (figure 1b): 1- the lid, 2- the motor, 3- body of the screwdriver, 4- the screwdriver, 5- vacuum connection, 6- the microscrew.

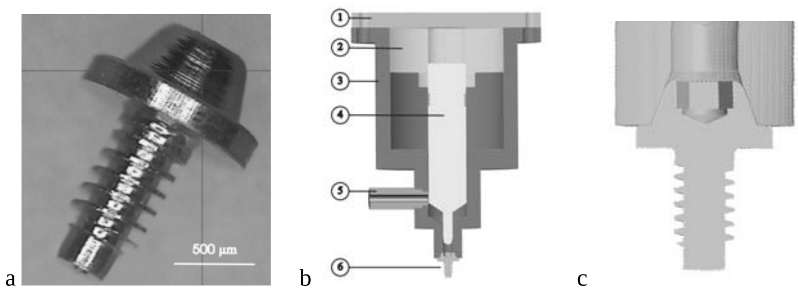


Figure 1: a – microscrew, b - sketch of the screwdriver, c - vacuum tube and the screw connection

3 Selection of Vacuum Principle

Vacuum was selected as the most promising method to pick up the screws from the workplace [2]. The required amount of vacuum was calculated considering the surface area in the contact between the screw head and the tube of the screwdriver. The calculated contact area was smaller than 1 mm^2 and the needed air pressure was found to be 0.2 bars.

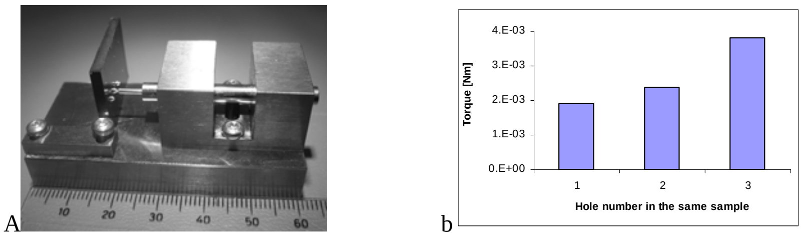
The design of the contact section between the microscrew and the screwdriver was made according to the dimensions and geometry of the screw head (figure 1c). With this design, the screw can be picked up and oriented correctly towards the substrate.

A vacuum pump was connected to the tip of the device. A modified needle, with an inner diameter of less than 1mm was used as tip. The microscrews were placed in a perforated plate, with holes having a diameter of 0.6 mm. This setup was used to pick the microscrews from the plate and test if the amount of vacuum was enough to manipulate the microscrews. The tests were successful.

4 Torque measurement

For microscrews there was no torque data available. The torque data was needed in order to select the proper motor and the gearings. Special testing equipment (figure 2a) was designed and manufactured in order to measure the torque for the particular microscrews [4]. The plastic specimens for the torque measurements were injection moulded in POM (Ticona, Hostaform C9021) and then cut into 20x30 mm^2 pieces. In each specimen three holes were drilled with the diameter of 0.4 mm.

In order to manipulate the screws, a screwdriver that fits the screws was manufactured. The end of the shaft was machined by means of a micro EDM milling machine in order to get the final shape of the screwdriver. As screwdrivers are not commercially available for microscrews and since there is no data available, experimental investigations were necessary in order to find the right dimensions for the hexagonal shaped tip of the screwdriver. The dimension (inner diameter) of the hexagonal shaped screwdriver tip was found to be 0.4 mm.

A 

b

Figure 2: a - the picture of the torque measurement device, b –the results for torque measurements in POM

The procedure of measurement was the following: a microscrew was placed manually on the tip of the screwdriver, a plastic specimen was placed and the screw was screwed manually by two revolutions. This step was necessary in order to ensure that the screw had entered the plastic specimen. In order to measure the torque, a force was applied on the shaft. The force was applied using a system with weights and counter-weights that are hung in a wire rolled around the shaft. In order to avoid that the wire slipped, it was turned five times around the shaft. At both ends of the wire a preload of 0.014 kg was used. At one end of the wire the load was always the same, while on the other one it was increased during the experiment. Thus it was possible to find the point where the shaft starts moving and the microscrew was starting to cut the plastic. The torque can easily be calculated from the mass of the weights. The mean value for the torque was found to be $1.9x10^{-3}$ Nm, $2.4x10^{-3}$ Nm and $3.8x10^{-3}$ Nm respectively to the holes nr.1, nr.2 and nr.3 (figure 2b). The torque of the system itself (coming from internal friction in bearings) was determined to be about $0.4x10^{-3}$ Nm. The torque was compared to the standard ISO metric screws [3] downscaled torque (about $5x10^{-3}$ Nm). It was found that the two torques were comparable.

Conclusions

This paper describes the development and design of a gripping tool, able to perform both handling and assembly of microscrews. A device for measuring the torque was successfully designed and manufactured. The torque for the microscrews was found to be comparable to the downscaled ISO metric screw standard data.

Acknowledgement

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