Evaluation of a UV-activated Adhesive Chuck for Double Sided Machining

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Abstract

To ensure precision handling and flipping of a work piece to enable double side machining, a new technique was developed at KULeuven. This technique involves a UV-activated adhesive gripper with exchangeable gripping pins and a System3R MatrixNano interface. The proposed technique allows flipping of a work piece on a machine table with the high accuracy. The involved gripping system also allows clamping of a work piece on a finished side without damaging the surface even for very sensitive applications such as glass work pieces.

1 UV-activated gripper

In this section the clamping mechanism used in the proposed flipping procedure will be discussed. The clamping system consists of the UV-activated adhesive gripper which is integrated into the System3R interface (Figure1). The advantage of using System 3R MacroNano chuck-pallet system is it high accuracy and repeatability on relocation of a chuck on a pallet.

For handling freeform and complex shaped surfaces, such as a micro lens array, the adhesive chuck comprises a set of exchangeable gripping (gluing) pins, which are fixed on the gripper in collets. An adhesive drop fills the gap between clamping surface on the work piece and each of the gripping pins. The UV-light is then applied to cure the adhesive drops, whereby the work piece is clamped on the gripping pins. To fit the surface curvature the height of the gripping pins can be adjusted; the minor variations on the surface can be compensated by the thickness of the adhesive layer.

The selection of the adhesives becomes an important factor in the proposed design. The adhesive bond must guarantee the high gripping force and stiffness in the system. It should not damage the surface of the work piece and should be easy to remove.

Therefore, some experiments have been carried out to investigate the curing behavior and the strength of the adhesives [1].

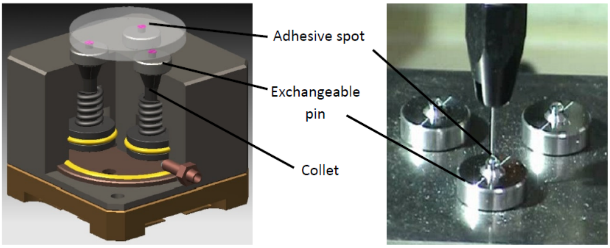

Figure 1: UV-activated gripper fixed on the System3R pallet

During the experiment it was discovered that the total stiffness of the system with 3 pins can be up to 50 N/µm and maximum gripping force per each independent pin can reach 100 N. In the preliminary tests, it has been concluded that no obvious damage is introduced on the lens surface after applying UV-curable adhesive [2].

2 Flipping concept of a work piece with the UV-activated gripper

In this chapter we will discuss an approach how the UV-activated gripper can be used for flipping of the work piece on a machine table (Figure 2).

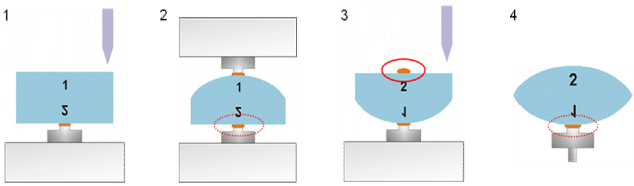

Figure 2: Concept of work pieces flipping

Step 1: The work piece with sides 1 and 2 is fixed on the UV-activated adhesive gripper. A tool is approaching and machines side 1 of the work piece.

Step 2: The second UV-activated adhesive gripper clamps the work piece on the machined side 1. Side 2 of the work piece is released from the first gripper by means of heat [3]. The second upper gripper together with the System 3R interface is realized from the clamp, flipped and mounted on a machine table.

Step 3. Side 2 of the work piece is ready for the machining. The debris of adhesive will be removed during cutting.

Step 4. Side 2 of the gripper is machined. The work piece with the glued gripper pins is removed from the gripper. The work piece can be released from the pin by means of solvents [3].

3 Machining test

To test proposed technique number of machining test were conducted. The machining test was performed on a KERN MMP micro-milling machine with a 2-teeth milling tool of 2 mm in diameter. The cutting parameters were: spindle speed 30000 rpm, feed rate 400 mm/min, depth of cut 50 µm. For this experiment an aluminum disk with a thickness of 10 mm and 50 mm in diameter was used as a work piece.

In the first part of the experiments the performance of the UV-activated adhesive gripper was compared with a conventionally used clamping system. After the machining both surfaces were measured with a Taylor Hobson profilometer. The result of these measurements showed that the Ra of the work piece clamped on the UV-activated gripper was a half of the Ra of the work piece clamped on the standard chuck: 0.06 and 0.112 µm respectively.

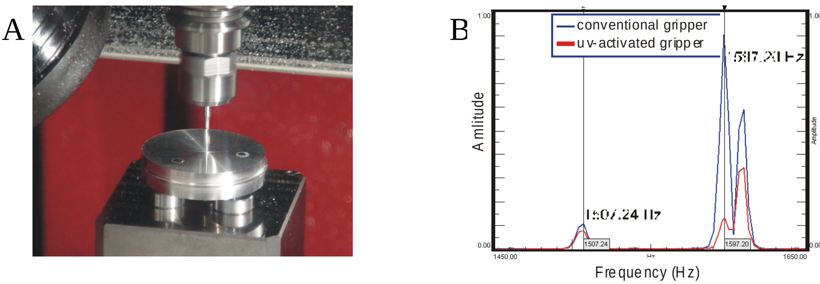

Figure 3: A. Micro-milling test on aluminium work piece; B. Modal analysis tests for the UV-activated and conventional gripper.

To investigate this phenomenon, the dynamic behaviour of the gripping system was examined (Figure 3 B). The improved cutting performance can be explained by an increased damping of the UV-activated gripper in comparison with the conventional one. This is consistent with other research demonstrating that adding damping improves the overall machining performance [4].

The developed flipping method was also tested on a Kern MMP micro-milling machine for the double sided machining of an aluminum work piece (Figure 3 A). The work piece was monitored during the machining by means of accelerometers and capacitive sensors. After machining the quality of the machined surface was investigated and compared. Performed machining test shows a very good correspondence between two surfaces. The Ra value for both surfaces is approximately 0.06 µm. Data received with the capacitive probes shows that during the flipping operation position of the work piece can be kept accurate within 0.4 µm. This misalignment will mainly occur due to the shrinkage of the adhesive during the curing process [2].

4 Conclusions

The primary objective of this research was to develop the procedure of flipping the work piece with the high quality finished surface for its machining. The proposed technique for double side machining of a component was examined, the performed machining test showed very good results in cutting and flipping of the work pieces. These allow us to state that presented flipping system can be successfully used in a production of free form optical components. It also can be used in any other application where flipping or tilting of the component with high accuracy is required.

Acknowledgements

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