On Performance of a UV-Adhesive Gripper

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Abstract

To avoid hard mechanical contact on finished workpiece surface, a method for clamping on optical surface is developed based on UV-curable adhesives. Grippers based on such a holding mechanism have been built up and their performance is tested. Experiments have shown sufficient stiffness with certain adhesives and the adhesive shrinkage can be alleviated by mixing additives in the adhesives.

1 Introduction

With the emerging of high performance requirements in optical system, complex optical parts with multiple freeform surfaces on one component have been proposed. It is foreseeable that clamping on finished precision surface will be unavoidable, thus fixing and handling such kind of components for precision manufacturing is putting forward new challenges to the industry. In the case of clamping on finished optical surfaces, it is desirable to avoid direct strong physical contact between the workpiece and the fixture in order to reduce the risk of damaging the delicate surface. Therefore, a gripping mechanism based on UV-curable adhesives has been developed at Katholieke Universiteit Leuven.

2 Design of a UV-adhesive gripper

Figure 1 shows the developed adhesive gripper fixed on a pallet of an industrial standard chucking unit. Once the workpiece is fixed, it can be transported throughout the process chain when measurement on a CMM or machining on another machine is required. To accommodate a freeform shape, the workpiece is held on three gripping studs (~3mm in diameter). These studs are kept in position in collets and they are pretensioned by springs. The studs can be released pneumatically. To fix a workpiece, a small volume of UV-adhesive are supplied on those gripping studs; then the workpiece is brought close to them till a predefined small distance; finally a UV-light source is applied to cure the adhesive, whereby fixing the workpiece for following manufacturing process. The curing process lasts for about 15 seconds.

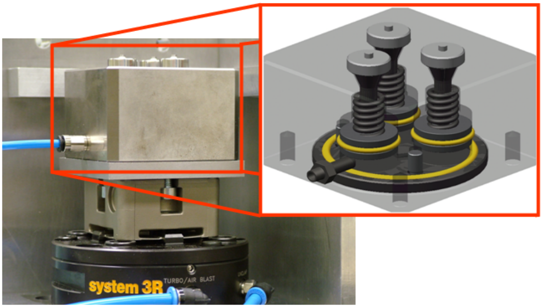

Figure 1: Mirror mechanism with a spider

3 Evaluation of gripper performance

The selection of the adhesives is an important factor in the proposed design. The adhesive bond must guarantee a high gripping force and a high stiffness in the system. Therefore, experiments on a test rig have been carried out to investigate the curing behaviour and the strength of different adhesives. Afterwards, the performance of the gripper with different adhesives and the feasibility of workpiece flipping for multifacet machining are further investigated.

3.1 Properties of adhesives and effects of additives

To investigate the effect of applied adhesives on the workpiece surface, experiments have been conducted on a glass lens. Two adhesives of different viscosities were preselected to be used in the experiments. In the second part of the experiment, the adhesives are mixed with micro glass beads (diameter of 200 µm, volume density of 10%). This modification is made in order to achieve the minimisation of the adhesive shrinkage. The parameters used during the measurements are: adhesive gap - 100 µm; contact spot radius - 2mm; amount of adhesive - 1,25 µl; curing time - 10 seconds.

As shown in Table 1, the pull-off force, stiffness and curing shrinkage of different adhesives vary in a large range. In general, it is possible to obtain the desired bonding force and to minimise the shrinkage by increasing the contact area of the gripper and decreasing the adhesive gap. It is reasonable to use several gripping pins to have sufficient strength to support a work piece of big mass. Low values of the adhesive shrinkage (1-5%) will cause the dislocation of the work piece from 1 to 5 µm. But as far as this value is repeatable the error can be corrected and will not have big influence on the system's accuracy. The mixing of the glass beads into the adhesive solution has a few positive consequences: improvement of the stiffness of the adhesive joint and decrease of the adhesive linear shrinkage (less than 1%).

Table 1: Adhesive properties and effects of additives

	Viscosity	Gripping force (N)	Stiffness (N/µm)	Shrinkage (%)		Gripping force (N)	Stiffness (N/µm)	Shrinkage (%)
Dymax 620	0.7 Pa*s	96.6	19.37	4.6	**Dymax 620** with glass beads	67.4	35.4	0.85
	3.5 Pa*s	98.8	20.15	5.1		71.1	37.4	0.95
	25 Pa*s	98.2	20	4.3		68.4	35.6	0.96
Dymax 621	0.8 Pa*s	97.4	18.53	0.6	**Dymax 621** with glass beads	63.4	34.4	0.2
	3.5 Pa*s	98.3	20.62	0.5		67.3	35.7	0.3
	25 Pa*s	99.4	21.53	0.7		68.5	36.1	0.2

3.2 Stiffness of UV-adhesive gripper with three studs

The stiffness of the gripper with different adhesives is experimentally investigated on a machine as shown in Figure 2. Three capacitive sensors are used to monitor the movement of the workpiece in vertical direction. A glass block is used as workpiece and metallic shims are attached to its edge as sensor target.

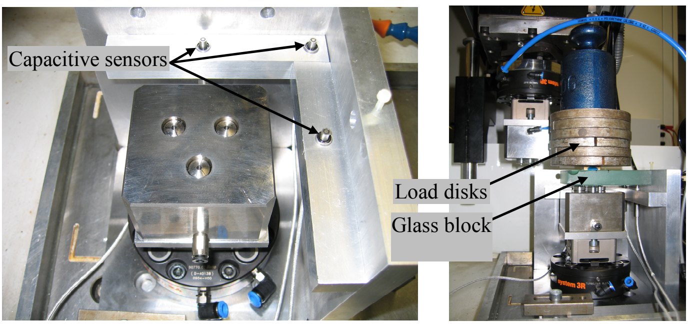

Figure 2: Experiment setup for gripper performance

In the experiments, the diameter of the studs is 3 mm and the adhesive gap is 0.3mm. Known mass disks are put on the glass block each by each as load. The movement of the workpiece is an average reading of the capacitive sensors for 2 seconds, and a linear fitting of these measurements results in the stiffness value (Figure 3).

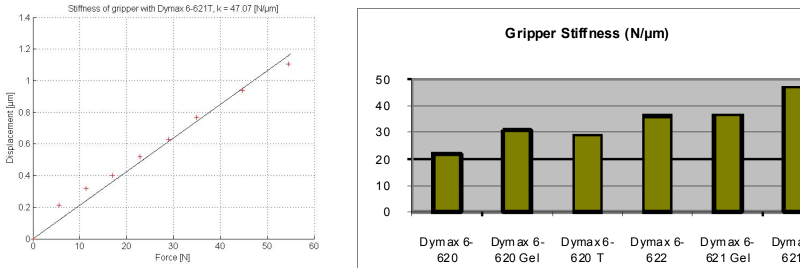

Figure 3: Gripper stiffness with different adhesives

3.3 Workpiece flipping with UV-adhesive grippers

To simulate the workpiece flipping operation in double-side machining, a glass block is first brought to and clamped on one gripper. Then the workpiece together with the gripper is flipped and put back on the machine. A second gripper with adhesive on its studs moves to the workpiece with a 0.3mm gap and UV-light is then applied to the gap for 20 seconds. During this curing period, the workpiece fixed on the first gripper moves about 0.3μm due to the shrinkage of the adhesive on the second gripper.

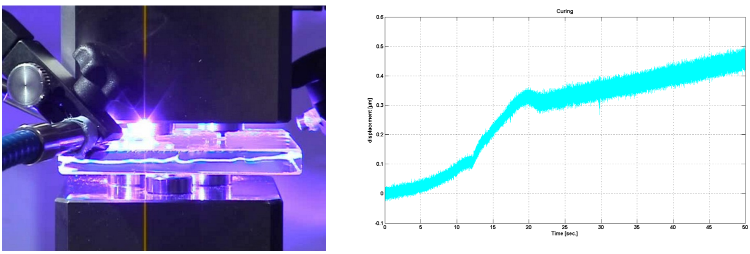

Figure 4: Workpiece movement during UV-curing

4 Conclusions

A UV-adhesive gripping mechanism has been developed and the performance of grippers has been tested. The stiffness with 3 studs can be up to about 50N/µm, and the position of the workpiece during flipping operation can be kept within 0.5 µm.

Acknowledgements

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References:

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