Study on Forming of Friction Stir Drilling Bushing with PLA Sheets

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Abstract

This study discusses the formation of bushings with the friction stir drilling on Polylactic Acid sheets. The results show that when tool rotation speed increases, the extrusion force and torque become smaller, but the formed bushing exhibits an irregular petal-like appearance. Higher drilling feeding rate is the key to bushing forming. The faster feeding rate, the bushing will appear thin and long. The lower feeding rate, the bushing will appear fat and short, and the tail end will break easily. These results are used to improve methods of producing fastening screw holes in hollow structural 3D products..

Research Methods

To study the drilling parameters of PLA sheet formation bushing during the FSD process, the friction stir welding and drilling tester with the measurement system [10] used in this study, as shown in Figure 1. The torque meter is mounted on the rotating spindle, the vice and load are stacked and assembled on an X-Y moving table, and the tool/plate temperature is recorded via an infrared camera. Therefore, the downward force, drilling torque, and temperature of the tool/sheet during the drilling process can be measured, and their signals are recorded by the data acquisition system, and then fed into a personal computer for data analysis. The FSD process can roughly be divided into two stages shown in Figure 3, and the points *a* to *f* represent the tool drilling depth on sheet position respectively. First stage occurs at the tool tip touch the upper surface of the specimen to the tool end leaving the lower surface of specimen. Second stage is the tool pull off and far away to the specimen. These drilling behaviours affect force, torque, and temperature that strongly related to the formability of the bushing

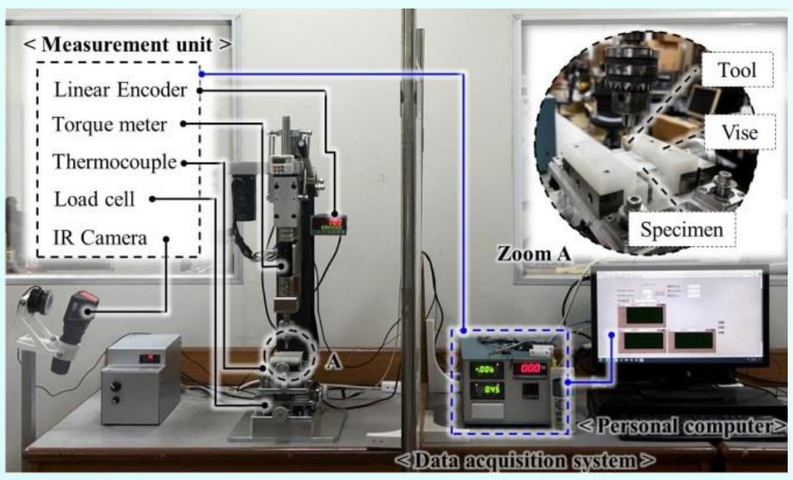

Fig. 1 Schematic diagram of the drilling tester with the measuring systems

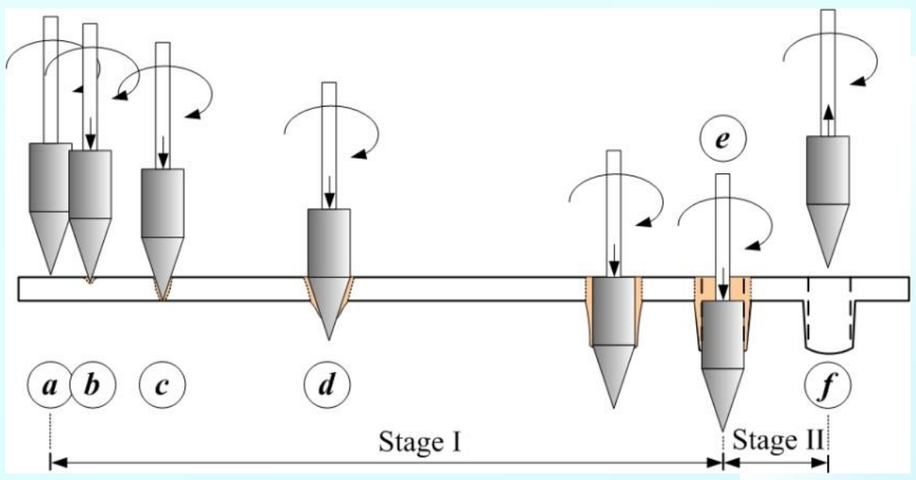

Fig. 3 The appearance of FSD process

Results and Discussion

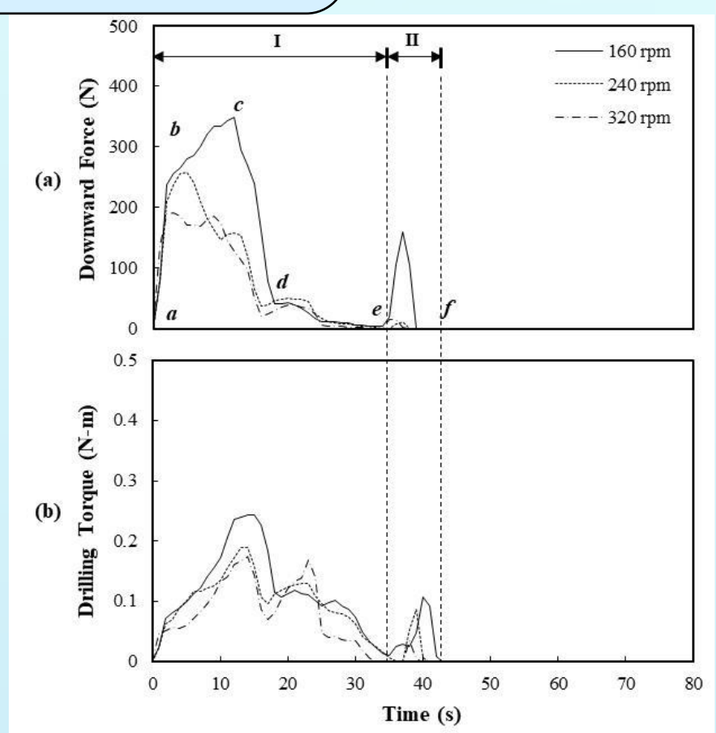

Figure 4. Time histories of the (a) downward force and (b) drilling torque under feeding rate of 0.41 mm/s and different rotating speed of 160, 240 and 360 rpm.

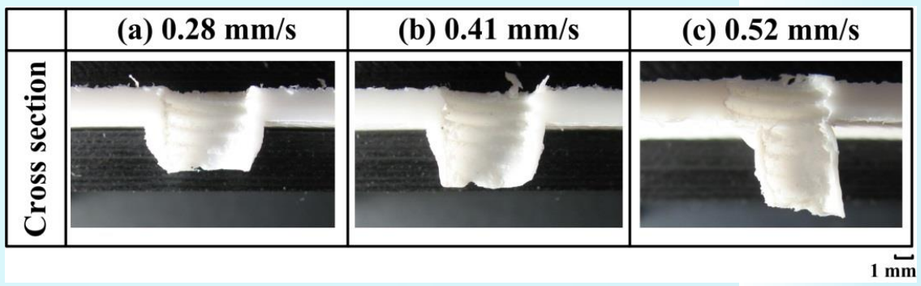

Figure 9. The cross-section of the bushing with m6 tapping holes under a rotating speed of 160 rpm and different feeding rates of (a) 0.28, (b) 0.41, and (c) 0.52 mm/s.

Conclusions

This study uses metal tools to generate bushings on PLA sheets using FSD as holes for fastening screws. The experimental results show: (1) The drilling torque continued to increase as the downward force decreased during the drilling process, indicating that the tool cone area brought more specimen material and moved downward to form the bushing. (2) At a high rotating speed, the bushing is incomplete whenever at different feeding rates, because the velocity of the inner and outer material of the bushing is big different, causing constant cutting and re-bridging causing internal damage and delamination. (3) At lower rotating, the bushing becomes complete and regular. The maximum length of the bushing increases significantly with increasing the feeding rate and appears longer and thinner, and it decreases obviously with decreasing the feeding rate and appears shorter and thicker. (4) The diameter of the bushing decreases with increasing feed rate and decreases along the length of the bushing, which affects the wall thickness of the bushing. Since the bushing ends have the smallest diameter and thinnest walls, longer bushings cannot create effective threads across the entire bushing. The screw-locking strength of these threaded bushing holes will be discussed later.

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