ABSTRACT

A right angle experimental mold is employed for anisothermal stamp forming of continuous CF/PP composites. Results about the effect of stamping time on the part shape, fiber movement at the bend range and mechanical behaviour of the part are presented. Experimental results showed that (a) a useful stamping time was 15 seconds, (b) fiber movement at the exterior bend range was much more intensive than that at the interior bend range, and (c) two modes of failure—transverse matrix cracking and interlaminar delamination—were observed.

INTRODUCTION

In a previous investigation /1/, a right angle tool was employed for experimentally studying of the anisothermal stamp forming of CF/PP composites. Optimum processing conditions, such as stamping temperature, stamping velocity and pressure in relation to the properties of stamped parts were determined. It is very important to further develop the advantage of the short cycle processing time of this technique and to determine the fiber waviness induced during the stamp forming from a flat layup. These and other issues, e.g. concerning the effect of stamping time on the springback phenomenon of the stamped bend part are content of the present study. Fiber movement at bend range were investigated with Cu tracer wires embedded in preconsolidated laminate samples. Finally, the mechanical behavior of stamped parts was studied by bending tests.
EXPERIMENTAL

The material used in this study is continuous carbon fiber (AS4) reinforced polypropylene prepreg with approximately 20% fiber volume fraction, known as PLYTRON, manufactured by ICI, U.K. The experimental set-up is shown in Fig. 1. The manufacturing process of preconsolidated flat laminates and the stamp processing conditions are explained in detail in reference /1/.

Cu tracer wires of diameter 0.063 mm were placed in the preconsolidated flat laminate with a lateral distance of 2.5 mm between each other prior to stamp forming. The stamped bend with Cu tracer wires was studied by X-ray analysis. Mechanical behavior of the bend samples is performed on a bending test set-up, as shown in Fig. 2. The test velocity is 5 mm/min.

RESULTS AND DISCUSSIONS

Effect of stamping time on part shape

Final part angles as a function of stamping time under two levels of stamping pressure are shown in Fig. 3. All angles are smaller than the actual angle given by the forming tool. In fact, it is well known that laminates exhibit a phenomenon referred to as "reverse springback" after forming. The extent of springback is mainly dependent on the applied time of loading. Further, the final part angle will be influenced by two factors, i.e. the wrinkling of fiber in the bend range /2/ and the thermal properties of the composite /3/. It should be noted, in addition, that shorter stamping times result in more irregular cross sections of the bend sides (Fig. 4). This effect leads to more extensive waviness of fibers and should therefore result in a further reduction of the part angle. As stamping time is above 15 seconds, the final part angle approaches a constant value. Under this condition, a higher stamping pressure causes more transverse flow of matrix between the fibers which seems to result in a greater movement of fibers near the bend region, thus giving birth to smaller final part angle.

Fiber alignment at bend range

By X-ray analysis of bend laminates with tracer wires, the Cu absorb more of the radiat waves and thus appears as dark lines on the film. Comparing with the original flat laminate, the variation of distance between Cu tracer wires at bend range give a qualitative idea of fiber misalignment during processing. A typical histogram for distance distribution of Cu tracer wires at the exterior bend range is shown in Fig. 5. The abscissa indicates the distance between the fibers and the ordinate.