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The mold-less casting technique for applying to auto mobile parts

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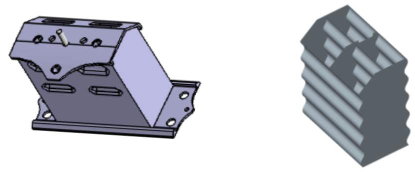
This paper deals with a newly-developed “mold-less casting technique” which permits high design freedom of aluminum alloy components. Some automotive parts e.g. a crash absorption component and a side frame, which are typically made of wrought aluminum alloys were fabricated by the mold-less casting technique. The crash absorption component with a wavy design fabricated by this process showed high absorption energy per unit weight.

Keywords: *Wrought aluminum alloys, Complex geometry, Capillary shaping, , Strength, Automotive components*

1. Introduction

The mold-less casting is one of the capillary shaping technique by which complex shaped aluminum products can be fabricated from an aluminum alloy melt. In this technique, a starting device is immersed into the melt through an opening of a shaper located on the melt surface. Then, the shaper is withdrawn upward, forming a melt column with a pre-determined shape, cooling a part above the solid-liquid interface by air blowing, allowing the wrought aluminum alloys to be cast without the hot-cracking. In general, it is difficult to fabricate wrought aluminum alloy components with high quality by the conventional casting processes. By this technique, however, kinds of geometries, such as a hollow, variable thickness and bent products can be fabricated and high tensile strength and elongation are obtained.

In this study, we investigated the mold-less casting technique to manufacture newly designed automotive components such as a crash absorption component and a side frame. In the case of the crash absorption component, a wavy design was introduced to a hollow structure with inner ribs (Fig. 1). The wavy design increased a number of buckling deformations and thus increased the energy absorption per unit weight. In order to fabricate the wavy design, factors affecting shape stability and defect formation were investigated using experimental and numerical techniques. We also investigated to fabricate aluminum frame components with inner ribs and a bent geometry in order to increase structural stiffness, enhance design freedom and reduce weight.



(a) Conventional design (b) New design
Fig. 1 Illustrations of crash absorption components.

2. Experimental procedure

A6xxx series aluminum alloys were used. The crash absorption components of the A6063 alloy were fabricated using the shaping device with an opening as shown in Fig. 2. The melt column was formed on this opening. Cooling air was blown to the outer shells from outer nozzles, while the inner ribs were cooled by air blown from the inner ribs. The wavy design was formed by control of a pulling path (Fig. 3). The specimens were T6 heat treated. Drop-weight tests were conducted to determine crash absorption energy (Fig.4).

A frame component of A6005C with inner ribs and a bent geometry (Fig.5) was fabricated using vertical and rotary pulling paths combined with a horizontal movement of the shaper. Because the pulling rate at an outer position was faster than that at an inner one during the rotary pulling, the flow rate of coolant air from outer and inner nozzles were varied to keep the pulling condition within the thermally stable conditions [1].

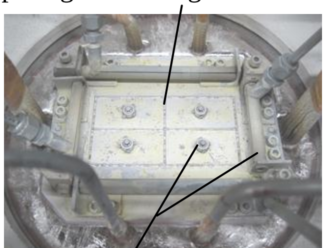


Fig. 2 A shaping device.

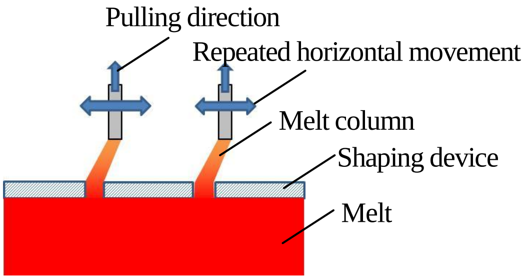


Fig. 3 Illustration of pulling of the wavy design.

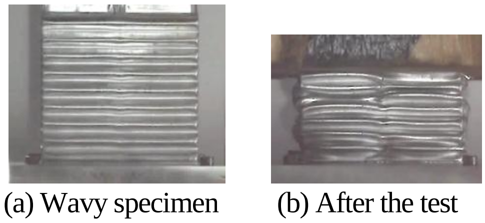


Fig. 6 Photos of the crash absorption component with the wavy design before and after the drop-weight test.

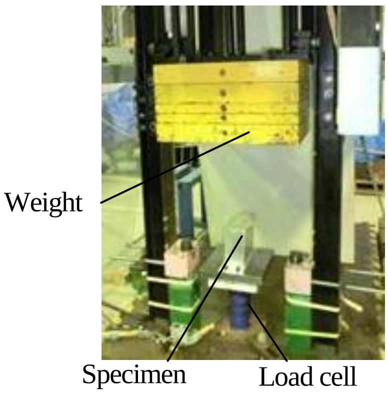


Fig. 4 Illustration of the drop-weight test.

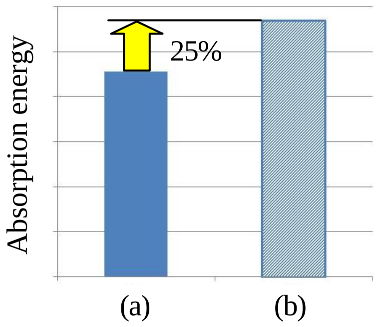


Fig. 7 Crash absorption energy

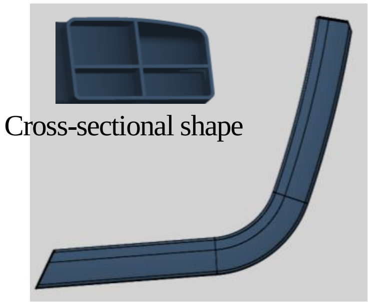


Fig. 5 A frame component.

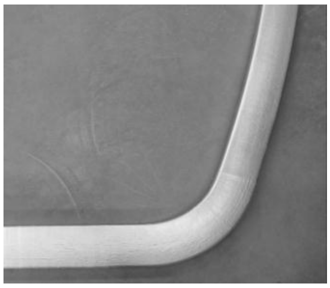


Fig. 8 A photo of the frame component with inner ribs and a bent geometry.

3. Results and discussion

Fig. 6 shows photos of the crash absorption components before and after the drop-weight tests taken by a high-speed camera. Buckling deformations appeared at antinodes of the wavy design. The crash absorption energy per unit weight of the wavy specimens increased approximately 25 pct. comparing to that of the specimens with a conventional design as shown in Fig. 7.

The frame components with inner ribs and a bent geometry could be fabricated by this technique (Fig.8).

4. Conclusion

In this study, the mold-less casting technique to manufacture newly designed automotive components was investigated. The wavy shaped crash absorption components with inner ribs could be fabricated by this technique. The absorption energy per unit weight of the wavy specimens increased approximately 25 pct. comparing to that of the specimens with a conventional design. A frame component with inner ribs and a bent geometry was also fabricated by this technique.

References

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