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Finite element analysis of AZ31B magnesium alloy double butted tube forming process

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In recent years, magnesium alloy tube has been widely used for structural components, remarkably in the hobby equipment e.g. bicycle frames. This is due to their light weight and higher specific strength when compared to other material. Since the magnesium alloy usually exhibits limited ductility at the room temperature, warm and hot forming is common for the magnesium alloy sheet. A variety of magnesium alloys have been applied to structural components manufacturing. As for press forming, AZ31B is considered as the suitable magnesium alloy for the stamping process at the present time.

Weight reduction is one of the primary considerations in the development of the bicycle, which operated by limited human power. The weight reduction of bicycle is focused on the bicycle frame. The application of butted tube is common way to reduce the weight of bicycle frame. Butted tube has increased thickness near the joints for strength while keeping weight low with thinner material elsewhere. The double-butted tube has two different thickness, with the thicker sections at the end of tube where they are welded.

The butting process in this study uses a mandrel press method. The mandrel press method consists of three forming processes such as doming process, ironing-extrusion process and stripping process. In a doming process, the end of tube was shrunk by die. More shrinkage is better for the success of following process but the amount shrinkage is limited by the tube wall buckling. After doming process, the tube is pushed through a die sinking it down onto the mandrel. The die determines the outside diameter, while the mandrel sets the inside diameters and defines the wall-thickness profile. After this process, the mandrel is trapped inside the tube in a conventional double-butted geometry, where the end wall thickness is greater than in the middle section. The mandrel is removed by pulling from the tube with stripper, which increases the diameter while having a negligible affects on the wall thickness. There is possibility of buckling during stripping due to large thickness difference.

The finite element study of a butting process for AZ31B magnesium alloy tube with elevated temperatures was conducted to develop the double-butted magnesium alloy tube forming process. The finite element analyses for three cases, shown at table 1, were done. As a result of study, the amount of tube end shrinkage at doming process is important factors to free from tube end fracture at ironing-extrusion process as shown at figure 1. There is also the limitation of thickness profile of tube due to tube wall buckling at stripping stage as shown at figure 2. As the amount of thickness reduction increases, the stripping load also increases that causes buckling at wall. Consequently, the analysis condition #2 could be an adequate double-butted forming condition for given tube size.

Table 1 Conditions for finite element analysis

Tube	Analysis condition	Butted Tube		
		OD	Max. Thickness	Min. Thickness
- AZ31B - OD:49.5 - 2.0t - Length : 730mm	#1	48,8	2.0	1.8
	#2	48.6	2.0	1.7
	#3	48.4	2.0	1.6

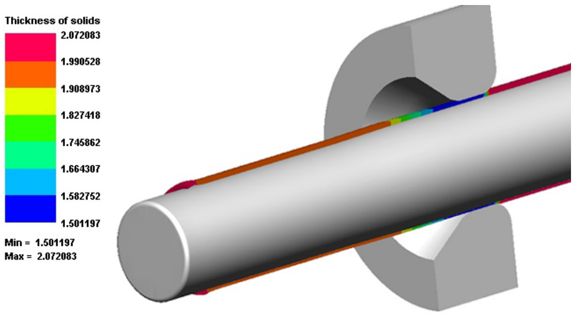

Fig. 1 Tube end fracture during ironing -extrusion process due to in sufficient doming amount or too much wall thickness difference

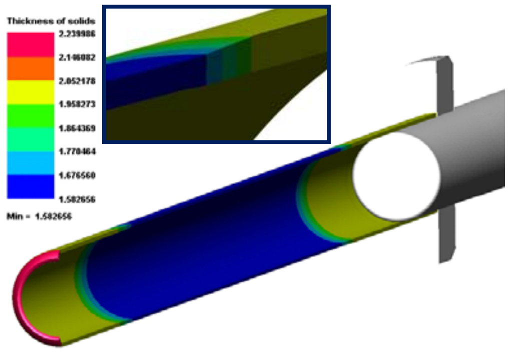

Fig.2 Buckling at tube wall during stripping process due to too much wall thickness difference

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