

Study on the Riveting Forming of Aluminum Ball Joint

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Abstract. Aluminum ball joint is an advanced structure using to connect steering parts with the merits of simple and lighting. Usually the ball sealed in the Aluminum housing through riveting forming method which has an impact on the push out strength and ball joint torques directly. So how to control the riveting process and achieve the best properties match is very important. In the paper, the relations in the riveting processes, push out strength and torque are studied using experimental method. The parameters affected the push out strength and torque are studied and the influence rules are achieved. The analytical model to present the push out strength is established.

1. Introduction

Automobile steering system is mostly used Aluminum and connected by ball joint to reduce weight. Figure 1 shows a typical type of ball joint structure which is assembled by ball stud, housing, bearing, housing cover, etc. Generally the housing is a part of control arm and made by Aluminum material, the ball stud is made by steel, the bearing is made by high polymer material and the housing cover is made by soft steel or Aluminum. During the assembly process, the ball stud, bearing, housing cover are put in the housing firstly, then the sloped edge on the housing is turned down (shown in the Figure 1-a)), then the housing cover and ball stud were sealed. References [1-2] show push out strength is the most major parameters to value the assembly quality and small push out strength can result in disaster. How to obtain the analytical model to present the push out strength is important to the application.

Riveting forming method is usually used to connect two parts in the automobile factory and aerospace factory [3]. But for the structure shows in Figure 1, it is difficult formed by the general riveted method, the die must be spun in the riveting processes to achieve the seal results [4]. References [4-5] show that housing size and shape have an impact on the push out strength. Thus, it is impossible to obtain the analytical model to present the push out strength. In this paper, the processes of ball joint sealing of Aluminum are studied, and the impacts of housing shape on the sealing quality are researched, which will provide necessary technical support for the ball joint sealing of control arms.



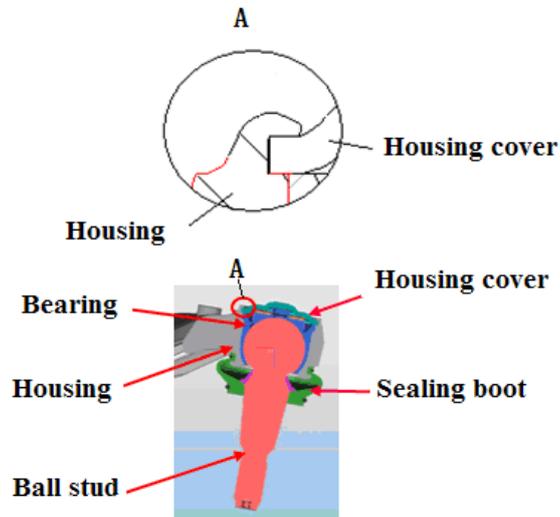


Figure 1. The structure diagram of ball joint

2. Die design and equipment

In the riveting process, the equipment and die show as Figure 2. In the forming, the die spinning and stepped down to make the part deform. In order to keep the force balance, two rollers are used. The part shows as Figure 3. In order to obtain the rule between part shape and push out strength, the parameters of parts show as table1. In the experiment, 800r/min and 2mm/s are used.



a) Riveting equipment



b) die

Figure 2. Riveting equipment and die

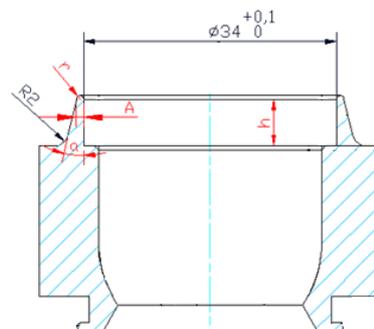


Figure 3. The shape of part

Table 1. Dimension of parts.

	a (°)	h (mm)	A (mm)	r (mm)
1#	13	5.09	1.24	0.62
2#	15	5.09	1.24	0.62
3#	18	5.09	1.24	0.62
4#	13	5.7	1.6	∞
5#	10	5.7	1.77	∞

3. Experiments and results

After the riveting processes, the following parts can be achieved (Figure 4).



a) 1#



b) 2#



c) 3#



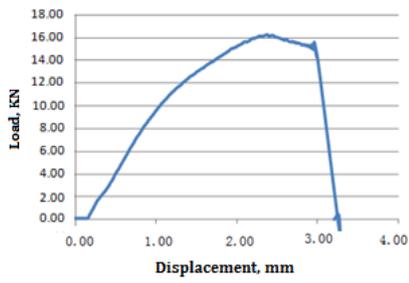
d) 4#



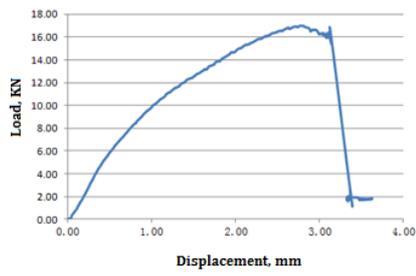
e) 5#

Figure 4. Parts after deformation

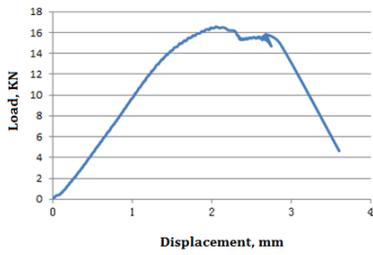
It can be seen that all of the parts have a good surface quality after riveting forming. Figure 5 show the push out strength-displacement curves and parts after push out test.



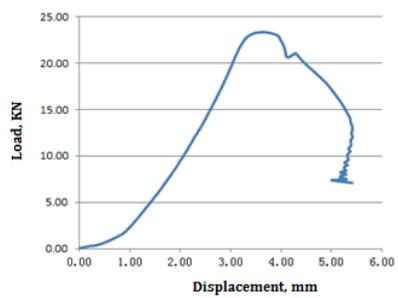
a) 1#



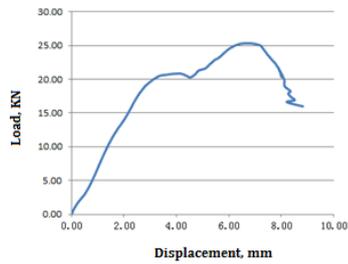
b) 2#



c) 3#



d) 4#



e) 5#

Figure 5. Push out force-displacement curves and parts after push out test

It can be seen from Figure 5 and Table 2 that push out strength is related to the shape of housing, and the push out strengths come from part 4# and 5# are larger than that come from part 1# to 3#. According to shearing theory, the push out strength can be calculated according the Equation (1).

$$Pos = \sigma_t S \tag{1}$$

Where, Pos is present the push out strength, MPa;
 σ_t is present the shear strength of housing material;
 S is present the shear area in the push out test.

For the housing material, its strain-stress curve shows as Figure 6 and the shear strength is mostly 350MPa. The shearing section area can be calculated from the shearing section thickness and list in the Table 2.

Table 2. Push out strength and shearing section area.

	Shearing section thickness,mm	shearing section area,mm ²
1#	0.39	36.738
2#	0.4	37.68
3#	0.38	35.796
4#	0.56	52.75
5#	0.592	55.76

According Equation (1) , The push out strengths can be calculated and showed in the Figure 7.

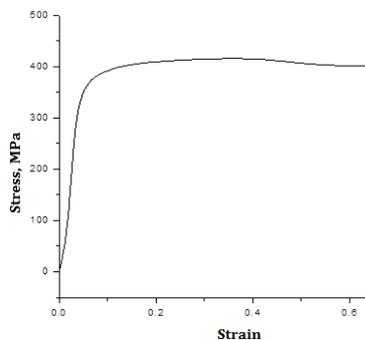


Figure 6. Strain-stress curve

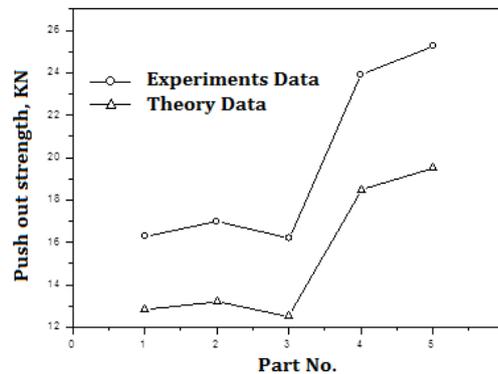


Figure 7. The push out strength

It can be seen from Figure 7 that push out strength obtained from experiment has a same trend with that come from calculation from equation (1) and higher than that obtained from calculation, this is because in the forming the material strength can be improved by the deformation.

4. Conclusions

- 1) The shape of housing has a major impact on the push out strength, and more material deformed more push out strength;
- 2) The push out strength is depended on the thickness of shearing section, the thicker thickness the bigger push out strength can be obtained;
- 3) The strength can be improved through riveting forming and the push out strength can be predicted by the thickness of shearing thickness.

Acknowledgments

This research was supported by the National Natural Science Foundation of China (Grant No. 51405284), and Leading Academic Discipline Project of Shanghai Polytechnic University (Grant No. XXKZD1601).

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