Study of Countersunk Rivet Forming

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1. Introduction

Countersunk rivets are becoming more and more popular due to its joining method in automobile and avionic industry. Within the automotive and avionic industry today, companies save significant amounts of money through computer simulation. Computer simulations are used to test crash worthiness, strength, failure mode fatigue life and residual stress and strains with a goal to increase safety.

A countersunk rivet is studies for von mises stress and residual strains for damage and durability. The model consist of three different diameter of rivet to thickness of the plate ratio (D/T), three different velocities (5, 10 & 15 meters/second) and two clearances between rivet and punch (0 and 1 milli meter).

In this study full model of riveting process is analyzed. Finite element analysis is performed using the LS-DYNA/970[2]. The isotropic elastic plastic material model is used. The simulation results contact forces; deformed head diameter and height are validated with experimental data.

2. Finite Element Analysis and Experimental Method

Experiment is conducted by Markiewicz and Langrand [1] for one result and the same criteria are verified through simulation, and rest of the simulations are done based on the same criteria with different parameters to study the response on rivet and plate in terms of stress, strain and force. The material property and dimensions for the riveting process is as follows. The model consists of rivet, base plate, top plate and a punch.

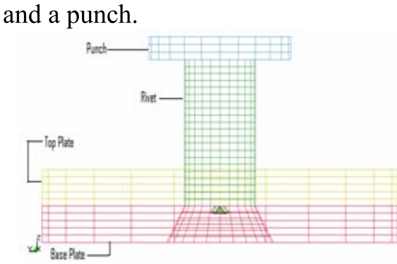
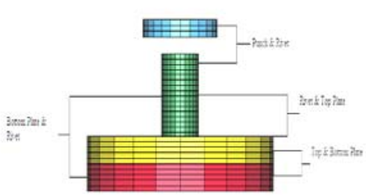


Figure 1 Riveting Process Setup

The model consists of one 7050 Aluminum alloy countersunk rivet, shank Diameter D=4mm, initial Length L= 8mm, two 2024-T351 aluminum alloy plates having thickness T=1.3mm, 1.6mm and 2mm. The contacts used in these simulations are as follows. contact between top and bottom plate, contact between rivet and punch, contact between rivet and top plate and contact between rivet and bottom plate.



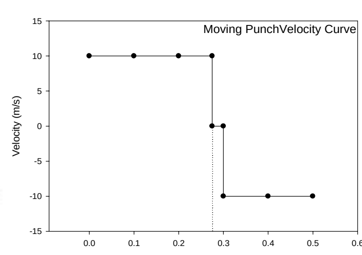


Figure 2(a) Part Contacts Figure 2(b) Velocity curve for rigid body

Material Property	E (GPa)	Y	P g/mm^3	G (GPa)	K (GPa)	A (GPa)	B (GPa)	n
Plate-Al2024-T351	74	0.33	0.0028	27.82	72.55	0.3052	0.3053	0.1461
Rivet-Al7075	74	0.32	0.0028	28.03	68.52	0.3125	0.2905	0.2503
Rigid Body	74	0.3	0.0028	-	-	-	-	-

Table 1. Material Properties for rivet model

3. Observations

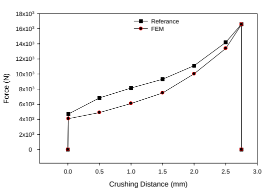


Figure 3. Force Vs. Crushing Displacement

Driven Head Property	FEA mm [1]	Norm[1]	Test Mean Value [1]	Validation
H_{out}	2.2	>1.19	2.2	2.04
Φ_{in}	5.5	>5.15	5.7	5.31
Φ_{max}	6.08	<6.70	6.15	6.17

Table 2. Validation

1) It is found that there is no influence of punch velocity, punch and rivet gap and change in length of the plate and diameter of rivet on von-misses stress and residual strain. The force on rivet is unchanged for all the simulations. Change in plate hole diameter is high for punch velocity 15 m/s and low for 10 m/s punch velocity. D/T ratio had less significance on variation on hole diameter. It's been also observed that higher velocity tends to distort hole diameter and damages to the skin on the plate.

2) The values for driven head internal diameter are high for all 2.5 D/T ratio and low for 2 D/T ratio for no clearance between punch and rivet but for 1 mm clearance between punch and rivet, values are high for higher punch velocities and lower D/T ratio. The values for driven head external diameter are increasing with increasing punch velocity with increasing D/T ratio for both the cases. The values for height of driven head rivet are consistent with small variation for all the simulations.

3) The values for maximum plastic strain increases with combination of D/T ratio and punch velocity for 0 mm gap between punch and rivet but for 1mm gap between punch and rivet are higher for low D/T ratio and high for increasing punch velocity.

4. Conclusions

Finite element analysis is performed to study the riveting process and validated with experimental results. This research discussed the influence of various parameters on the riveting process. The results will be used in the application of design of riveting process.

5. References

1) Markiewicz, E., Langrand, B., Deletombe, E., Drazetic, P, and Patronelli, L.,1998 "Analyses of riveting process forming mechanisms," Int. J. of Materials and Product Technology, Vol. 13, Nos. 3-6, pp. 123-145.

2) Livermore Software Technology Corporation, 2003, LS-DYNA LS-DYNA "Key words user manual".