Presentation on

DESIGN, DEVELOPMENT AND ANALYSIS OF INDEXABLE TOOL HEAD AND AUTO-FEED TABLE MECHANISM FOR PORTABLE ORBITAL FORM RIVETTER

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Abstract - Riveting procedure is orthodoxly carried out using also a press machine , or physically striking. This process is not precise, takes substantial time and effort and so also may result into damage of section. The Movable orbital riveter uses the principle of orbital riveting where in a high speed rotating riveting tool held at an angle in the riveting head is fed into the rivet. This results in cold forming of the rivet head of maximum strength and with moderately low force (less than 80% force that of conventional method) result into a strong and accurate bond. The approach of the riveting tool held in the riveting head plays a substantial role in the reduction in forming force , where as the table motion will control the accurate positioning of the rivet in to tool profile , ensuing into exact shape and size of rivet top portion formed. Project deals with development of portable orbital form riveting machine with portable drilling machine as power tool and auto-positioning feed table will be designed and modeled using Unigraphix software , Analysis will be done using Ansys work bench 16.0.

***Key Words*:** riveting, rivets, orbital riveting

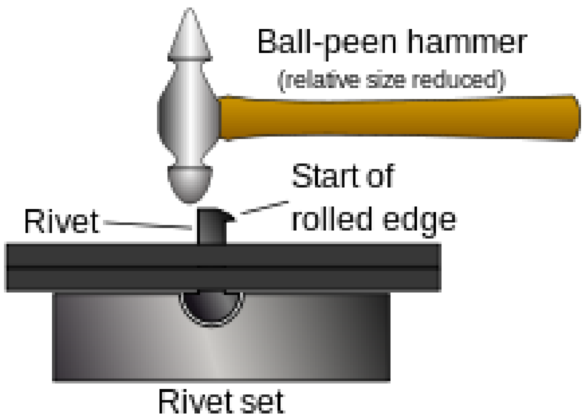
1. INTRODUCTION

A rivet is a lasting mechanical snap. Earlier being installed, a rivet consists of a smooth cylindrical shaft with a head on one end. The termination opposite to the head is called the tail. On fitting, the rivet is placed in a stamped or drilled hole, and the tail is upset, or bucked , so that it expands to about 1.5 times the initial shaft width, holding the rivet in place.

Fastenings used in outdated wooden boat building, such as Cu nails and settle bolts, work on the same code as the rivet but were in use long earlier the term rivet was presented and, where they are remembered, are usually classified among nails and bolts respectively.

By riveting we mean the upsetting of an rivet to form a head to hold several parts composed. The rivet can be in the form of a pin or an eyelet.

Conventional Riveting methods :



Manual installation of a solid rivet

Impact method for solid rivet and semi tubular rivets

Objectives

1. Design Selection of Electric power source for orbital riveting
2. Design of electric screw jack for table feed.
3. Development of mathematical model of system of forces, and validation of strength of critical components of the riveting machine using ANSYS software
4. Experimental validation of maximum and minimum speeds of riveting available from the device under different rivet materials conditions

PROBLEM STATEMENT

The above mentioned processes of riveting are conventional processes used commercially for making riveted joints, the offer advantages such as fast production rate , possibility of automation etc., but some inherent disadvantages in process limit their use,

1. The head formation by the push method uses excessive force that is applied while forming the head, this leads to the deformation of the parts being riveted, hence the use of the process is limited to components that are strong and solid.
2. The push or pull process can be used to make the fixed type of riveted joints, as in either of the processes the force applied for formation of head hence parts are virtually fused together , thereby permitting no relative motion between the mating parts, hence hinged joint is not possible.
3. Due to application of force while head formation the process cannot be applied to riveting of materials like plastics, glass, ceramics, poly -urethane, etc.
4. Due to impact nature of force application the process are excessively noisy.
5. Special shapes like ladder rungs cannot be riveted by these processes.

Current condition

Riveted unions were produced by peening bolt rivets over with a hammer.

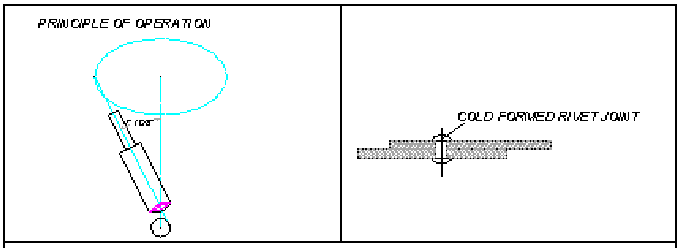
As mechanization was on the rise, also presses or mechanical hammers for metal working were gaining ground but were soon replaced by specific riveting machines. The excessive amount of force to be applied along with high sound levels on the one hand and, on the other hand, the changes in the structure of the rivets and their embrittlement were less and less accepted by users who demanded higher quality standards.

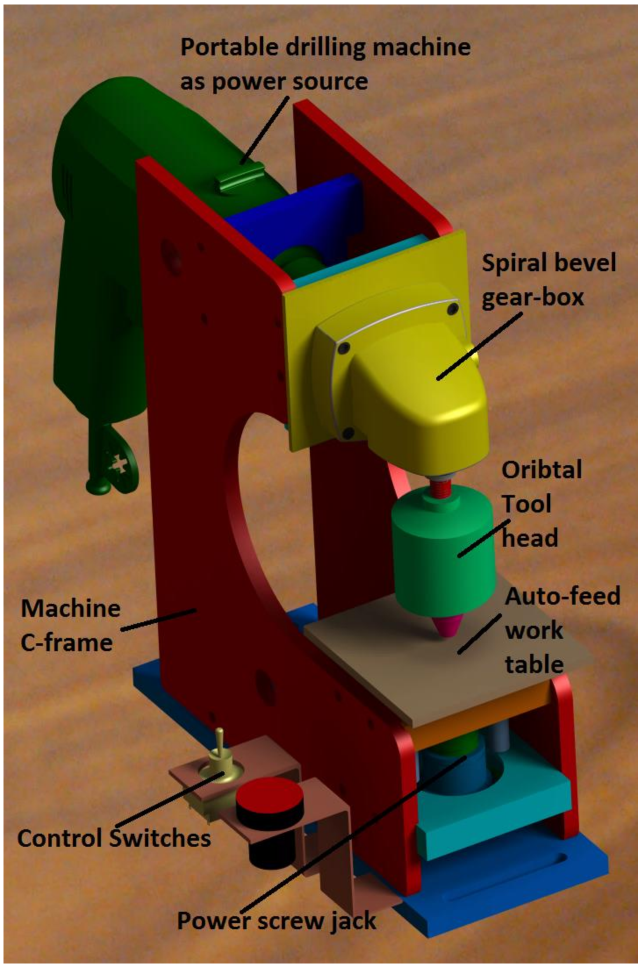
Though, the orbital riveting experience did bring some developments in its wake, the hardenings of the rivet assembly and the harm to the closing head surface still remained.

Proposed Condition

ORBITAL RIVETTING

Rivet is set at the joint such that the rivet set angle is from 10 to 80 depending upon the joint to be obtained. It turns around the vertical axis at about 2000 to 3000 rpm and describes a cone whose apex corresponds to the center of gravity of the joint formed. It is the tool which gives the shape.





FEATURES OF PROPOSED ORBITAL RIVETTING MECHANISM

- This riveting development allows fixed or hinged assemblies to be made.
- It allows unusual shapes to be riveted without difficulty. (eg. Square section tubes as ladder rungs)
- Due to orbital riveting principle and specific location of tool (rivet set) on the part to be riveted, the upsetting load required is six times lower than for direct push(press).

POSSIBILITIES DUE TO ORBITAL RIVETTING

- Immovable or hinged assembled portions can be done.
- Many types of materials can be riveted eg. Steel, SS, Plastics, aluminium, etc.
- All working positions possible.
- All potentials of automation.

METHODOLOGY

The experiment for validation of this idea will be conducted as follows:

THEORETICAL WORK

1. Literature review. Study of various configuration of roll forming process by using handbooks, United State Patent documents, Technical papers , etc.

Design and Planned Development of Machine:

System design as to and theoretical derivation of dimensions of the Rollers section for three stage roll forming of U-section by theoretical method , rollers profile geometry by graphical method .

System Design and theoretical derivation of power required to perform the roll forming operation , determination of gear train dimensions to get desired surface speed during roll forming operation.

System Design and theoretical derivations of critical components of the system as to shaft , bearings , pressure adjustment screw etc.

Design , modelling , drafting and analysis of roller system and critical machine components of roll forming machine by use of Unigraphix NX 8 and Ansys Workbench 16.0

Equipment

Fabrication: Suitable industrial methods will be employed to manufacture the components and then assemble the test set –up. Creation assembly and testing of machine to by experimentation validate the stage wise section profile dimensions by all three methods ie, theoretical , software and experiment Facilities available:-

The following facilities to carry out fabrication work are available at sponsor site

- Centre lathe
- Milling machine
- DRO – Jig Boring machine
- Electrical Arc Welding
- Digital Vernier
- RPM meter
- Depth gage.

DESIGN

Design consists of application of scientific principles, technical information and imagination for development of new or improvised machine or mechanism to perform a specific function with maximum economy & efficiency . Hence a careful design approach has to be adopted . The total design work , has been split up into two parts

1) System design

2) Mechanical Design.

EMPIRICAL METHOD TO COMPUTE FORGING LOAD

OPEN DIE FORGING

The load required to forge a flat section in open dies may be estimated by;

$P = \sigma A C$., N

A = Forging projected area ; mm2

σ = mean flow , stress N/mm2

C = Constant (Constraint factor) to allow for in homogeneous deformation

The deformation resistance increases with Δ which is defined as;

Δ = mean thickness of deforming zone / length of deforming zone

$= h/2L$

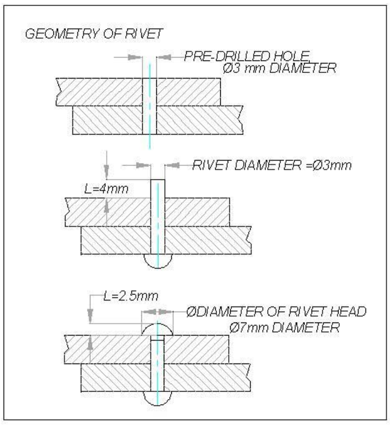
Then C is given as;

$C = 0.8 + 0.2\,\Delta$

INPUT DATA

MATERIAL OF RIVET

Designation	Tensile Strength (N/mm2)	0.2%ProofStrength (N/mm2)
5300	215	100



Δ = mean thickness of deforming zone / length of deforming zone

= h/2L

= 3/2(4) = 0.375

Δ = 0.375

C = 0.8 + 0.2 Δ

= 0.8 + 0.2 (0.375) = 0.875

C = Constant (Constraint factor) =0.875

σ = mean flow stress = 100 N/mm2

A = Forging projected area ; mm2

= π x D2 /4

= π x 32 /4 =7.06 mm2

P = σ A C

= 100 x 7.06 x 0.875

= 617.75 N

Most of the work during orbital forming is focused at the tool's line of contact, not along the entire tool surface. This reduces axial loads by as much as 80%, which has several advantages.

Hence , Peff = 0.2 x 617.75 = 123.5

Peff = 124 N

This is the load that acts in the downward direction while forming the rivet, where as the rivet head diameter is 6mm, hence the torque required at the spindle is given by :

T = Peff x r

= 124 x 3

= 372 N-mm

T = 0.372 N-m

Power required at spindle is given by ,

P = 2 π N T /60

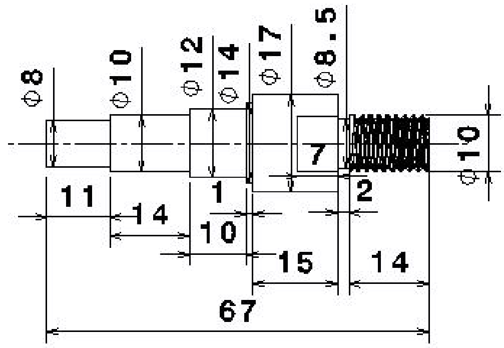
= 2 π x 900 x 0.372 /60 = 70 watt

Considering 100 % overload

Power at spindle = 140 watt

Thus motor of 150 watt will be sufficient for the operation

DESIGN AND ANALYSIS OF SPINDLE OF ORBITAL RIVETTING MACHINE :



MATERIAL SELECTION : - Ref :- PSG (1.10 & 1.12) + (1.17)

DESIGNATION	ULTIMATE TENSILE STRENGTH N/mm^2	YEILD STRENGTH N/mm^2
EN 24	800	680

ASME CODE FOR DESIGN OF SHAFT

Since the loads on most shafts in connected machinery are not constant , it is necessary to make proper allowance for the harmful effects of load fluctuations

According to ASME code permissible values of shear stress may be calculated form various relation.

fs_{max} = 0.18 fult

= 0.18 x 800

$= 144 N/mm^2$

OR

$fs_{max} = 0.3\ fyt$

$= 0.3 \times 680 = 204\ N/mm^2$

considering minimum of the above values

$\Rightarrow fs_{max} = 144\ N/mm^2$

Shaft is provided with notch for locking ; this will reduce its strength. Hence reducing above value of allowable stress by 25

$\Rightarrow fs_{max} = 108\ N/mm^2$

This is the allowable value of shear stress that can be induced in the shaft material for safe operation.

$T = 2.84 \times 10^3$ N-mm

Assuming 25% overload.

CHECK FOR TORSIONAL SHEAR FAILURE OF SHAFT.

minimum diameter of the spindle is 8,.5 mm at the M10 x 1.5 pitch threaded section

$\Rightarrow d = 16$ mm

$Td = \Pi/16 \times fs_{act} \times d^3$

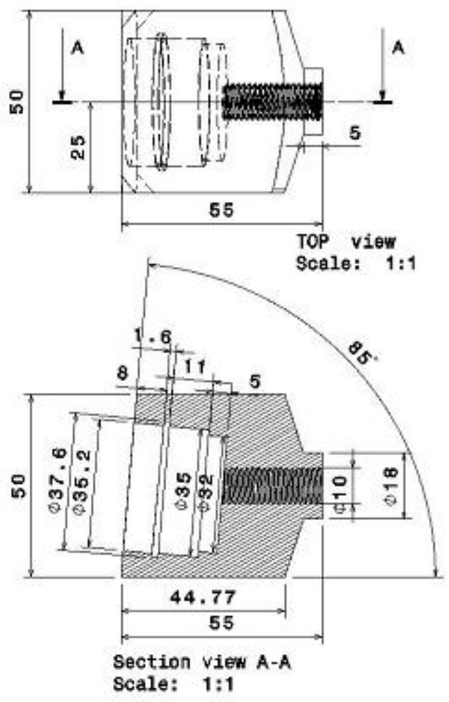
$$\Rightarrow fs_{act} = \frac{16 \times Td}{\Pi \times d^3}$$

$$= \frac{16 \times 2.84 \times 10^3}{\Pi \times (8.5)^3}$$

$\Rightarrow fs_{act} = 23.54\ /mm^2$

As $fs_{act} < fs_{all}$

$\Rightarrow$ I/P shaft is safe under torsional load



MATERIAL SELECTION : -Ref :- PSG (1.10 & 1.12) + (1.18)

DESIGNATION	ULTIMATE TENSILE STRENGTH N/mm^2	YEILD STRENGTH N/mm^2
EN8	520	360

$\Rightarrow fs_{max} = uts/fos = 520/2 = 260\ N/mm^2$

This is the allowable valve of shear stress that can be induced in the shaft material for safe operation.

Assuming 100 % efficiency of transmission

$\Rightarrow$ T design = 2.84 Nm

$Td = \Pi/16 \times fs_{act} \times (D^4 - d^4)/D$

$$\Rightarrow fs_{act} = \frac{16 \times Td}{\Pi \times (D^4 - d^4)/D}$$

Outside diameter of drum boss = 18mm

Inside diameter of drum boss = 10mm

$$= \frac{16 \times 2.84 \times 10^3 \times 18}{}$$

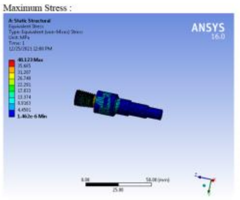
$$\Pi \times (18^4 - 10^4)$$

$\Rightarrow fs_{act} = 2.74 N/mm^2$

As $fs_{act} < fs_{all}$

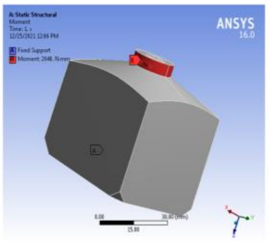
$\Rightarrow$ TOOL HOLDER is safe under torsional load

Maximum Stress :

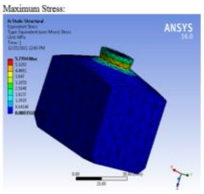


The maximum stress induced is 40.123 Mpa is less than permissible stress hence the part is safe

DESIGN OF TOOL HOLDER



Maximum Stress:



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Fabrication :

Suitable manufacturing methods will be employed to fabricate the components and then assemble the test set –up.

Fabrication assembly and testing of machine to experimentally validate the stage wise section profile dimensions by all three methods ie, theoretical , software and experiment

Facilities available:-

The following facilities to carry out fabrication work are available at sponsor site

1. Centre lathe
2. Milling machine
3. DRO – Jig Boring machine
4. Electrical Arc Welding
5. Digital Vernier
6. RPM meter
7. Depth gage.

WORKING

Motor is started which rotates the main spindle at high speed. The tool or rivet set mounted in the tool holder rotates at high speed. The job to be riveted along with the rivet is placed in the work holder .The feed motor is operated to move in upward direction to lift the table slide and table in the table guide by means of roller arrangement.

The tool spins about the rivet projecting out of the joint thereby cold forming the head on the rivet side. The amount of pressure applied depends upon the type of joint ie, fixed or hinged to be done.

After riveting is done, the feed handle is released which brings the table slide down by self weight. Job is replaced in holder to form the next riveting joint.

Test and Trial



Procedure of trial

1. Place rivet in specimen holes

2. Place specimen in fixture on table

3. Start machine

4. Operate direction control switch

5. Operate push button to move table towards the tool

6. Reverse direction control switch

7. Remove specimen

Sr. No	Mild steel		Aluminium		Acrylic	
	Size	Time (Sec)	Size	Time (Sec)	Size	Time (Sec)
1	Ø 3mm	18	Ø 3mm	17	Ø 3mm	17
2	Ø 4mm	20	Ø 4mm	20	Ø 4mm	21
3	Ø 5mm	23	Ø 5mm	22	Ø 5mm	23

COST ANALYSIS

BILL OF MATERIALS:-

SR NO.	PART CODE	DESCRIPTION	QTY	MATERIAL
1.	ORM –1	BASE PLATE	01	MS
2.	ORM –2	LH CASING PLATE	01	MS
3.	ORM –3	LH CASING PLATE	02	MS
4.	ORM –4	LINEAR BRG	02	STD
5.	ORM –5	TABLE	01	MS
6.	ORM –6	DRILL MC	01	STD
7.	ORM –7	DRILL MC BRACKET	01	AL
8.	ORM –8	GEAR BOX	01	STD
9.	ORM –9	SPINDLE	01	EN24
10.	ORM –10	TABLE FEED SCREW	01	EN24
11.	ORM –11	PINION	01	STD
12.	ORM –12	GEAR	01	STD
13.	ORM –13	MOTOR (12 V DC)	01	STD
14.	ORM-14	BRACKET HOLDER	02	EN9
15.	ORM-15	GUIDE BAR	02	EN24
16.	ORM-16	TOOL HOLDER	01	STD
17.	ORM-17	TOOL	01	STD
18.	ORM-18	BOLTM6X15	24	STD

MATERIAL PROCUREMENT

Material is procured as per raw material specification and part quantity. Part process planning is done to decide the process of manufacture and appropriate machine for the same.

GENERAL MATERIAL USED

EN24- ALLOY STEEL

EN9- PLAIN CARBON STEEL

MS-MILD STEEL

CI – CAST IRON

STD- STANDARD PARTS SELECTED FROM PSG DESIGN DATA/MANUFACTURER CATALOGU

RAW MATERIAL COST

The total raw material cost as per the indivORMual materials and their corresponding rates per kg is as follows,

Total raw material cost = Rs3600/-

- MACHINING COST

OPERATION	RATE Rs /HR	TOTAL TIME HRS	TOTAL COST Rs/-
LATHE	80	18	1440
MILLING	90	10	900
DRILLING	60	3	180
HOBBING	-	-	1780
TOTAL			4300

MISCELLANEOUS COSTS

OPERATION	COST(Rs)
FABRICATION	400
ASSEMBLY	300
BENCH WORK	200
TOTAL	900

COST OF PURCHASED PARTS :-

SR NO.	DESCRIPTION	QTY	COST
1.	MOTOR	01	1950
2.	Gearbox	01	940
3.	Motor_12VDC	01	540
4.	BEARINGS	4	340
5.	BOLT	-	80
6.	TOOL HOLDER	01	240
7.	TOOL	01	190

The cost of purchase parts = Rs 4280

Total cost = 13680/-

Result Discussion :

1. After careful review the shortcomings of the conventional riveting process are observed and the orbital riveting process is found to offer better joint strength , join-ability. Although the portable form of the orbital riveting machine that uses the portable hand drill machine as power source is not been researched

2. The maximum power required for riveting operation was found to be 150 watt

3. The motor selected was in the form of portable drilling machine and the power of the machine is 650 watt at 2900 rpm

4. The design of the spindle was done by theoretical method and analytical method part was proved safe by both methods.

5. The design of the tool holder was done by theoretical method and analytical method part was proved safe by both methods.

6. The design of the tool was done by theoretical method and analytical method part was proved safe by both methods.

ADVANTAGES OF ORBITAL RIVETTING MACHINE

1. The rivet head is gradually formed into desired shape, hence excellent mechanical holding or security of joint.
2. Resultant joint by orbital riveting machine is more resistant to vibrations.
3. Orbital riveting machine gives quieter riveting.
4. Orbital riveting machine causes limited deformation and pressure on parts to be assembled.
5. Orbital riveting reduces cost of riveting.
6. Fast riveting process.
7. Many types of materials can be riveted.
8. Can make both fixed as well as hinged joints.
9. Excellent mechanical holding(security)
10. Limited deformation and pressure of the parts to be assembled.
11. Fast and rational implementation
12. Noiseless operation
13. Reduced cost.

APPLICATIONS

1. Work, tools, toys, kitchen utensils, general hardware.
2. Scissors, pliers, hinges, etc.
3. Fabrication hinges
4. Agricultural trimming and cutting equipment.
5. Parts subjected to thermal cycling ,eg. ,Boiler shells

RESULTS AND DISCUSSION

1. After careful review the shortcomings of the conventional riveting process are observed and the orbital riveting process is found to offer better joint strength , join-ability. Although the portable form of the orbital riveting machine that uses the portable hand drill machine as power source is not been researched

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4. The design of the spindle is safe by theoretical method and analytical method.

5. The design of the tool holder is safe by theoretical method and analytical method.

6. The design of the tool was done by theoretical method and analytical method.

REFERENCES

1. S. Amancio " Friction Riveting: development and analysis of a new joining technique-for-polymer-metal-multi-materialstructures",GKSSForschungszentrum Geesthacht GmbH • Geesthacht • 2007
2. Tushar A patil, Asst prof P.N Ulhe, and Pratik D Bhoyar, " Analysis & design of drilling cum orbital riveting machine. " January 2016 | IJIRT | Volume 2 Issue 8 | ISSN: 2349-6002
3. Prof. K.G.Sontakke, Prof. R. D. Vaidya, Prof. D.M. Mate " Design and Analysis of Drilling Cum Riveting Machine " Nov 2014 (Volume 1 Issue 6) JETIR (ISSN-2349-5162)
4. Worldwide | Germany PC Control 01 (4) (2011)
5. K. H. Salian, P. S. Sanku, S. P. Shah, U. A. Shaikh, Dr. N.P. Gulhane, S.B. Shedge" Elimination of Cracks Formed on Rivet Head " International Journal of Engineering and Technical Research (IJETR) ISSN: 2321-0869, Volume-2, Issue-4, April 2014
6. Sachinkumar Jagtap, Mukund Kavade " ORBITAL RIVETING – A design and development of new machine" Proceedings of 7th IRF International Conference, 27th April-2014, Pune, India, ISBN: 978-93-84209-09-4

7. Bijay Bhatacharya ". Effect of variations of riveting process on the quality of reveted joint" Thesis , Gonzaga University 2006
8. G.Di BellaaC.BorsellinobL.CalabresebE.Proverbiob " Durability of orbital riveted steel/aluminium joints in salt spray environment" Journal of Manufacturing ProcessesVolume 35, October 2018,
9. Casalino G, Rotondo A, Ludovico A. On the numerical modelling of the multiphysics self piercing riveting process based on the finite element technique. Advances in Engineering Software. 2008 Sep 1;39(9):787-95.
10. Ma Y, Lou M, Li Y, Lin Z. Effect of rivet and die on self-piercing rivetability of AA6061-T6 and mild steel CR4 of different gauges. Journal of Materials Processing Technology. 2018 Jan 1;251:282-94
11. Mori K, Abe Y, Kato T. Mechanism of superiority of fatigue strength for aluminium alloy sheets joined by mechanical clinching and selfpierce riveting. Journal of Materials Processing Technology. 2012 Sep 1;212(9):1900-5.
12. Bonora N, Testa G, Iannitti G, Ruggiero A, Gentile D. Numerical simulation of self-piercing riveting process (SRP) using continuum damage mechanics modelling. Frattura ed Integrità Strutturale. 2018 Mar 25;12(44):161-72
13. Huang L, Shi Y, Guo H, Su X. Fatigue behavior and life prediction of self-piercing riveted joint. International Journal of Fatigue. 2016 Jul 1;88:96-110.
14. Porcaro R, Hanssen AG, Langseth M, Aalberg A. The behaviour of a self-piercing riveted connection under quasi-static loading conditions. International journal of solids and structures. 2006 Aug 1;43(17):5110-31.
15. Mori K, Abe Y, Kato T. Self-pierce riveting of multiple steel and aluminium alloy sheets. Journal of Materials Processing Technology. 2014 Oct 1;214(10):2002-8