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“Experimental Investigation of Effect of Tool Angle Variation of Orbital form Tool and Auto Feed Table on Geometry and Strength of Rivet and Cycle Time in Portable Orbital Riveting Machine”.

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ABSTRACT

Orbital riveting is a relatively new technology in which parts are produced by specific movement of tools. Special incremental motion enables smaller contact area between tool and work piece and therefore, lower forming load and friction. Hence, orbital forging in some cases makes it possible to produce a desired part in only one operation, whereas in conventional riveting two or more operations would be required. However, orbital riveting has number of setbacks, such as more complex machine maintenance and production times.

The cycle time is lower in case of the 5 degree tool angle, indicating that the 5 degree tool angle will result in better productivity as compared to the 4 degree tool angle.

Tolerance is lower in case of the 5 degree tool angle, indicating that the 5 degree tool angle will result in better accuracy as compared to the 4 degree tool angle. The Rivet Strength is higher in case of the 5 degree tool angle, indicating that the 5 degree tool angle will result in stronger joint as compared to the 4 degree tool angle.

Keywords- riveting, tool, degree, compared, angle.

I.INTRODUCTION

1.1. 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, and 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 eurathane, 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.

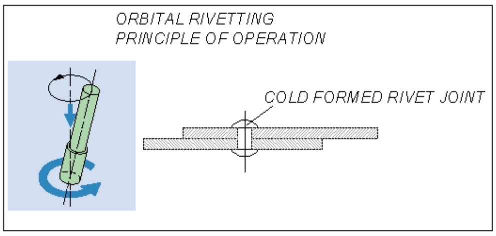

Fig.1. Orbital riveting principle of operation

1.2. Scope of work

a) The preliminary problem in conventional process is that of forming force and cycle time. Forming force will be reduced by the geometry of tool head and will be reduced by at least 70 percent , so also cycle time will drastically come down to a mere 40% of the cycle time required in conventional process.

b) The problem that index able head for multiple orientation positions , namely vertical positions, horizontal position is solved by providing machine with the orientations of tool head at 5 degree and 4 degree respectively.

c) The problem that the setting time for the tool set should be minimum is solved using a Quick change riveting head; to enable the operator to quickly change the tool set .The actual rivet tool is fast removable and loadable making the cycle time of tool change extremely negligible.

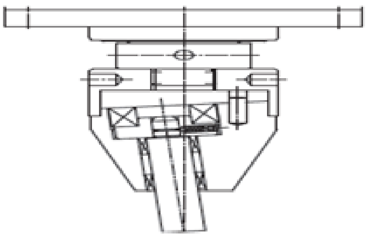

Fig. 2.Quick change spin head

d) The problem that fast production rate with the least cycle time is solved by using aauto feed mechanism for fast feed rates. The table will be fed into the rivet to form the desired head shape by a jacking arrangement using a 12 volt motor and screw jack arrangement.

1.3. Objectives:-

1. Fabrication of orbital riveting head for quick change ability.
2. Fabrication of index able riveting head with auto feed arrangement.
3. Test & Trial of machine for two tool head angles 5 degree and 4 degree
4. Derive performance parameters of machine for rivet head geometrical accuracy, cycle time, strength of joint and comparison of the parameters at two tool head angles.

II. FIGURES AND TABLES

2.1. Materials used for orbital riveting- Wrought aluminium alloy 5300

2.1.1. Characteristics: Ductile in soft condition, but work hardens rapidly, becoming extremely tough, having high resistance to corrosion attack, especially in marine applications.

Table: 1. Wrought aluminium alloy 5300

Designation	Tensile Strength (N/mm^2)	0.2%ProofStrength (N/mm^2)
5300	215	100

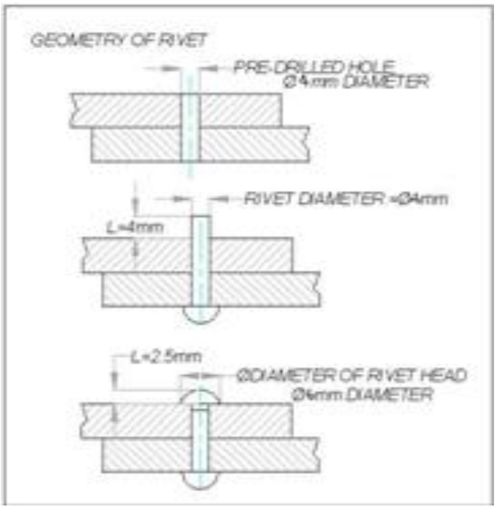

Fig. 3.Geometry of rivet

2.2. Empirical method to compute forging load:-

2.2.1. 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; mm^2

σ = mean flow, stress N/mm^2

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

$\Delta = h/2L$

Then C is given as;

$C = 0.8 + 0.2\ \Delta$

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

$\Delta = h/2L$; $\Delta = 4/2(4) = 0.5$

$C = 0.8 + 0.2\ \Delta$; $C= 0.8 + 0.2\ (0.5) = 0.9$

C = Constant (Constraint factor) =0.9

σ = mean flow stress = 100 N/mm^2

A = Forging projected area; mm^2

$A = \pi \text{ x } D^2 /4$

$A = \pi \text{ x } 4^2 /4 = 12.56 \text{ mm}^2$

$P = \sigma A C$; $P= 100 \text{ x } 12.56 \text{ x } 0.9$

P= 1130.4 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, $P_{eff} = 0.2 \text{ x } 1130.4$

$P_{eff} = 226.08$ 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

$T = P_{eff} * r$; $T = 226.08 \text{x } 3$

T = 678.24 N-mm ; T = 0.6782N-m

Power required at spindle is given by,

$P = 2\ \pi\ N\ T /60$; $P = 2\ \pi \text{ x } 900 \text{ x } 0.6782 /60$

P = 63.89 watt

P=64 watt

Considering 100 % overload

Power at spindle = 128 watt

Thus motor of 150 watt will be sufficient for the operation.

2.3. Material used for Spindle or shaft of orbital riveting machine:-

Table: 2. Material of Spindle of orbital riveting machine

Designation	Ultimate tensile strength N/mm^2	Yield strength N/mm^2
EN24	800	680

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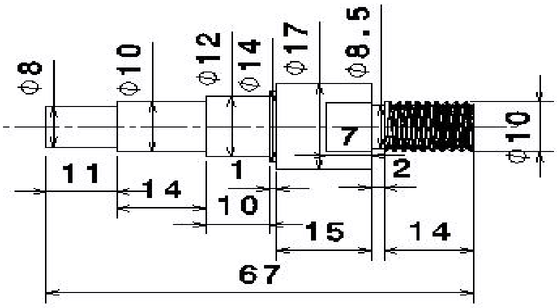

Fig. 4. Spindle or shaft of orbital riveting machine

2.3.1. ASME code for design of spindle or 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 from various relations.

fs_{max} = 0.18 fult

fs_{max} = 0.18 x 800 ; fs_{max}= 144N/mm^2 OR

fs_{max}= 0.3 fyt

fs_{max}=0.3 x 680= 204 N/mm^2

Considering minimum of the above values;

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 %.

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.

Power is given by;

P= 2ΠNT/ 60 ; T=P*60/ 2ΠN

T=128*60/2Π*900 ; T=1.36 x10^3 N-mm

Assuming 25% overload.

T=2.36 x10^3 N-mm

2.3.2. Check for torsional shear failure of shaft or spindle

Minimum diameter of the spindle or shaft is 8 mm at the M10 x 1.5 pitch threaded section

Td = Π/16 x fs_{act} x d^3

$fs_{act} = \frac{16*Td}{\Pi*d3}$; $fs_{act} = \frac{16 \text{ x } 2.36\text{x } 10\ 3}{\Pi\text{x } (8.5)\ 3}$

fs_{act} =23.48 N/mm^2

As $fs_{act} < fs_{max}$

I/P shaft is safe under torsional load

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2.4. Material used for tool holder

Table: 3. Tool holder

Designation	Ultimate tensile strength N/mm^2	Yield strength N/mm^2
EN8	520	360

2.4.1. Design of tool holder

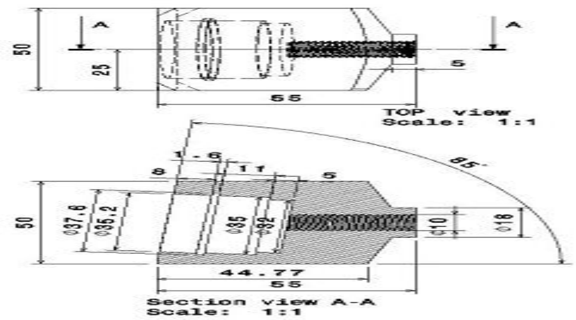

Fig.5.Tool holder

fs_{max} = uts/fos = 520/2 ; fs_{max}= 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

T design = 2.36 Nm

Td = $\Pi/16 \times fs_{act} *(D^4 - d^4)/D$; $fs_{act} = \frac{16*Td*D}{\Pi*(D4-d4)}$

Outside diameter of drum boss = 18mm ; Inside diameter of drum boss = 10mm

$fs_{act} = \frac{16*2.36*103*18}{\Pi*(184-104)}$; fs_{act} = 2.30 N/mm^2

As, $fs_{act} < fs_{max}$ is safe under torsional load.

2.5. Result table for 5 degree tool angle

Table: 4.Result for 5 degree tool angle

Sr.No.	Feed (mm/rev)	Cycle time (sec)	Tolerance	Rivet Strength(MPa)
01	0.05	21	0.25	232
02	0.058	18	0.22	235
03	0.066	15	0.18	236

04	0.075	14	0.16	240
05	0.0833	12	0.19	239
06	0.092	11	0.2	238
07	0.1	10	0.21	236

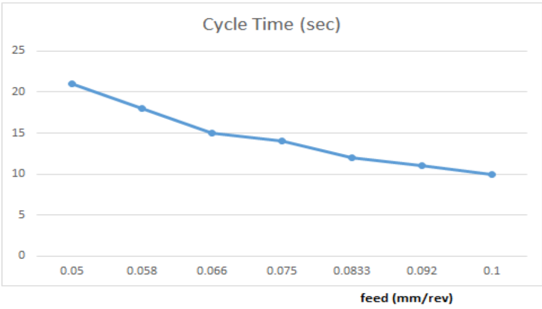

Fig.6.Graph of Cycle time Vs feed rate

The graph indicates that the cycle time reduces with increase in rate of table feed.

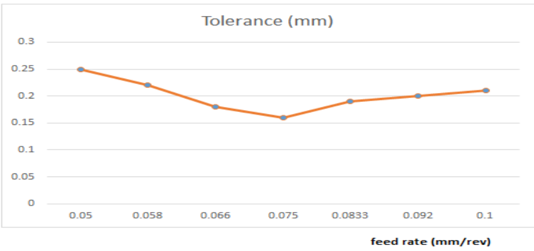

Fig.7. Graph of tolerance Vs Feed rate

The graph above indicates that the minimum tolerance is observed at a feed rate of 0.075 mm and so also all values are well below the permissible tolerance of +/- 0.5 mm

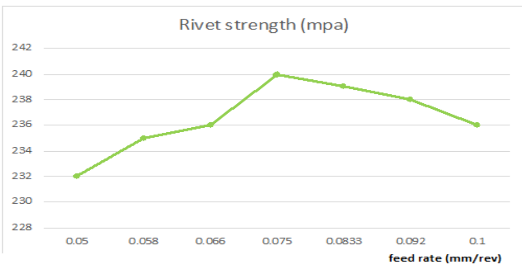

Figure.8. Graph of rivet strength Vs feed rate

The graph above indicates that the maximum strength of joint is observed at feed rate of 0.075 mm /rev but so also the values are in close agreement with the average strength of joint of 232 MPa.

2.6. Result table for 4 degree tool angle

Table: 5. Result for 4 degree tool angle

Sr.No.	Feed (mm/rev)	Cycle time (sec)	Tolerance	Rivet Strength(MPa)
01	0.05	24	0.31	218
02	0.058	21	0.26	221
03	0.066	18	0.23	226
04	0.075	16	0.2	224
05	0.0833	14	0.22	220
06	0.092	12	0.24	218
07	0.1	11	0.29	216

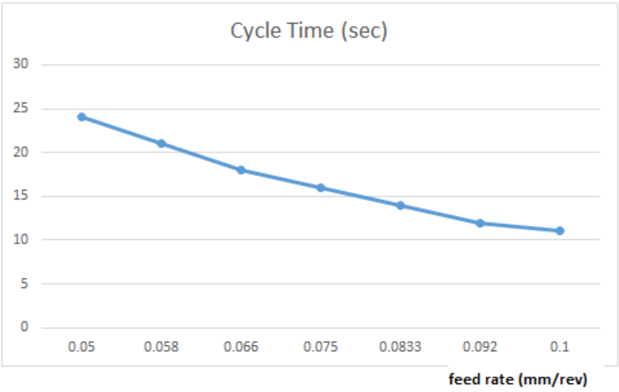

Fig.9.Graph of Cycle time Vs feed rate

The graph indicates that the cycle time reduces with increase in rate of table feed.

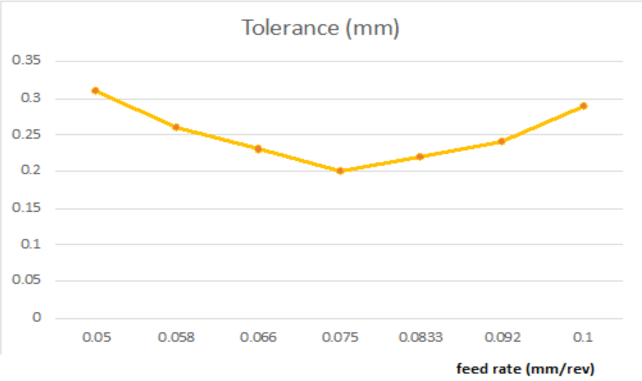

Fig.10.Graph of tolerance Vs Feed rate

The graph above indicates that the minimum tolerance is observed at a feed rate of 0.075 mm and so also all values are well below the permissible tolerance of +/- 0.5 mm.

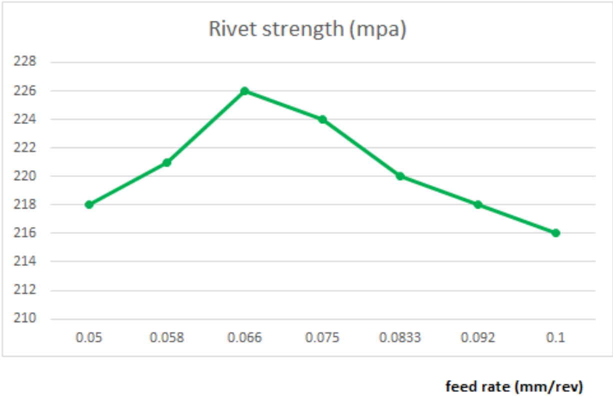

Fig.11. Graph of rivet strength Vs feed rate

The graph above indicates that the maximum strength of joint is observed at feed rate of 0.066 mm /rev but so also the values are in close agreement with the average strength of joint of 224 MPa.

2.7. Comparison graphs for 5 degree and 4 degree

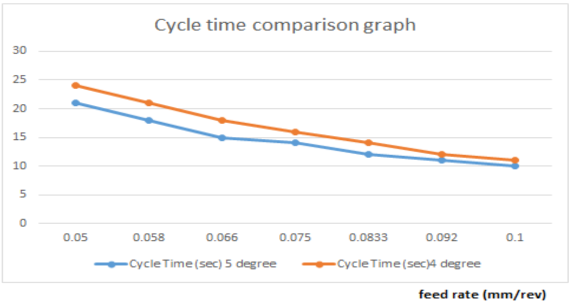

Fig.12. cycle time Comparison graphs for 5 degree and 4 degree

Graph indicates the cycle time is lower in case of the 5 degree tool angle, indicating that the 5 degree tool angle will result in better productivity as compared to the 4 degree tool angle.

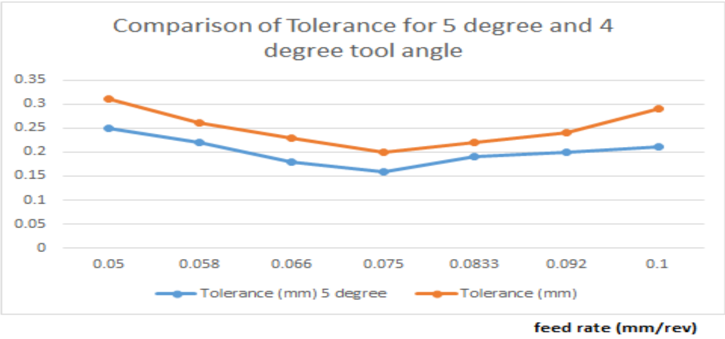

Fig.13.Tolerance Comparison graphs for 5 degree and 4 degree

Graph indicates the Tolerance is lower in case of the 5 degree tool angle, indicating that the 5 degree tool angle will result in better accuracy as compared to the 4 degree tool angle.

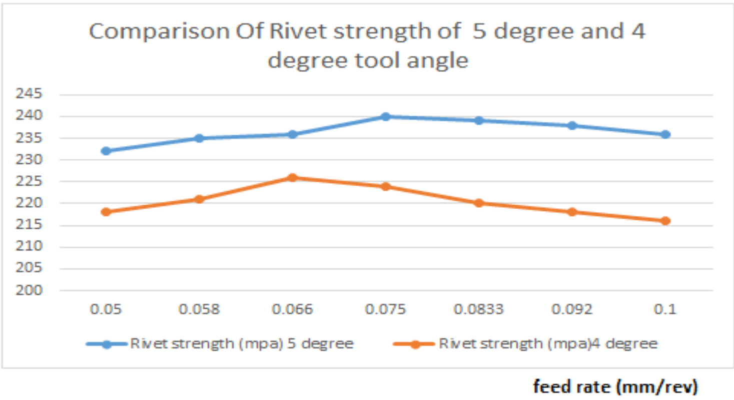

Fig.14.Rivet strength Comparison graphs for 5 degree and 4 degree

Graph indicates the Rivet Strength is higher in case of the 5 degree tool angle, indicating that the 5 degree tool angle will result in stronger joint as compared to the 4 degree tool angle.

III. CONCLUSIONS

1. Ansys Analysis was done again and the results of Vonmises stress and deformation were found out
2. Experimental analysis was done on two specimens of the optimal values.
3. The Results of experiment and Ansys analysis are also in close agreement. As the Analytical and Experimental results are in close agreement it is safe to say that the method to find the optimal values of the influential.
4. Graph indicate the cycle time is lower in case of the 5 degree tool angle , indicating that the 5 degree tool angle will result in better productivity as compared to the 4 degree tool angle.

5. Graph indicate the Tolerance is lower in case of the 5 degree tool angle , indicating that the 5 degree tool angle will result in better accuracy as compared to the 4 degree tool angle.
6. Graph indicate the Rivet Strength is higher in case of the 5 degree tool angle, indicating that the 5 degree tool angle will result in stronger joint as compared to the 4 degree tool angle.

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