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Design of Rivet Association Using FEM and Fabricating Using 3D Printing

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ABSTRACT:

The technology development in steel constitution has comprehensive in every discipline corresponding to theory, material, and process. The metal structure is constructed from the junction of exclusive metal member field by means of rivets, high-tensile bolt, welding, and so forth. Project deals with stress analysis of riveted lap joint subjected to eccentric load intensity. It is trial to prepare the rivet in such manner that riveted joint withstand for highest loading situation by way of altering the association of rivets for the equal no of rivets. For that made some specimen of lap joint of moderate steel plate dimension of 150 × 80 × 5 mm thick joint with 4 rivets in distinct method of arrangement and proven on numerical basis situation to find out maximum load bearing capacity of riveted joint. Optimization by using composite material for rivets. Calculating design stress from Analytical and compared with Numerical method. As per Design final product of rivet will be fabricated from 3D printing and test practically

INTRODUCTION:

3D Printing is a process for making a physical object from a three-dimensional digital model, typically by laying down many successive thin layers of a material. It brings a digital object (its CAD representation) into its physical form by adding layer by layer of materials. There are several different techniques to 3D Print an object. We will go in further details later in the Guide.

3D Printing brings two fundamental innovations: the manipulation of objects in their digital format and the manufacturing of new shapes by addition of material. Technology has affected recent human history probably more than any other field. Think of a light bulb, steam engine or, more latterly, cars and aeroplanes, not to mention the rise and rise of the world wide web. These technologies have made our lives better in many ways, opened up new avenues and possibilities, but usually it takes time, sometimes even decades, before the truly disruptive nature of the technology becomes apparent. It is widely believed that 3D printing or additive manufacturing (AM) has the vast potential to become one of these technologies.

3D printing has now been covered across many television channels, in mainstream newspapers and across online resources. What really is this 3D printing that some have claimed will put an end to traditional manufacturing as we know it, revolutionize design and impose geopolitical, economic, social, demographic, environmental and security implications to our everyday lives? The most basic, differentiating principle behind 3D printing is that it is an additive manufacturing process. And this is indeed the key because 3D printing is a radically different manufacturing method based on advanced technology that builds up parts, additively, in layers at the sub mm scale. This is fundamentally different from any other existing traditional manufacturing techniques.

There are a number of limitations to traditional manufacturing, which has widely been based on human labour and handmade • ideology rooting back to the etymological origins of the French word for manufacturing itself. However, the world of manufacturing has changed, and automated processes such as machining, casting, forming and moulding are all (relatively) new, complex processes that require machines, computers and robot technology.However, these technologies all demand subtracting material from a larger block â whether to achieve the end product itself or to produce a tool for casting or moulding processes and this is a serious limitation within the overall manufacturing process. For many applications traditional design and production processes impose a number of unacceptable constraints, including the expensive tooling as mentioned above, fixtures, and the need for assembly for complex parts. In addition, the subtractive manufacturing processes, such as machining, can result in up to 90% of the original block of material being wasted. In contrast, 3D printing is a process for creating objects directly, by adding material layer by layer in a variety of ways, depending on the technology used. Simplifying the ideology behind 3D printing, for anyone that is still trying to understand the concept (and there are many), it could be likened to the process of building something with Lego blocks automatically.

3D Printing Technologies:

The starting point for any 3D printing process is a 3D digital model, which can be created using a variety of 3D software programs in industry this is 3D CAD, for Makers and Consumers there are simpler, more accessible programs available or scanned with a 3D scanner. The model is then ‘sliced’ into layers, thereby converting the design into a file readable by the 3D printer. The material processed by the 3D printer is then layered according to the design and the process. As stated, there are a number of different types of 3D printing technologies, which process different materials in different ways to create the final object.

Functional plastics, metals, ceramics and sand are, now, all routinely used for industrial prototyping and production applications. Research is also being conducted for 3D printing bio materials and different types of food. Generally speaking though, at the entry level of the market, materials are much more limited. Plastic is currently the only widely used material — usually ABS or PLA, but there are a growing number of alternatives, including Nylon. There is also a growing number of entry level machines that have been adapted for foodstuffs, such as sugar and chocolate.

DLMS 3D PRINTER USED BY INTECH DLMS PRIVATE LIMITED

FASTENINGS BY RIVETED JOINTS:

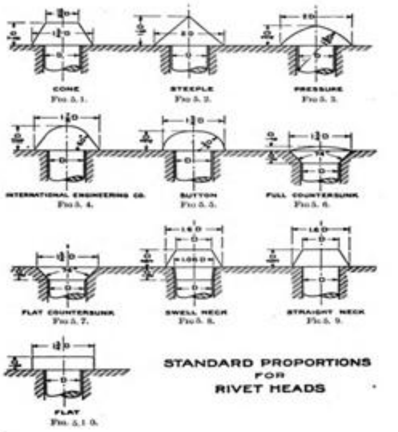
Rivets: — The rivet constitutes the simplest form of fastening. It consists essentially of a permanent bolt; the head, nut and body forming one piece. When once set in place it cannot be removed except by chipping off the head. Bolts and screws are usually arranged to hold their loads by axial tension. Owing to the flexibility in rivet heads, such fastenings are not considered wholly reliable when subjected to tension. Hence, when possible, rivets are set to bear their loads by shear. In some cases, such as the staying of the walls of certain pressure vessels, a small amount of flexibility is desirable to accommodate expansion and contraction. The rivet under such conditions is well adapted to hold a tensile load. Rivets are hot-pressed to shape from round bar stock. The shank is sometimes slightly tapered near its end to facilitate its entrance into the hole. One head and the shank are finished at the time of manufacture though the shape of the head may be altered later, due to the method of driving the rivet. For ease in placing rivets in position, their shanks are made one-sixteenth inch less in diameter than that of the holes they are to fill. When well set, however, they are assumed to fill the holes entirely. Therefore the actual diameter used in calculation, and that specified on design drawings, is the driven or hole diameter.

Rivet Heads:

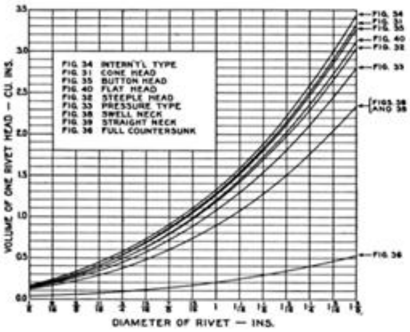
While there is no exact agreement among rivet manufacturers or users as to the standard shape of rivet heads, Figs. 1 to 10 inclusive show the usual proportions in terms of the actual or undriven diameter. The American Society of Mechanical Engineers has published in their Boiler Code a series of rivet heads especially designed for high pressure boilers. These heads do not differ essentially from those here illustrated. The particular form of the rivet head for a given case is determined by the purpose for which the joint is intended. When the riveting is designed merely to resist rupture, as for instance in the members of a roof truss, heads of smaller size and containing less material can safely be used. On the other hand when the seam must not only sustain severe stresses but be staunch enough to confine fluid pressure as well, heads of greater stiffness and amplitude must be used.

Figs. 5.1, 5.2, 5.3 and 5.4 show the proportions of heads generally used in pressure work, as their width and depth would indicate. The cone head, Fig. 5.1, is the usual one pressed upon commercial rivets as they come from the manufacturers. In hand-riveted work this head appears on the underside of the seam. Fig. illustrates the usual form of hand-driven rivet head. The straight slope of its-sides can be accurately fashioned with a hand hammer. The thin edges render it too flexible for heavy pressures and the sharp point is liable to burn off when used in externally-fired boilers. The type most widely used in machine riveting is shown in Fig.5.3. 'Its large diameter and staunch sides commend it for pressure use.

A special head very deep and stiff, used by the International Engineering Company in their boiler shop, is illustrated by Fig. 5.4. The usual form of structural head appears



STANDARD PROPORTIONS FOR RIVET HEADS



Volumes of Rivet Heads

Holes:

Preparing Rivet Holes — The injury done to the plate by punching holes may be partially remedied in two ways:

Annealing

Reaming

A thorough annealing after punching will restore in large measure the plate strength. The rough holes, however, are still severe in their action upon the rivets. It is generally impracticable to anneal portions of large sheets merely for the sake of the rivet holes. A more effective method is to drill or ream out the punched holes to size, thus removing the rough edges as well as the adjacent distorted plate. It is perfectly possible to ream several thicknesses of plate at once and thus secure a correct alignment of all the holes.

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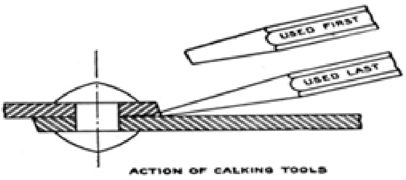
After punching and bending the plates to shape, the tank or boiler may be assembled and all the rivet holes reamed in place. In the case of plates1/4 in. and less in thickness, the punched hole is made1/8 in. less in diameter than the hole desired after reaming. For 5/16 in. plates and above, the punch must be 1/4 in. less in diameter than the finished hole, under Massachusetts Boiler Rules. When punched holes are so treated the strength of the metal between them is unimpaired. In very careful work the plates are taken apart after reaming and the burrs around the holes upon both surfaces removed by a special countersink.

Calking:

The distance of the rivet center back from the edge of the plate is governed by conditions of staunchness quite as much as of strength. There must be metal enough ahead of the rivets in all cases to prevent them from rupturing the lap. At the same time the lap must be a proper one to facilitate calking to tightness. The action of calking is represented by Fig.5.11. The flat-ended tool shown above actuated either by hand or pneumatic hammer, gives the lap edge a preliminary beating down and leaves a thin sharp edge. A second tool having a narrower end is then sub action of calking tools.



ACTION OF CALKING TOOLS

Lap Limits:

To be proof against leakage the lap acting like a deflected cantilever must react against the lower plate, Fig. 5.11, with an intensity of pressure greater than that of the fluid within. Tests have shown that while there are areas under the rivet heads where the fluid pressure does not penetrate, in general the calked edge itself, especially in new work, is the final barrier to leakage. It is perfectly evident, therefore, that short laps and rivets close together render the calking easy, while large pitches and long laps, due to continuous springing back, render the process difficult. On the other hand small laps are liable to fail by bursting out, while large ones remove all danger in this direction. A satisfactory method of designing laps, when considered from both of the above standpoints, will be given later.

Test Pressure:

Boilers and closed tanks are ordinarily calked to tightness under cold-water test pressure equal to one and one-half times the working pressure, as was noted under the Massachusetts State Rules in Chapter I. Usually the outside seams only are calked. In marine boilers and other very carefully riveted vessels, a preliminary calking is given to the inside laps. Absolute tightness is finally secured, however, by calking on the outside.

5.9 Friction between Plates — The question of friction between plates is regarded with varying degrees of importance. American designers for the most part recognize its presence and desirability in enhancing the holding power of riveted joints but doubt its value as a basis for calculation. European writers, how-ever, have held this feature in much higher esteem and have gone so far as to base a theory of joint design upon the intensity of the friction between plates. Inasmuch as it is known that joints slip or "take up" a little, while in use, it seems hardly possible that friction between plates can be relied upon as a holding power in joints. When plates are new and clean there is considerable slip discernible in the testing machine long before the working load of the joint is reached. An extended series of tests upon the holding power of riveted joints due to friction was made at the U. S. Arsenal at Watertown, Mass., in 1882. These tests show a wide variation in results depending upon the condition of the plate surfaces, but in all cases indicate considerable slippage at loads constituting but a fraction of the ultimate strength.

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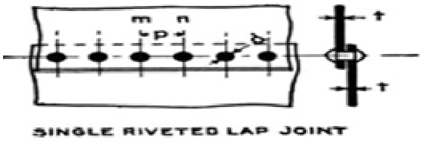
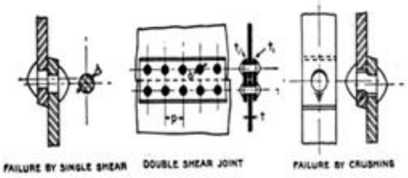
Riveted Joint Failures

Riveted joints may give way in either of four different ways:

(o) Tearing of the plate;
(b) Failure of the rivets;
(c) Tearing of plate and rivet failure combined;
(d) Lap rupture.



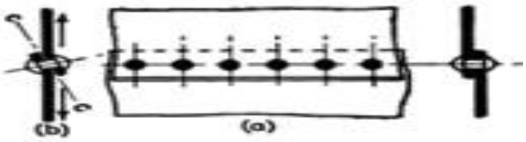


Lap Failure:

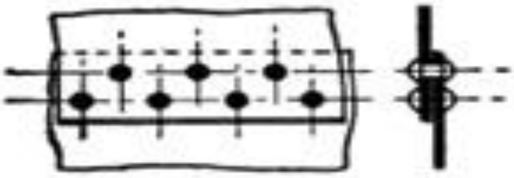
A fourth method of failure for riveted joints is by lap rupture. With very thin plate a rivet may be imagined to plow its way to the lap edge, as shown at b in Fig. 5.16, removing the plate in front of it by shear. As a matter of fact with practical sizes this rarely happens. The way in which lap rupture ordinarily occurs is represented by a,

LAP FAILURE

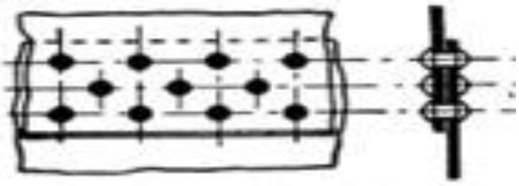
Types of Riveted Joints



Single riveted lap joint



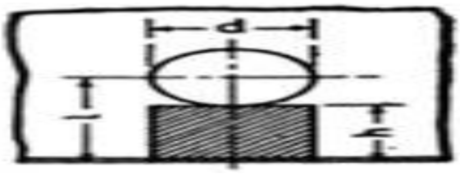
Double riveted lap joint



Triple riveted Lap Joint

Lap Calculation:

While the margin of plate I, Fig. 5.39,from edge to center of rivet hole is often arbitrarily assumed to be one and one-half times the driven rivet diameter, its Value is nevertheless a very important factor in the success of a riveted joint. As was briefly pointed out early in the discussion of riveted joints, Art. 29, page 93, the function of the lap is twofold. Its office in pressure work is, first, to provide a stiff piece of plate which, when initially sprung back by calking, will react against the other plate of the joint with sufficient intensity to prevent the escape of the fluid. The second object of the lap is to throw lap calculation



Lap Calculation:

Across in front of the rivets a piece of plate of width sufficient to bring the full rivet strength into play. It has been found by experiment to yield good practical results if the rivet load is taken as concentrated at the center of the lap-beam. The bending moment at the center of a beam so loaded is

$M = WL/8$

The letters having the usual significance. The load which the rivet can impose upon the lap-beam will depend upon the manner of rivet failure. Three cases may be considered:

I. Shearing the rivet once,
Load = πd2/4 fs
II. Shearing the rivet in double shear,Load = πd2/2 fs
Crushing the rivet or plate,
Load = dtfc
These three constitute all possible rivet loads.

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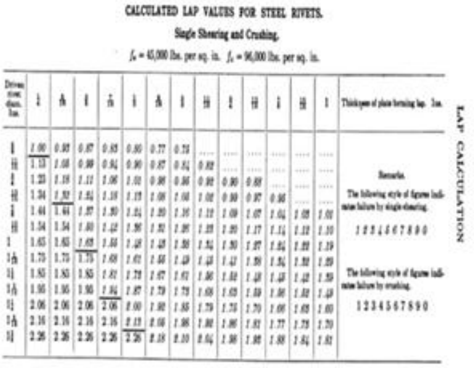
THEORITICAL RESULTS

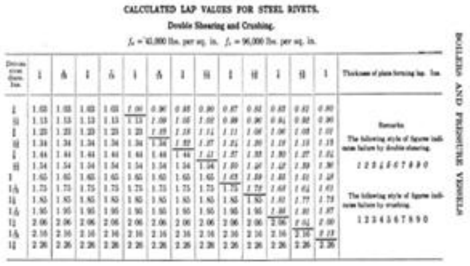

CALCULATED LAP VALUES FOR STEEL RIVETS.
Single Shearing and Crushing.
f_s = 45,000 lbs. per sq. in. f_c = 96,000 lbs. per sq. in.

Thickness of plate forming lap. Ins.

Remarks.
The following style of figures indicates failure by single shearing.
1 2 3 4 5 6 7 8 9 0
The following style of figures indicates failure by crushing.
1 2 3 4 5 6 7 8 9 0

LAP CALCULATION

Calculated Lap Values for Steel Rivets single shearing


CALCULATED LAP VALUES FOR STEEL RIVETS.
Double Shearing and Crushing.
f_s = 45,000 lbs. per sq. in. f_c = 96,000 lbs. per sq. in.

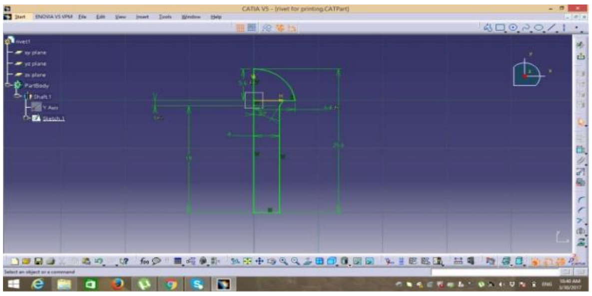
Thickness of plate forming lap. Ins.

Remarks.
The following style of figures indicates failure by double shearing.
1 2 3 4 5 6 7 8 9 0
The following style of figures indicates failure by crushing.
1 2 3 4 5 6 7 8 9 0

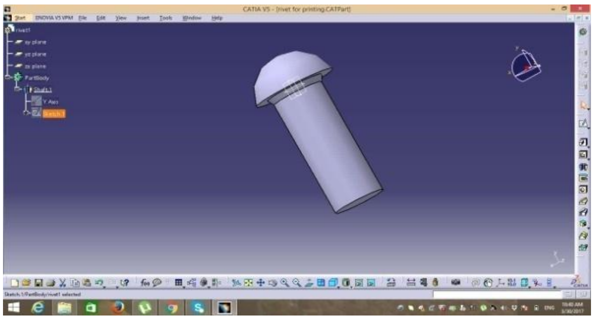
BOILERS AND PRESSURE VESSELS

Calculated Lap Values for steel Rivets for Double Shearing

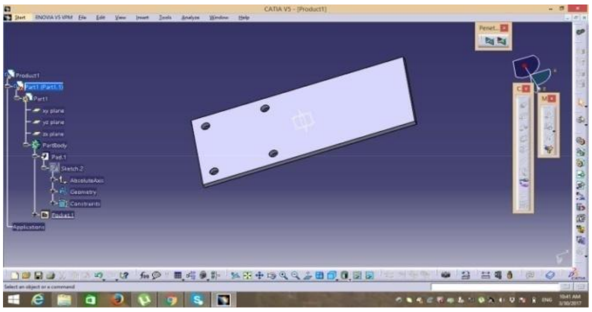
RIVET DESIGN I N CATIA SKETCHER



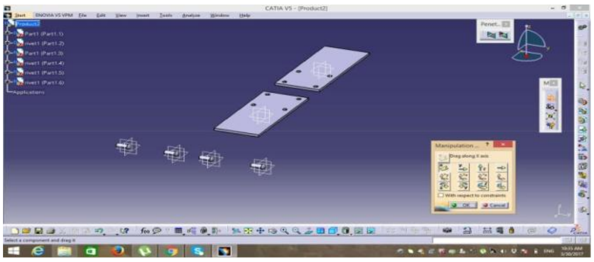
OPTIMISED REVIT



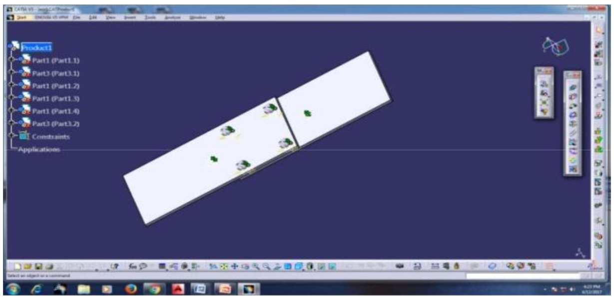
PLATE



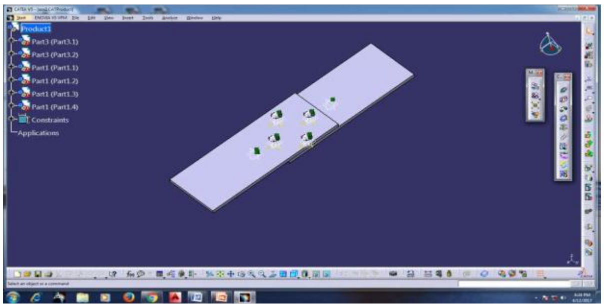
Importing individual part components into assembly design



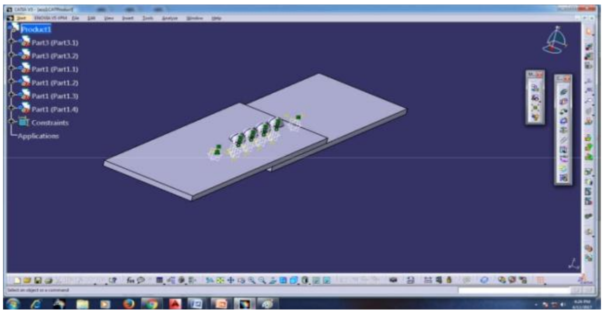
Rectangular Arrangement



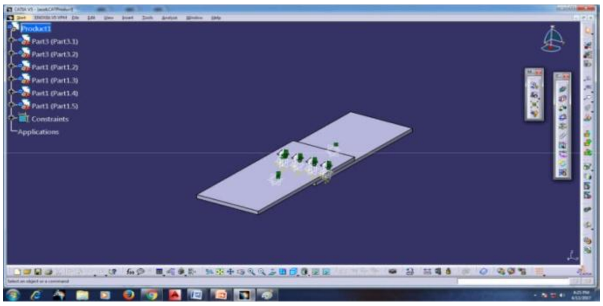
Diamond Arrangement



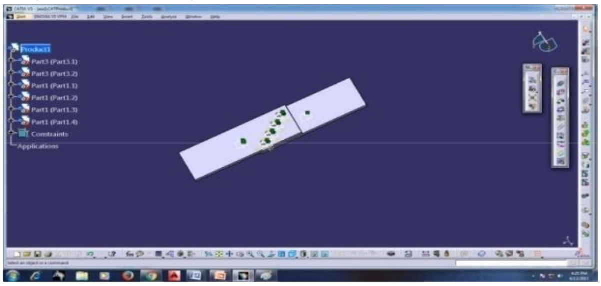
Horizontal Arrangement



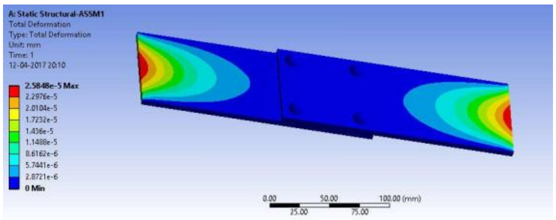
Vertical Arrangement



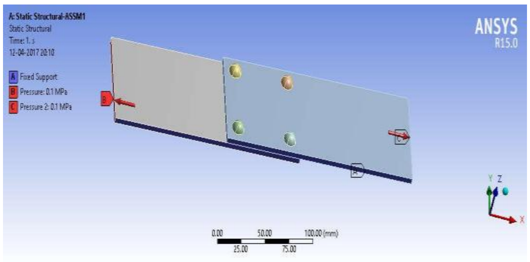
Diagonal Arrangement



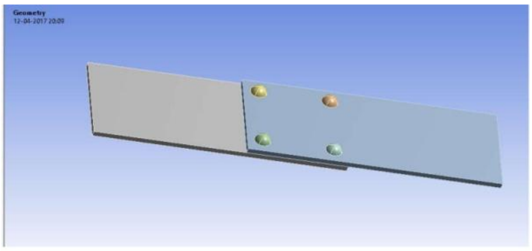
INPUT VALUES APPLIED ON THE RIVET ASSEMBLY IN ANSYS WORKBENCH

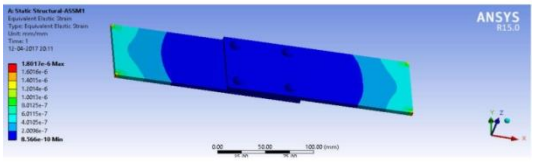


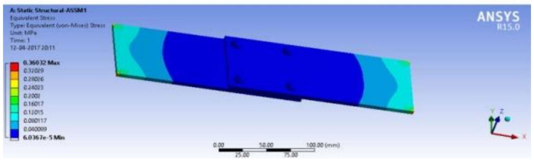
Static structural Analysis Total deformation



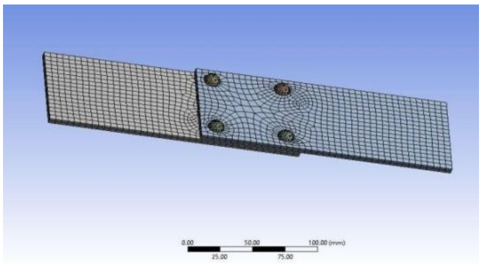
Pressures Applied



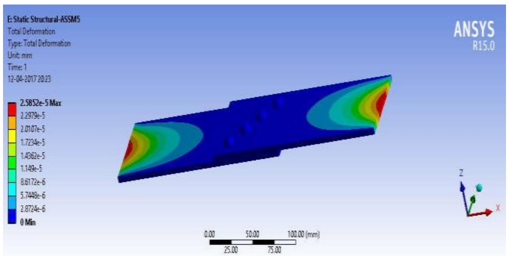




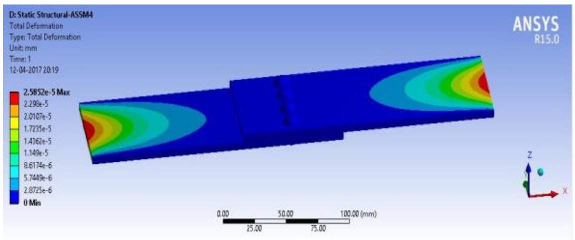
Shows the Stress and Strain Values



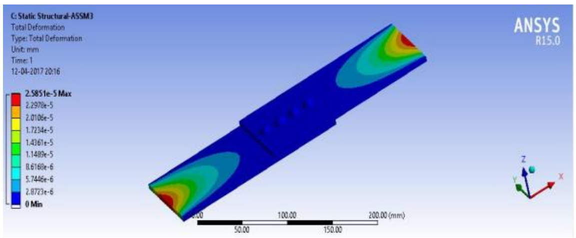
MESH GENERATION



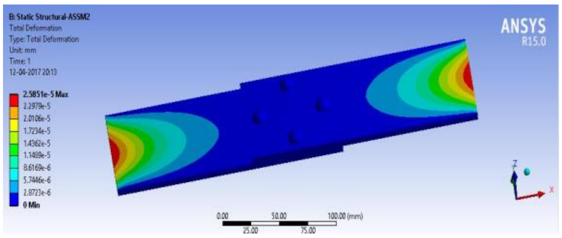
Diagonal Arrangement of Rivets



Horizontal Arrangement of rivets

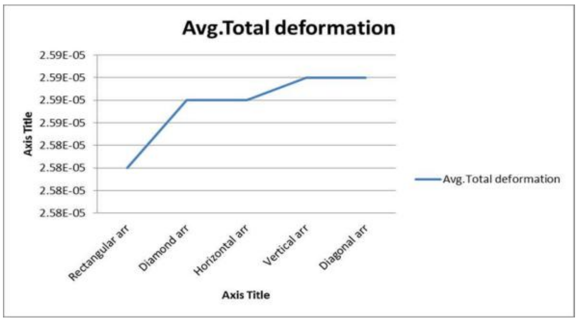


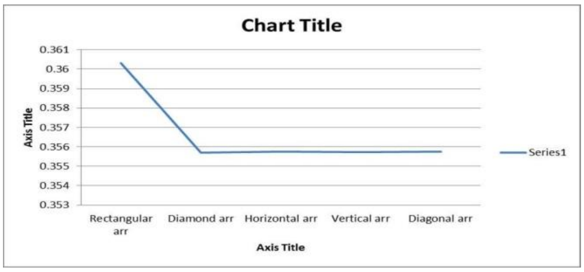
Vertical Arrangment of rivets



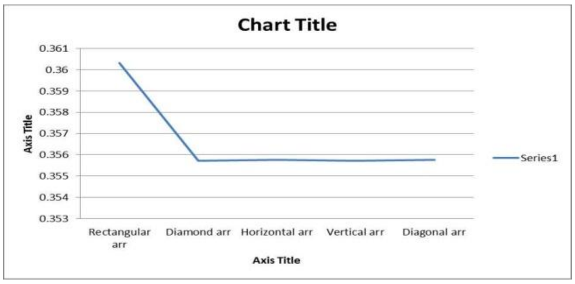
Diamond Arrangment of rivets

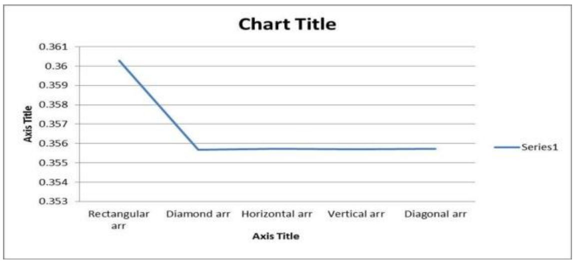
Sl No.	Rivet Arrangement	Avg. total deforamtion	Avt Von Miss stress
1	Rectangular	2.5848e-5	0.36032
2	Diamond	2.5851e-5	0.35571
3	Horizontal	2.5851e-5	0.35576
4	Vertical	2.5852e-5	0.35573
5	Diagonal	2.5852e-5	0.35576





Sl No.	Rivet Arrangement	FEA (MPa)	EXP (MPa)
1	Rectangular	0.36032	0.36029
2	Diamond	0.35571	0.35567
3	Horizontal	0.35576	0.35573
4	Vertical	0.35573	0.35569
5	Diagonal	0.35576	0.35572





EXPERIMETAL 3D PRINTED REVIT ASSEMBLY:

The pressure with stand capacity of a machined 8 mm rivet is 65 KN

Material Description:

4mm X 70 mm X 270 mm Lg. , 2 plates riveted with 8mm Dia. 3D printed rivets at a distance of 40mm & overlap of the plate is 100 mm. At temperature of 36 Degree centigrade of room temperature.

DRILLING

Riveted joint

Universal testing machine to apply load

Installing plates for testing

Tested breaking Load of 50 KN

CONCLUSION:

This report shed light on some interesting trends in 3D printing. The price history was somewhat predictable with massive drops in the initial years. In the years 2010 - 2015, there were vast developments in available technology and the introduction of many new companies. Both of these factors would play a large role in the average price dropping considerably. Another interesting statistic was the lack of improvement in the average print volume. As previously mentioned this may have been a result of different priorities and limited room for improvement on the cheaper, lower-end of the market. The final prediction was that the average price of a fully assembled entry level 3D printer would drop below $300 in the year 2018. I feel this is a fairly accurate and realistic prediction.

Even if it is 5 years before they are in every household, the printers will become increasingly available. Already in the USA, there are many private stores that own and rent 3D printers. There are currently world changing applications for 3D printers being developed for the future. Such developments include printing edible for manufacturing, medical, etc.. These developments, if achieved could positively affect the lives of millions of people

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