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INDEX

Sr. No.	Title	Author	Subject	Page No.
1	Cost of capital: an empirical case study of hindustan unilever limited	Dr. Vinod K. Ramani	Accountancy	1-2
2	Self Revolution	Mohanapriya.P	Arts	3-4
3	Wound healing activity of Cestrum elegans	V. Subhaa, Dr. D. Sukumarb, Dr. V. Elangoc	Chemistry	5-6
4	Anti Bacterial Activity of Apigenin 7-0-(6"caffeoyl) neohesperidoside from chrysanthemum indicum	M.Jerome Rozario, Dr.A.John Merina, Dr.V.Srinivasana	Chemistry	7-10
5	Adsorption Studies of Cu (II) and Cr (VI) from metal solution using crosslinked chitosan-g-acrylonitrile copolymer	Shankar.P, Gomathi T., Vijayalakshmi.K, Sudha P.N	Chemistry	11-13
6	An Insight into Derivative Markets: Indian Perspective	Dr. C.Shobha, Dr. T. Hanumantha raya	Commerce	14-16
7	Vision and Planning	Dr. J. K Sehgal	Commerce	17-18
8	An Analytical Study of Employee's Productivity in Some Selected Nationalized Banks of India	Dr. Jyotindra M. Jani, Manish B. Raval	Commerce	19-20
9	New Products of Tourism in India	Dr. M. K. Maru	Commerce	21-22
10	Inventory Management in Sugar Mills - A Comparative Study	Promila	Commerce	23-25
11	Price -Mix Straregy of Jammu and Kashmir Co-Operatives Supply and Marketing Federation Limited in Jammu District of J&K State	Tarsem Lal	Commerce	26-28
12	Warehouse Management Information System: A New Perspective in Supply Chain Management	Dr. Vipul Chalotra	Commerce	29-30
13	A Study on Consumer Satisfaction of Aavin Milk in Salem City	Dr.A.Vinayagamoorthy, Mrs. M.Sangeetha, C.Sankar	Commerce	31-33
14	Hybrid Attribute Selection Process for Decision Tree Based Classification Algorithms	Mr. A. Jebamalai Robinson, Mrs. S. C. Punitha, Dr. P. Ranjit Jeba Thangaiah	Computer Science	34-36
15	Visualizing the validation of UML diagrams	Lavleen Kambow	Computer Science	37-38
16	Effectiveness of coconut palm insurance scheme in the coastal belts of India-A SWOT analysis	Prof. (Dr.) D. Rajasenan, Bijith George Abraham	Economics	39-41
17	An Analysis of the Efficiency of Selected Public and Private Banks in India during 2005-2011	Dr.Dinesh Kumar, Sanjeev	Economics	42-44
18	Measurement of Emotional Development of the Students	Dr. Nivedita K. Deshmukh	Education	45-46
19	A comparative study of effect of method of lecture and dramatization of Marathi teaching	Dr. Nivedita K. Deshmukh	Education	47-48
20	Peer pressure-problems and solutions	V.Vaithyanathan, Dr.P.Sivakumar	Education	49-50
21	Language Anxiety In Indian L2 Learners: Male or Female Learners - Who Scores High?	S. Gandhimathi, Dr.R.Ganesan	Education	51-52

22	Topological Characteristics of ECG Signal using Lyapunov Exponent and RBF Network	Abinash Dahal, Deepashree Devaraj, Dr. N. Pradhan	Engineering	53-55
23	Development of slicing package of solid model for cone and sphere in rapid prototyping	Dineshkumar M. Patel, Prof. P.D.Solanki	Engineering	56-58
24	Hardware modeling Simulation with COSSAP	Krunali Amrutlal Ratanpara, Devendra Soni, Shrenik Rajesh Golwelkar	Engineering	59-61
25	Coordination Of Pss And Statcom To Enhance The Power System Transient Stability	Lalit K. Patel, Kaushik M. Sangada, Sunil S. Changlani , Ankit M. Patel	Engineering	62-64
26	Cooling Performance Analysis of Heat Sink	Mr. Pritesh S. Patel, Prof. Dattatraya G. Subhedar, Prof. Kamlesh V. Chauhan	Engineering	65-67
27	Thermal Modeling and Analysis of Friction Stir Welding	Rankit Patel, Prof. Bindu Pillai	Engineering	68-70
28	Review on shrinkage defect – A case study	Mr. Ravi N. Kalotra, Mr. Gajanan Patange, Mr. J.K. Gohil	Engineering	71-75
29	Stream Function Formulation of Lid Driven Cavity	Mr. Zankhan C. Sonara, Prof. Dattatraya G. Subhedar, Mr. Kartik Patel	Engineering	76-78
30	Implementation of ABT (Availability Based Tariff) - its Treatment & Proceedings	Dilip m.Bhankhodiya, Dipak t. Vaghela	Engineering	79-82
31	Active Filters for Power Quality Improvement	Dipak t. Vaghela, Dilip m. Bhankhodiya	Engineering	83-87
32	Design and Analysis of Air Bearing using Orifice and Feed Hole Pocket	Nileshkumar T. Raval, Prof. M.Y.Patil	Engineering	88-90
33	Drip irrigation technique enhancing water and fertiliser use efficiency in cauliflower	Dr. S.S. Yadav, Dr. R.S. Meena	Engineering	91-92
34	Experimental and FEA Evaluation of Hybrid Joint Strength of Single Lap joint.	S. S. Kadam, P. A. Dixit	Engineering	93-96
35	CFD Analysis of Mixed Flow Submersible pump Impeller	Mitul G Patel, Subhedar Dattatraya, Bharat J Patel	Engineering	97-100
36	EVA: An Innovative Parameter for Shareholders' Wealth Measurement	Shri. Arvind A. Dhond	Finance	101-103
37	Profitability and consistency analysis of Textile Sector in India	Dr. K. S. Vataliya, Rajesh Jadav	Finance	104-107
38	Harmonious Relationship between Art and Music Critical vision (comparison)	Dr. Marwan Imran	Fine Arts	108-109
39	Land Use Pattern and Crop Combination Region in Satara District : A Geographical Study	Dr. Rathod S. B., Mane-Deshmukh R. S.	Geography	110-111
40	Garlic---Benefits and Uses	Dr. Sneh Harshinder Sharma	Geography	112-114
41	An Assessment of Thermal Comfort Zones in Terms of Tourists: A case study of Karveer Tehsil	Mr. Prashant Tanaji Patil, Miss. Mane madhuri maruti, Miss. Mugade Nisha Ramchandra	Geography	115-117

42	Hematological changes due to the impact of Lead nitrate on economically important estuarine fish <i>Mystus gulio</i>	Dr.S.Palani Kumar	Horticulture	118-119
43	Stress Management level in the employees of Manufacture Industries By considering key parameters with reference to Bhavnagar city	Dr. K. S. Vataliya, Adv. Ajay H. Thakkar	Human Resource	120-122
44	The Case of ABC Group-A Case on Performance Appraisal System	Shivani Sah	Human Resource Management	123-124
45	A Study On Performance Appraisal of Employees in Health Care Industry in a Private Multi-Speciality Organization	Dr. C. Swarnalatha, T.S. Prasanna	Human Resource Management	125-126
46	(Upanyas - Jansi ki Rani Laxmibai (vrundavanlal varma)	Dr. Sneh Harshinder Sharma	Literature	127-128
47	"Educational Technology for Professional Development of English Teachers: A Case Study of the College Teachers of English in Jammu Province"	Dr. Wajahat Hussain	Literature	129-130
48	The Reality of Sultana's Dream: A step towards success Rokeya Sakhawat Hossein	Riju Sharma, Ruchee Aggarwal	Literature	131-132
49	Road blocks of Match Industry in Andhra Pradesh: Certain Issues and Concerns	Anuradha Averineni	Management	133-134
50	Government's Assistance Towards the Development of Small Scale Industries in India with Special Reference to Krishnagiri District	B. Mohandhas, Dr. G. Prabakaran	Management	135-140
51	Effects of Role Stress on Employee Job Satisfaction and Turnover	Dr. T.G.Vijaya, R.Hemamalini	Management	141-144
52	"MNP – A major concern of Telecom Operators in Gujarat"	Mohsinali Momin, Dr. Deepak H. Tekwani	Management	145-147
53	A Study on Fiscal Support Provided by Vijaya Bank to Msme in Coimbatore City	Mrs. G. Murali Manokari, Mr. G. Lenin Kumar, Mrs. G. Sathiya	Management	148-150
54	Competencies for HR Professionals	GAYATHRI. M	Management	151-153
55	Cost and Strategic Management - Application, Framework and Strategies for the Growth of Sme Sector	Manisha gaur	Management	154-156
56	Development of Management Education System in India	Mr. Goudappa Malipatil	Management	157-158
57	Study on Volatility and Return of Major Indices of Indian Stock Market with Reference to Sensex And Nifty	Mr. Mukesh C .Ajmera	Management	159-160
58	A Need for an Epitome Shift in Management Education A study on Conceptual Teaching practices	Mrs. Vanishree K. Jamashetti, Mr. Sanjeev Rathod	Management	161-162
59	Personal Social Responsibility – A novel thought	Parul Jain, Dr. N.C Pahariya	Management	163-164
60	Green Marketing – A Consumer's Perspective in the Indian Scenario	Nidhi Srivastava, Preeti Pillai	Management	165-166
61	Challenges and Opportunities of Mobile Banking - An Indian Scenario	Sandhya.Ch.V.L	Management	167-169
62	A pragmatic study of civilizing amortment among The diverse countries	Mr. Vimal P. Jagad, Mr Mukesh .C Ajmera	Management	170-171
63	Celebrity Endorsement in India An Effective Tool of Sales Promotion	Piyush Shah, Dr. N C Pahariya	Management	172-176

64	A Study of Prominent Character Strengths and Their Relationship with Well Being Among Business Management Students	GarimaKamboj, DikshaKakkar	Management	177-180
65	Coffee Consumption in India: An Exploratory Study	Shri. Arvind A. Dhond	Marketing	181-183
66	Applicability of Retail Service Quality Scale (RSQS) in India	M. Ramakrishnan, Dr. Sudharani Ravindran	Marketing	184-186
67	Account Holders perceptions towards Self Service Technologies: a study of selected Private Sector Banks	Dr A Kumar, Prof Ankur Gangal	Marketing	187-189
68	Impact of Sales Promotion on Sales figures of Select International FMCG Brands	Dr.Sharif Memon	Marketing	190-193
69	Factors Affecting Green Product Design: Marketing Professional's Perspective	D. S. Rohini Samarasinghe	Marketing	194-196
70	The Impact of 'Ambience' and Variety on Consumer Delight: A Study on Consumer Behaviour in Ahmedabad	Dr A Kumar, Prof Vineeta Gangal	Marketing	197-200
71	Co-Relation of Social Justice with Human Rights: A Review	Dr. Monica Narang	Marketing	201-202
72	Study of Iron Status and Free Radical Activity in Plasmodium Falciparum and Plasmodium Vivax Malaria Infection	Sangita M. Patil, Ramchandra K. Padalkar	Medical Sciences	203-205
73	GOAL SETTING TENDENCIES, COMMUNICATION SKILLS AND WORK MOTIVATION VIS-À-VIS AGE DIFFERENCE – A STUDY ON PUBLIC SECTOR ORGANIZATION	Dr. Swaha Bhattacharya, Dr. Monimala Mukherjee	Psychology	206-208
74	Role of NGOs in Social Mobilization in the context of SGSY	Dr.Veershetty C. Tadalapur	Sociology	209-211
75	Age at menarche and its secular trend in rural and urban girls of bathinda district	Jyoti Sharma, Dr. Ajita	Sports Science	212-213
76	Effect Of Resin Finishing On Stiffness And Drape Of Khadi Fabric	Dr. Suman pant, Ms. Noopur Sonee	Textiles	214-216



Experimental and FEA Evaluation of Hybrid Joint Strength of Single Lap joint.

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ABSTRACT

Hybrid joint deals with joining of two dissimilar metals or dissimilar joints like Bolted-Bonded, Riveted-bonded, Welded-riveted etc. Metal joint plays an important role in load transfer through the assemblies which gives importance in metal joints. Current paper deals with the experimental and analytical analysis of rivet joint, adhesive joints & Rivet-Adhesive. Joints (Hybrid Joint).

Keywords : Rivet, Adhesive, Hybrid joint, Strength

Introduction

Often small machine components are joined together to form a larger machine part. Design of joints is as important as that of machine components because a weak joint may spoil the utility of a carefully designed machine part. Mechanical joints are broadly classified into two classes viz., non-permanent joints and permanent joints. Non-permanent joints can be assembled and disassembled without damaging the components. Examples of such joints are threaded fasteners (like screw-joints), keys and couplings etc. Permanent joints cannot be disassembled without damaging the components. These joints can be of two kinds depending upon the nature of force that holds the two parts. The force can be of mechanical origin, for example, riveted joints, joints formed by press or interference fit etc, where two components are joined by applying mechanical force. The components can also be joined by molecular force, for example, welded joints, brazed joints, joints with adhesives etc. Not until long ago riveted joints were very often used to join structural members permanently. However, significant improvement in welding and bolted joints has curtailed the use of these joints. Even then, rivets are used in structures, ship body, bridge, tanks and shells, where high joint strength is required.[11] Modern applications for adhesives are very diverse, ranging from aircraft, automobile and civil structures to pressure sensitive films and tapes. Some of the attributes should possess include: the ability to distribute external loads within the bonded joint, the ability to carry static and fatigue loads throughout the service life of the bonded joint, and the ability to adequately wet and bond to the adherent

Surfaces and make for a durable bond over the service life of the intended application. Adhesives are classified in many different ways, and some of the most common ways of classification depends on i) their physical appearance or state, ii) chemical composition or functionality, iii) curing or processing conditions and iv) end use or final. Application. [12] In hybrid joining two or more joining operations are carried out either simultaneously or sequentially, leading to enhanced properties of the joint due to a synergistic load bearing interaction under service conditions. Combining pressure sensitive adhesive bonding with mechanical joining or with structural adhesives can offer advantages in terms of processability and load bearing capacity when high levels of both static and dynamic mechanical resistance are required. Hybrid joining has become a preferred practice in the assembly of modern lightweight automotive and commercial vehicle structures. One of the reasons for this development has been the increased demand in

mixed material design (e.g. as in combinations of steel and aluminum parts) that cannot be realized with traditional joining technologies such as welding. Furthermore combining different joining technologies in hybrid joining can build on their individual strengths and advantages and counterbalance specific weaknesses. Such hybrid joining technologies are, for example, being used today in the automotive industry for the manufacturing of the body in white (BIW) structure, where BIW refers to the stage in which the car body sheet metal parts (including doors, hoods etc.) have been assembled but components like chassis, engine and trim have not yet been added. Today's standard practices in hybrid joining with adhesives include spot weld bonding, hem flange folding and bonding, clinch bonding and adhesive bonding in combination with self-piercing rivets.[13] In the proposed work the finite element analysis and experimental analysis is carried out to finding out the strength of hybrid joint, riveted joint and an adhesive joint .

A) Hybrid joining creates robust, attractive assemblies

Aerospace and automotive manufacturers have been incorporating hybrid joining into their production for years now this joining method, however, has been largely ignored by appliance manufacturers.

A novel approach to assembly construction, the method is surely applicable within the appliance industry and stands to benefit both appliance manufacturers and end

Users. Hybrid joining refers to the use of an adhesive in combination with a mechanical method of joining. There are three main varieties of hybrid joining: rivet-bonding, weld-bonding [4].

B) Hybrid joints for an assembly.

i) A more recent study examined the influence of several joining process relative to geometrical and environments factors. It was generally found that in comparison with simple welded joints, hybrid weld-bonded joints, there is a strong reduction of dependence from temperature and aging. With other methods of hybrid-fastened joints, the contribution of the adhesive bonding to the maximum load is very high, while a generally little reduction of relevance of temperature and aging was found.[10]

ii) Hybrid joining also can produce assemblies that are watertight and corrosion-resistant, owing to the adhesive's coating and sealing the substrate. Assemblies wrought by hybrid joining also exhibit high fatigue resistance, which has made

the method a favorite among the aerospace and automotive industries [4]

iii) The use of hybrid joining could also lead to other benefits such as increased joint rigidity, contributing to overall stiffness gains and reduction of vehicle mass. Additionally, the use of adhesive in conjunction with mechanical fasteners could significantly reduce stress concentrations, which serve as locations for crack starters. Hybrid joining methods can also provide additional joint continuity to allow increased spacing between fasteners or weld. [7]

2. EXPERIMENTAL ANALYSIS

For the experimental analysis it requires the following Material.

- i) Adhesive
- ii) M.S. Rivet.
- iii) Al-Plates of 100mm length.(as per ASTM std)

2.1 Adhesive.

The test was carried about with an adhesive of the company Locite as request of the sponsoring company. The adhesive used was the Hysol product E-214HP is a light paste, industrial grade epoxy adhesive. This one-component, no-mix, and heat activated formulation develops tough, strong, structural bonds. Which provide excellent peel resistance and impact strength. Bonds to wide variety of materials, including metals, glass, ceramics and plastics, these are the typical application of this product.

2.2 Lap Joint.

For the experimental setup the Al- Al lap joint was taken into consideration with the following configuration.

- i) Al-Al lap joint with rivet joint
- ii) Al-Al lap joint with the adhesive joint
- iii) Al-Al lap joint with Hybrid (Adhesive-riveted) joint.

2.3 M.S. Rivet

Simple M.S. Rivet of 3.5 mm diameter.

3. EXPERIMENTAL RESULTS.

Testing was carried out using universal testing machine having maximum capacity 100Kn/10Tone (star testing machine model: STS 248, software based) (see fig 2) one end of the sample was held by a lower self tightening grip. That was fixed. And the other end was held by an upper grip that operates at a constant rate of the 5mm/min.

Load was applied using load cell at a speed of 5mm/min load required to shear the specimen. Load/displacement graph were recorded on the software. For the different joints configurations.

Table 1

Sr. No	Lap joint	Total load carried in N
1	Adhesive alone	3875N
2	Rivet alone	3865N
3	Hybrid joint (MS+Rivet)	5185 N

The following diagrams can verify the data obtained in experimental set up which themselves have been got from the mentioned experimentation.



Fig: 1 Hybrid joint on tensile testing machine.

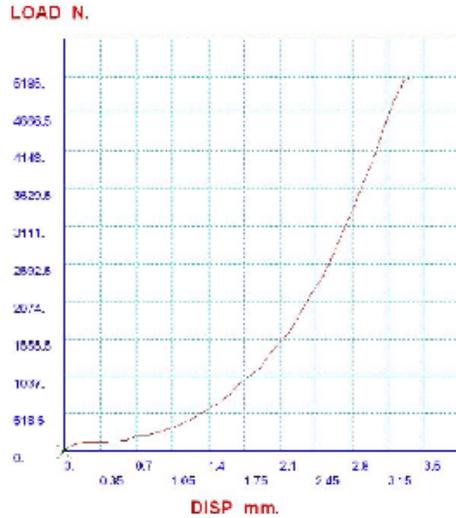


Fig 2 Load vs. displacement graph (Hybrid joint) Used M.S. Rivet.

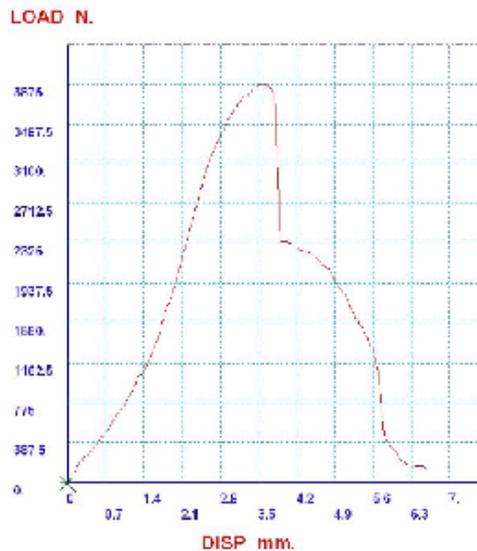


Fig 3 Load vs. displacement graph (Adhesive alone)

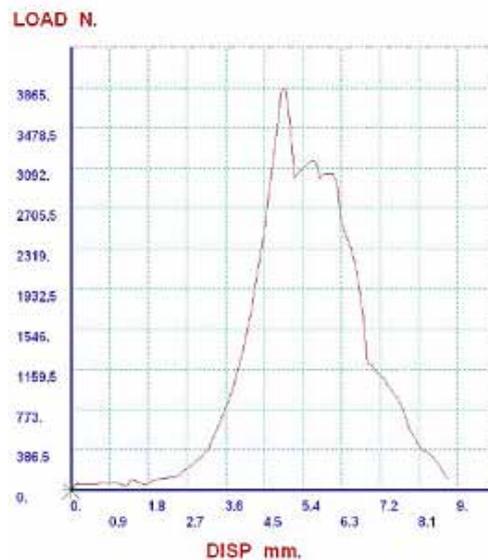
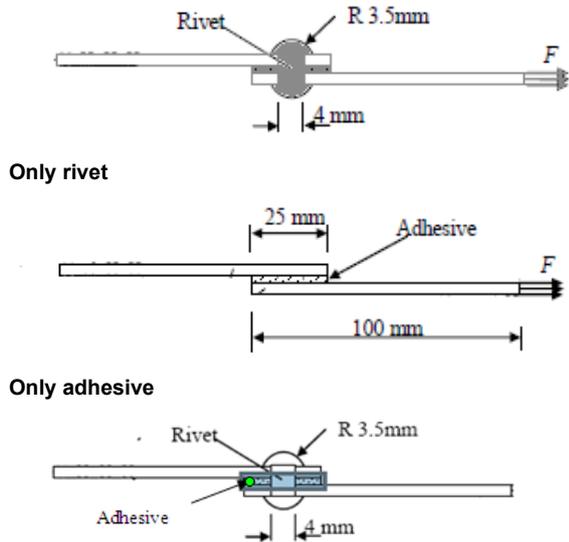


Fig 4 Load vs. displacement graph (Rivet only)

4. FINITE ELEMENT ANALYSIS

In the present work, the finite element analysis was carried out using UG NASTRAN software. A 3D cad model was created. And carried out shear test for the same load .for Rivet joint, Adhesive joint, Hybrid joint. The stresses occur for each configuration during the analysis is shown in Table 3.

The result is comparing with the load versus displacement diagram value obtained in Experimental analysis. Figure 5. Shows the simple lap joint (2D) of different joint configuration.



Rivet-adhesive bonding

Figure 5

Table 2 Material properties of rivet - adhesive.

Material	Yield strength(MPa)
Aluminum	179
Mild steel	250
Adhesive	30(Shear strength).

Parametric Solid model of the plate assembly with adhesive and rivet joint in between them has made. As shown in fig 4.

- Adhesive modeled with 0.38 mm thickness between the plates.
- Load applied at the end of the plate.
- Surface to surface contact applied between the Adhesive and plate.

5. FEA STEPS.

FEA was performing on. Following steps.

- Cad modeling
 - Meshing
 - Joint preparation
 - Thickness and material assignment
 - Boundary conditions
 - Surface to surface Contact
- i) CAD model of the plate assembly with adhesive and rivet joint between them.

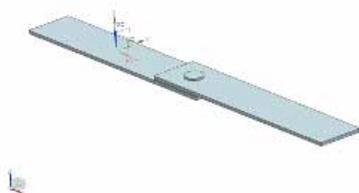


Fig 5.1

Finite elemnt model and Boundary conditions

ii)Meshing

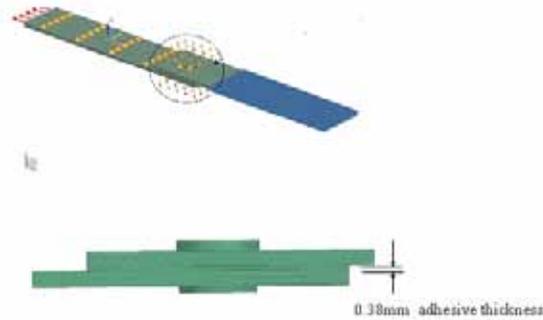


Fig 4.2

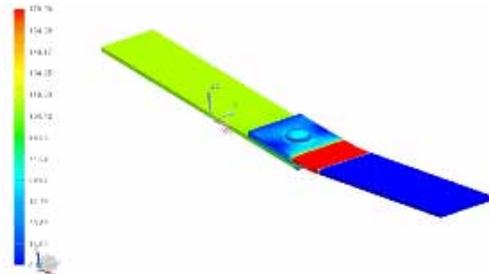


Fig 5.3 Finite element Analysis of Hybrid joint

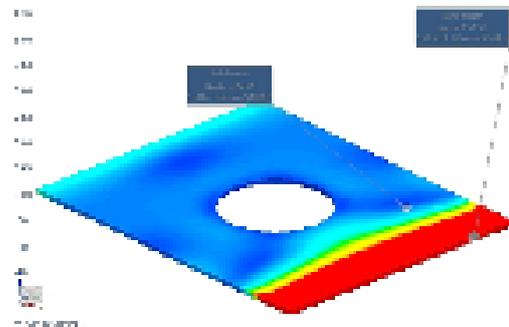


Fig 5.4 (Stresses in adhesive)

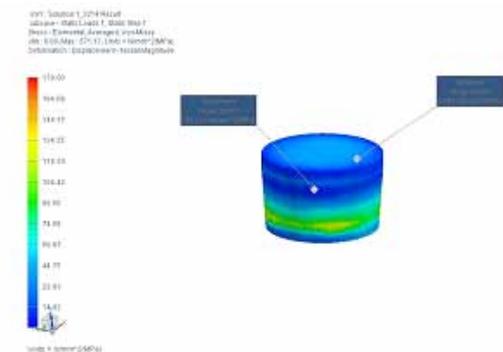


Fig 5.5 (Stresses in M.S rivet.)

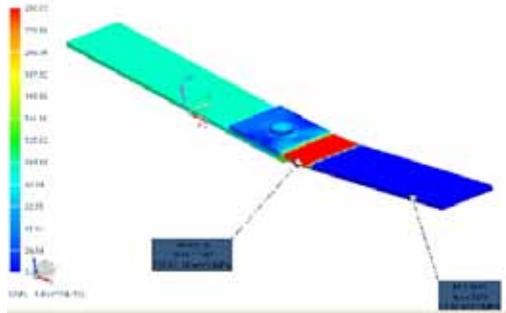


Fig 5. 6 FEA of (only) Rivet joint.

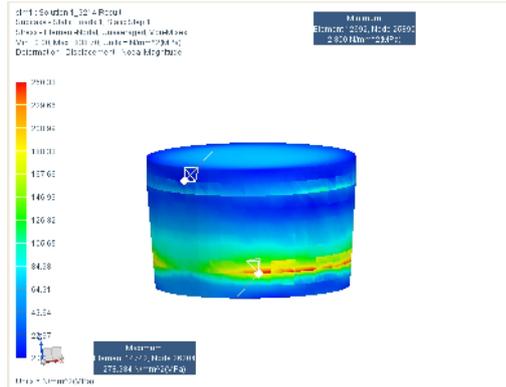


Fig 5. 7 Stresses occur in only Rivet. Joint.

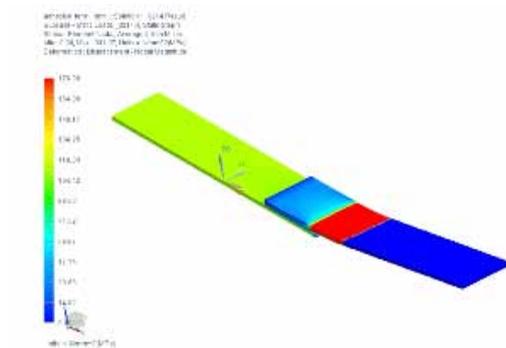


Fig 5. 8 FEA of only Adhesive joint.

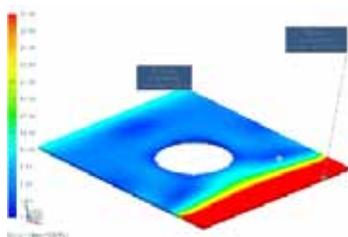


Fig 5. 9 Stresses occur only in adhesive.

Table 3

Lap joint	Yield strength (MPa)	Stresses occur (MPa)	Factor of safety
Rivet alone M.S.	250 MPa	278	0.89
Adhesive alone.	30MPa (Shear strength)	266	0.112
Hybrid joint (stresses occur only in Adhesive)	30 MPa (Shear strength)	234	0.128
Hybrid joint (stresses occur only in MS-Rivet)	250 Mpa	152	1.6
Hybrid joint (stresses occur only in AL-Rivet)	179 Mpa	119	1.5

6. Result and discussions.

The factor of safety must be greater than one to prevent the failure. as shown in table 3, For the lap joint of only rivet joint (M.S. Rivet) the stresses occur was 278 MPa.250<278 hence it is less than the yield strength of M.S Rivet. So the FOS became 0.89. <1

When plate is bonded with only adhesive the stresses occur

Are 266 MPa. 266>30 MPa (Shear strength of adhesive) plate get fail. When the lap joint of adhesive- rivet (Al-rivet) was taken, stresses occur in adhesive is 234 MPa. That means 266 Mpa reduced to 234 hence other load taken by al rivet. And stresses occur in Al rivet is 242, which is greater than its yield strength 179 MPa. 119< 179 MPa.

Factor of safety for al hybrid joint is 179/119 =1.5. >1. Adhesive-rivet (M.S) was taken stresses occur in adhesive become 232 Mpa hence the stresses is around the range of 200Mpa >30 MPa. At the same time stresses occur in the M.S. rivet is 119 MPa< 250MPa. Factor of safety For M.S. hybrid joint is 250/152 = 1.6.>1 so stresses occur in the Hybrid joint is within the yield strength limit, as its FOS is greater than 1.hence this configuration having high load carrying capacity

Compare to only adhesive or only rivet joint. This is experimentally proved.

7. Conclusions

1. The adhesive bond with M.S. Rivet (Hybrid joint) gives high load carrying capacity.
2. Also decreases the stresses developed in adhesive.
3. Correctly designed rivet/bonded joints are much stronger than the adhesive only or rivet only.
4. The rivet Material is important factors in determining the load carrying capacity.

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