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SHRINKAGE CONTROL OF POLYPROPYLENE DURING INJECTION MOLDING IN AL6061 TUBE

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ABSTRACT

World of engineering is in deep trouble in finding the alternate materials to use in place of traditional metals, without compromising in deviation of mechanical properties of the new inherent materials. Composites were seemed to be more relevant and alternate materials for traditional metals since there origin. Taking composites to advanced level several researcher are working on improving some mechanical properties of composites like elasticity, thermal resistance, bonding. In conclusion to the experimental work done on two different approaches the results were quite interesting, the bonding obtained for first experiment was examined and seen that there is no bonding between these two materials due to shrinkage, but in the second experiment we came across a good level bonding between aluminum 6061 and polymer this is due to shrinkage over the inner tube surface and also a good interlocking.

Keywords: Aluminum 6061, Composites, Mechanical Properties, Interlocking.

I INTRODUCTION

Monarchy of metals towards industrial sectors about 3000 years and was unstoppable, many alternatives came in to the race but they have to give up to metal, due to their extraordinary mechanical properties. But every era in this world must be ended at one point of time, so composites stared as just a word but due their unmatched mechanical properties and applications took over the race from the metals, putting an end card to the metal monarchy on the industrial sectors.

Composite material became raw material in the hands of designers, and they are finding their importance in all engineering branches. But the degrees of performance are yet define in some applications like aerospace, defense, and high precision engineering. Ordinary composites has great outlook, but from the other side looking at complexity structure they find difficulties in meeting the required stress, strain, deformation values. They couldn't find their applications in tennis rocket, rotor blades and etc. But, some high performance composites are finding their way in these kinds of complex engineering problems.

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II LITERATURE REVIEW

Hart-Smith et al [1], says bonded joint efficiency is purely depended on physical properties of the surface, cornering preparation of effective surface for adhesion. Bonded joints had versatile application in aviation industry, especially more applications in smaller aircrafts. Factors like surface roughness, temperature, humidity, contamination will affect the joint efficiency resulting low stiffness, less bond interlocking and interfacial failure. Failures of bonding had been studied extensively on various parameters which include types of load, application area, application area profile, load distribution on joint. Many failures where happened to seen just below expected range and other followed to fail in service due to unfriendly environmental condition[2-11].

III METHODOLOGIES

This paper present work carried on bonding aluminum 6061 with polypropylene, the main theme of this paper is to bond or join aluminum and polymers. This new composite materials will have huge impact of their own on automobile sector. Primarily a literature work had been carried on bonding concepts, primly focused on bonding of two dissimilar metals, metals with different mechanical properties, bonding of metals with polymers.

This work had been done on two themes of bonding one with tube and polymer and other with tube in tube and polymer. The aluminum tube is primarily cleaned thoroughly to make sure of non presence of foreign materials in the tube; thereby the polymer granules are tested for their grade then they are taken for the experiment. The certified granules are poured into the hopper and injected into aluminum tube through heater nozzle at 160C and cooled to room temperature naturally. Secondly, the heated granules at 160 C are now injected into a tube in tube aluminum tube where the inside tube has surface holes which has been illustrated in the paper.

Fig. 1.Specimen for test **Fig. 2.End caps**

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IV EXPERIMENTAL PROCEDURES

Method- 1

Specimen: An Aluminum 6061 tube having outer diameter of 26mm and Inner diameter of 24mm and length of 100mm is taken as specimen.

Polypropylene (PP) is taken as polymer and injected by injection Molding machine into the aluminum tube which is covered two ends with clamps in which a clamp is having hole to flow the molten polymer and another clamp is fully covers the end of tube. After filling the aluminum tube with polymer by injection molding machine the specimen is allowed to cool at room temperature for 3 hours.

Fig.3. Injection mould **Fig.4. Shinkage gap between Al6061 and PP**

Fig.5. Debonding due to shirnkage

V RESULT

Shrinkage of PP in aluminum tube is seen clearly and is illustrated in figure 4. Due to high shrinkage factor the surface bonding between Al 6061 and PP could not been obtained. The shrinkage factor is considered as per the date obtained from the log sheets provided from the laboratories of the manufacturing companies.

Shrinkage allowances details:

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PP shrinkage allowance is 1-2.5%

Based on theoretical calculations the shrinkage allowance should be 0.25 -0.6mm for 24mm diameter shell in practice shrinkage for test 1 is seen about 0.4mm resulting of debonding after shrinkage. In conclusion of test 1, shrinkage is taken as primary parameter in debonding featuring a complex study on minimizing shrinkage by introducing intricate profiles on the Al 6061 tubes.

Method- 2

Specimen: An Aluminum 6061 tube having outer diameter of 26mm and Inner diameter of 24mm length of 100m m is taken as specimen

Fig.6. Aluminum Tube

High density polypropylene is taken as polymer and the aluminum tube is internally threaded with 0.5mm depth and 2mm pitch with the help of lathe machine.

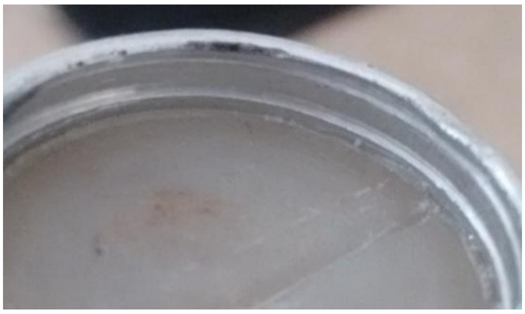

Fig.7. Threaded Inner surface

By injection Molding machine the polymer is injected into the aluminum tube which is covered two ends with caps in which a cap is having hole to flow the molten polymer and another end of tube fully covers with end cap. After filling the aluminum tube with polymer by injection molding machine the specimen is allowed to cool at room temperature for 3 hours.

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Fig.8. Srinkage After cooling.

VI RESULT

In this experiment of implementation of intricate threaded profile to the al 6061 tube internal surface, it had been observed that a interlocking between Al 6061 and PP but fortunately shrinkage could not be controlled and is illustrated in figure 8.

Method -3

Step 1: An Aluminum 6061 tube having a outer diameter of 26mm and Inner diameter of 24 mm and length of 100 mm is taken as specimen.

Fig.9. Aluminium Tube

Polypropylene (PP) is taken as polymer, and internal tube of Outer diameter of 24mm is changed to 23.6mm and inner diameter is 22mm and also Internal tube is unevenly holed to form a meshed shape tube with the help of drilling machine (Drill bit size 4.5mm). an Inner tube is inserted into the outer tube and Caps are fixed at the both ends.

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Fig. 10. Inner tube before and after drilling holes on surface

Fig. 11. After Assembly

Using injection molding machine Polymer is injected into metal tube and is allowed to cool at room temperature for 3hrs to solidify the polymer inside the tube. After Solidification clamps are removed from the tube.

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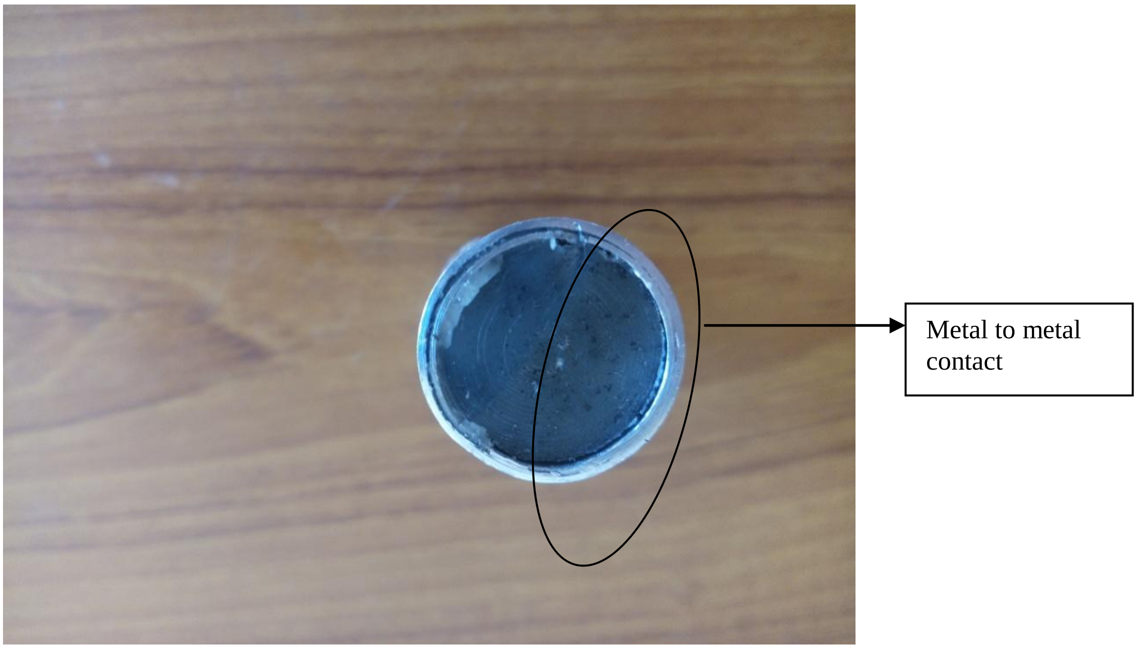

Fig. 12. Metal to metal contact

Visual Inspection: Due to the offset of central axis of the two tubes, surfaces are in contact.

VII CONCLUSION

Bonding between the polymer and the metal is found and the metal to metal
Contact is to be eliminated.

Method-4

Specimen:

An Aluminum 6061 tube having a outer diameter of 26mm and Inner diameter of 24.mm and length of 100mm is taken as specimen.

Fig.13. Aluminum Tube

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High density polyethylene is taken as polymer and a internal tube of outer diameter of 24mm is changed to 23.6mm and inner diameter is 22mm. An Internal tube is Unevenly holed to form a meshed shape tube with the help of drilling machine (Drill bit size4.5mm).

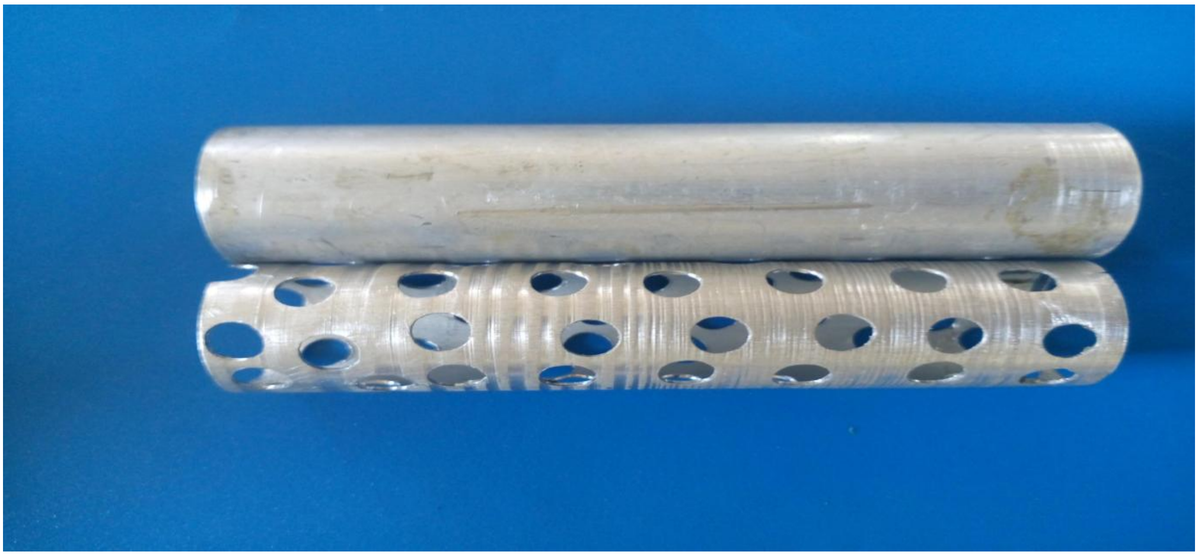

Fig. 14. Inner tube before and after drilling holes on surface

To avoid the offset of central axis, caps are designed to locate both tubes on axis.

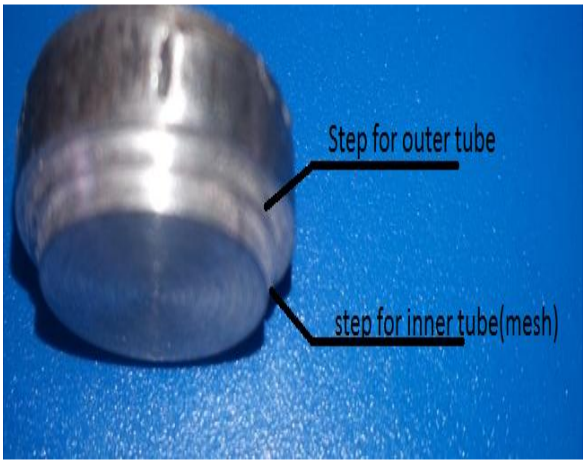

Fig. 15.End cap step location for Inner and outer tubes for center location

Its visualization in creo modeling

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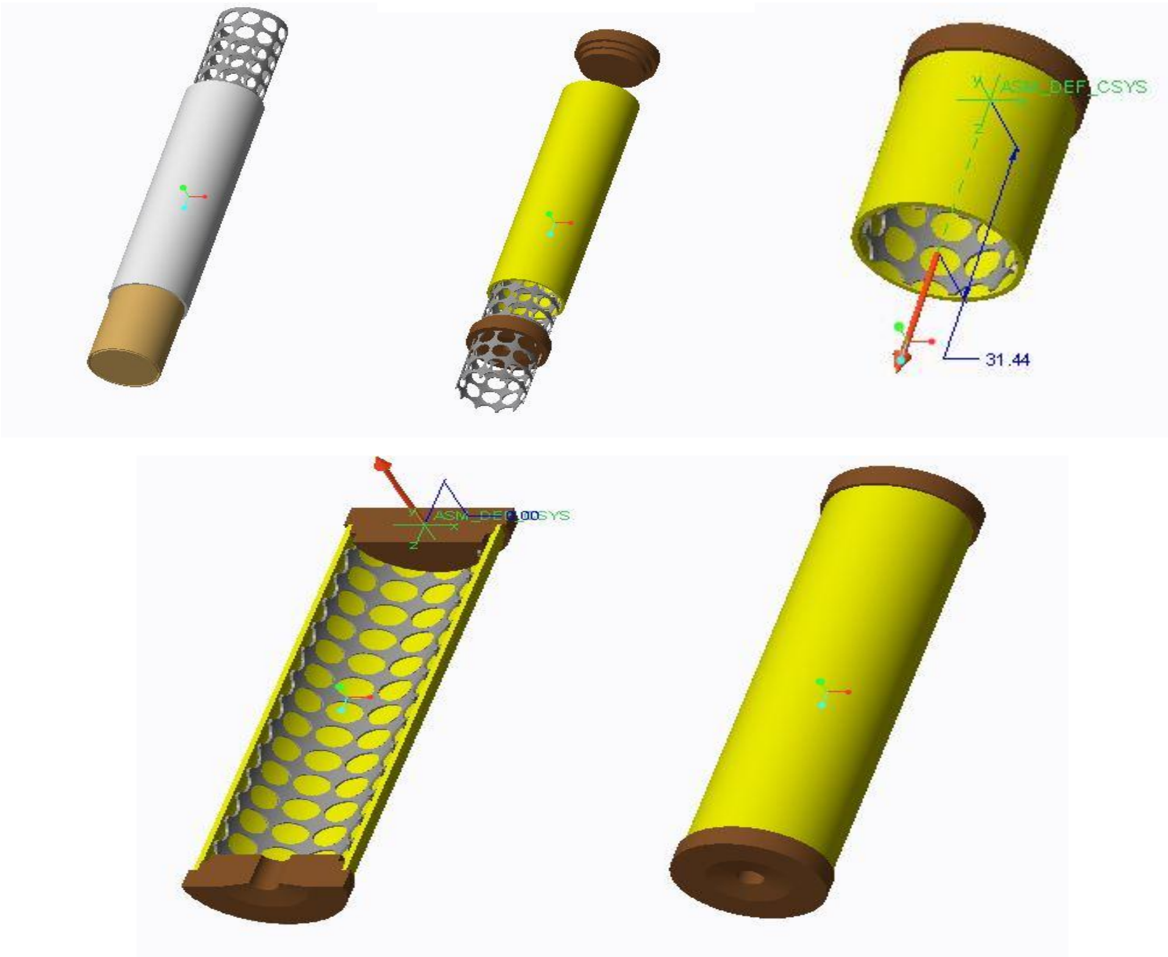

An Inner tube is inserted into the outer tube and Caps are fixed at the both ends.

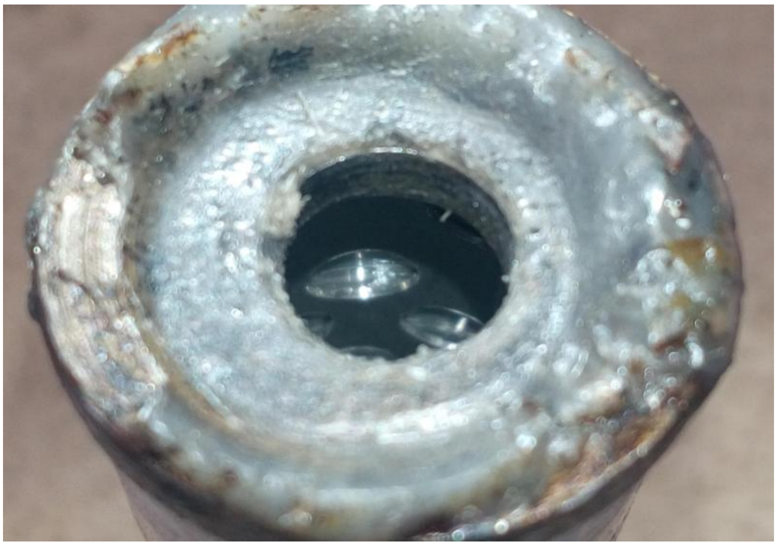

Fig.16. After Assembly

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Using injection molding machine Polymer is injected into metal tube and is allowed to cool at room temperature for 3hrs to solidify the polymer inside the tube clamps are removed from the tube after solidification.

Fig.8. Top view of composite **Fig.9 Bottom view of composite**

Visual inspection: Central Axis Offset is eliminated in the tubes and bonding between the polymer and the metal is obtained.

Micro structure study: the bonding between the Al 6061 and polymer test piece is studied under microscope and examined. It shows absolutely no gap between polymer and metal and its concludes that the shrinkage is fully controlled in tube in tube method.

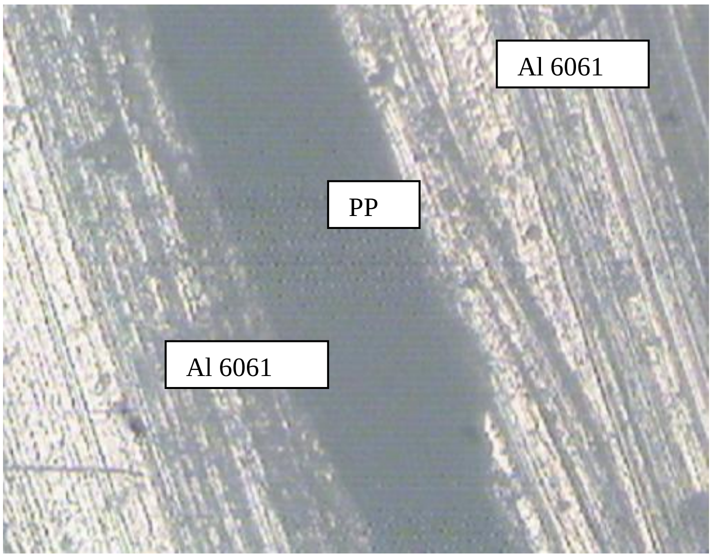

Fig. 17. Micro structure of specimen

VIII RESULTS

It had seen that shrinkage of polymer after condensation been a fearing factor for bonding these two materials, one can concentrate more on minimizing shrinkage percentage by different techniques to achieve good bonding.

In the second method mechanical locking had been achieved, this is due to the threaded profile on inner surface of the inner tube and same profile developed on the polymer surface. In visual inspection it clearly shows shrinkage is not controlled.

In the third method good bonding had been achieved, this is due to the profile of the inner tube. This irregular profile and intricate shapes may give more interlocking further giving a scope for good bonding as shrinkage was controlled.

Scope

1. Strength of the joint is depended on the linearity of the solidification.
2. Multidimensional flows must be studied to improve linearly in strength.
3. Effects of thickness layers are to be cornered and analyzed.
4. Shrinkage control of polymer techniques must be developed.

IX CONCLUSION

In conclusion to the experimental work done on three different approaches the results were quite interesting, the bonding obtained for first method was examined and seen that there is no bonding between these two materials due to shrinkage, follow by development of interlocking in second method between two surfaces but this technique could not control the shrinkage, in the third method we came across a good level bonding between aluminum 6061 and polymer this is due to shrinkage over the inner tube and observed a tight fit for outer tube inner surface.

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