ISSN 2395-1621

Design and validation of windscreen wiper arm for suitable composite material

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ABSTRACT

Windshield wipers play a key role in assuring the driver's safety during precipitation. The traditional wiper systems, however, requires driver's constant attention in adjusting the wiper speed and the intermittent wiper interval because the amount of precipitation on the windshield constantly varies according to time and vehicle's speed. Wiper arm is the heart of windshield wipers system and in present era it is made up of galvanized steel. The research is an endeavour towards an effective design development and validation of a windshield wiper arm with composite material through reverse engineering. A FE result of galvanized steel validated through IS 7827 (Part 3/Section 1):1993 and compared with alternative material in terms of free play, transverse rigidity, and torsional rigidity. The design constraints were displacement. Compared to the steel arm, the composite arm has deflection that is within range, and the wiper arm weight is nearly 70% lower.

Keywords- **Wiper arm, Composite material, FEA analysis, validation.IS**.

ARTICLE INFO

Article History

Received :18th November 2015

Received in revised form :

19th November 2015

Accepted : 21st November , 2015

Published online :

22nd November 2015

I. Introduction

A windscreen wiper or windshield wiper is a device used to remove rain and debris from a windscreen. Almost all motor vehicle, including trains, aircraft and watercraft, are equipped with such wipers, which are usually an essential requirement. A wiper generally consists of an arm, pivoting at one end and with a long rubber blade attached to the other. The blade is swung back and forth over the glass, pushing water from its surface. The speed is normally adjustable, with several continuous speeds and often one or more "intermittent" settings. Most automobiles use two synchronized radial type arms. It takes a lot of force to accelerate the wiper blades back and forth across the windshield so quickly.

Wiper system development is based on for targets reliability, style, weight reduction and cost. Important researcher are made to develop new products traditional material is replaced by some alternative material even if environmental conditions are drastic i.e. high mechanical stresses, chemical and physical constraints.

Nowadays, composite materials are used in large volume in various engineering structures including spacecraft's, airplanes, and automobiles. Widespread use of composite materials in industry is due to the good characteristics of its strength to density and hardness to density. The possibility of increase in these characteristics using the latest technology and various manufacturing methods has raised application range of these materials. Application of composite materials was generally begun only at aerospace industry in 1970s, but nowadays after only three decades, it is developed in most industries. Meanwhile, the automotive industry considered as a mother one in each country, has benefited from abilities and characteristics of these advanced materials. Along with progress in technology, metallic automotive parts are replaced by composite ones. Despite this, alternative material for wiper arm is relatively uncommon in modern vehicles. Existing wiper arm (made up of steels) are often too expensive, too unsightly, or too unreliable to be desired in new automobiles. Many attempts have been made at constructing an effective, reliable, and cheap wiper arm with alterative material.

For solving these problems, in this project, we present with a vision-based wiper arm with composite material.

II. SPECIFICATION OF THE PROBLEMS

The objective of the present work is to suggest a best available composite material for design, fabricate complete composite windshield wiper arm.

II. Tests

A. *Classification of Tests*

The following shall constitute type tests:

a. Visual dimensions

b. Dimensional check

c. Performance test

B. *Visual dimensions*

The wiper arm shall be visually examined for material, construction, workmanship and finish. The arm shall be free from injurious flaws and damages**.**

C. *Dimensional check*

The dimensions of the wiper arm shall conform to those agreed between the suppliers and the purchasers.

D. *Performance test*

a. *Free Play*

The arm shall be supported horizontally with a rigidly held wiper arm head. A horizontal force of 20 N shall be applied in a direction perpendicular to the arm in a horizontal plane at a distance of 250 mmfrom the spindle centre. The deflection shall not exceed 10 mm.

b. *Torsional Rigidity*

A torque of 0.5 Nm shall be applied in a transverse plane normal to the longitudinal axis of the arm at the tip in clockwise and anti-clockwise directions. The total angular deflection shall net exceed 20”.

c. *Transverse Rigidity*

A force shall be applied in a plane normal to the axis of the spindle and at the tip of the arm in a line perpendicular to the longitudinal axis of the arm to produce a torque of 11 Nm in clockwise and anti-clockwise directions. The total deflection at the tip shall not exceed 50 mm.

III. FINITE ELEMENT ANALYSIS (FEA) OF WIPER ARM

a To design Wiper arm, reverse engineering method is used. Existing wiper arm of Suzuki swift is considered and modelled in UNIGRAPHICS software. Astatic analysis wasperformed using finite element method done through ANSYS software. Modeling was done for wiper arm with eight-node 3D brick element (solid 185) and five-node 3Dcontact element (contact 174) used to represent contact between adjacent surfaces of Arm and arm holder. Also, analysis carried out forcomposite wiper armof 3.5 mm thickness with Carbon/Epoxy, Glass/Epoxy, Kevlar epoxy composite materials and the results were compared with steel wiper arm. The maximum deflection were measured. Figures 1 to 3 showsFEA results for steel and figures 4 to 12 shows composite wiper arm (Carbon/Epoxy,Glass/Epoxy,Kevlar epoxy) for free play, transverse rigidity and torsional rigidity. A comparison graph of deflections among all the composites and steel are shown in the Figure 13.

A. *Material properties*

Table no 1: Material properties of different composites

PROPERTIES	STEEL	CARBON EPOXY	KEVLAR EPOXY	GLASS EPOXY
EX	210000	58093	80000	34000
EY	210000	58093	55000	6530
EZ	210000	9759	55000	6530
NUXY	0.25	0.5356	0.34	0.217
NUYZ	0.25	0.1575	0.4	0.366
NUXZ	0.25	0.0154	0.4	0.217
GXY	-	3545	2200	2433
GYZ	-	2564	1800	1698
GXZ	-	2564	1800	1698

B. *Results and discussion*

FEA results of wiper arm under static loading containing the deflection are listed in the Table 2. Figure 1 to 3 represents the deflection pattern of Steel wiper arm. Figure 3 to 12 show the maximum deflection for different composite materials and these values are tabulated in the Table 2. We can observe from Table 2 that there is a much weight reduction for composites materials. Carbon epoxy 76%, glass epoxy73%. And Kevlar epoxy 79%.

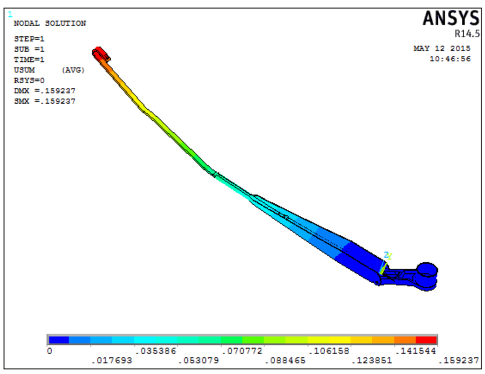

Figure 1: displacement pattern of steel in free play condition

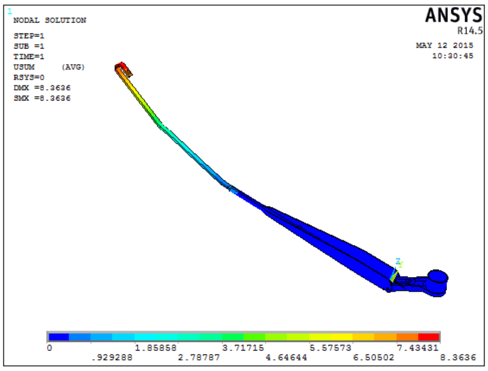

Figure 2: displacement pattern of steel in transverse rigidity

Table no 2: Comparison results of displacement

PERFORMANCE TEST	FREE PLAY	TORTIONAL RIGIDITY	TRANSVERSE RIGIDITY	WEIGHT
	DISPLACEMENT IN MM			KG
STEEL	0.15	0.2	8	0.06595
CARBON EPOXY	1	0.06	11	0.01575
KEVLAR EPOXY	1.1	0.13	14	0.013811
GLASS EPOXY	1.6	0.06	15	0.017757

From table 2 it is observed that maximum weight is reduced by using Kevlar epoxy as compared to glass epoxy and carbon epoxy.

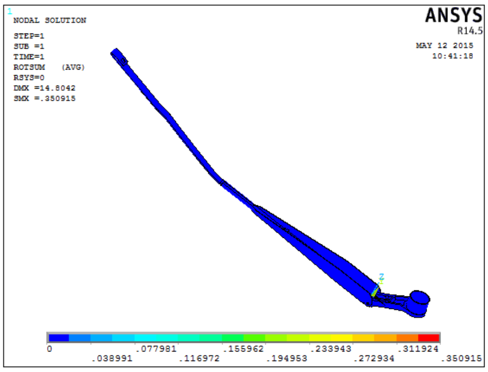

Figure 3: displacement pattern of steel in torsional rigidity

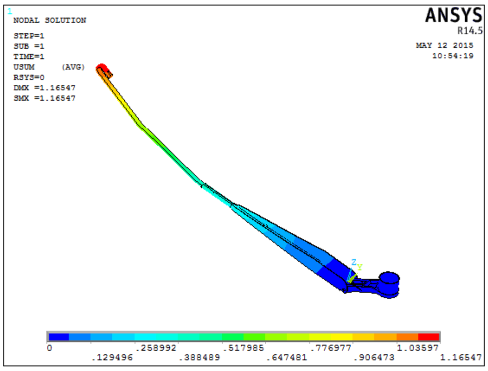

Figure 4: displacement pattern of carbon epoxy in free play

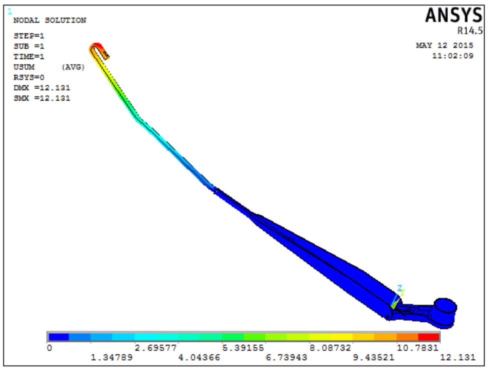

Figure 5: displacement pattern of carbon in transverse rigidity

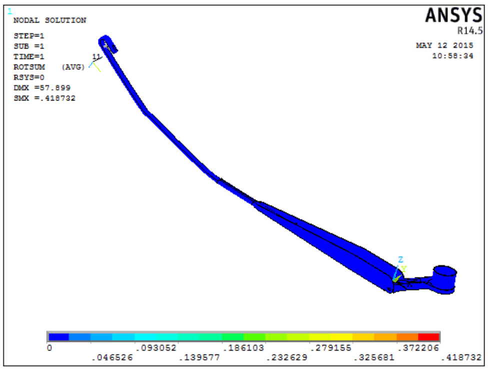

Figure 6: displacement pattern of carbon in torsional rigidity

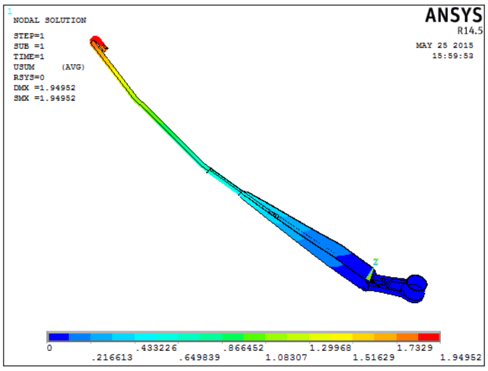

Figure 7: displacement pattern of glass in free play condition

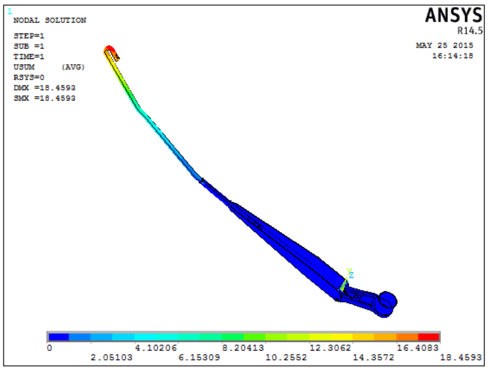

Figure 8: displacement pattern of glass in transverse rigidity

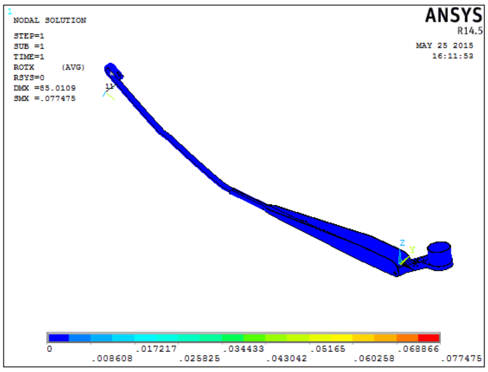

Figure 9: displacement pattern of glass in torsional rigidity

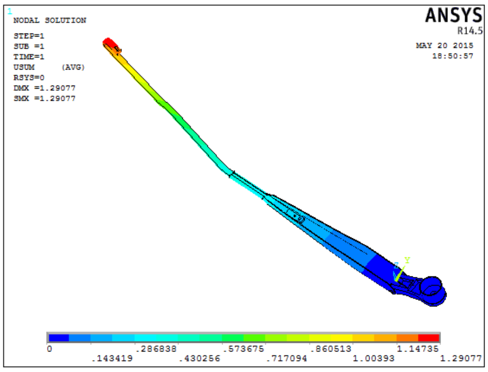

Figure 10: displacement pattern of Kevlar in free play condition

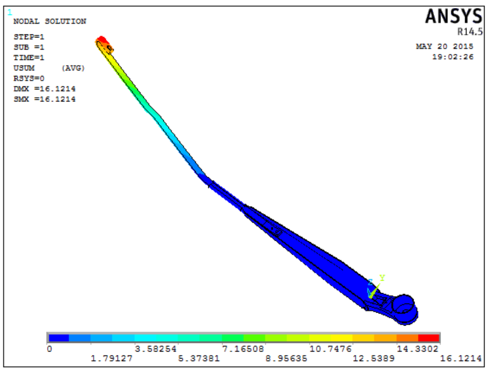

Figure 11: displacement pattern of Kevlar in transverse rigidity

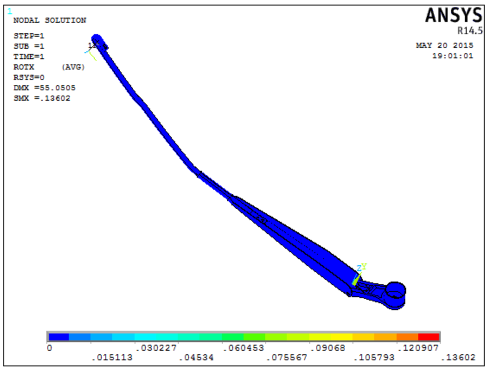

Figure 12: displacement pattern of carbon in torsional rigidity

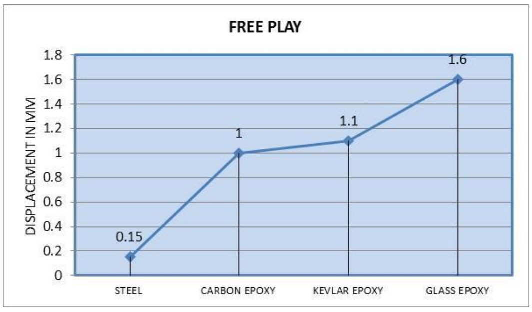

Figure 13: Free play graph of composite material

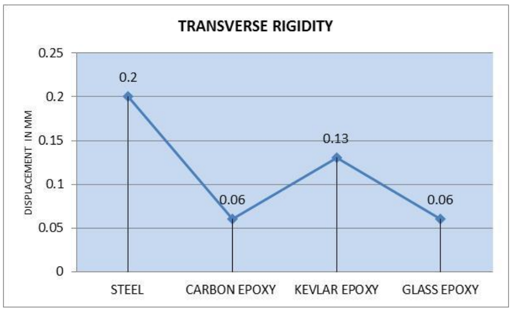

Figure 14: Transverse rigidity graph of composite material

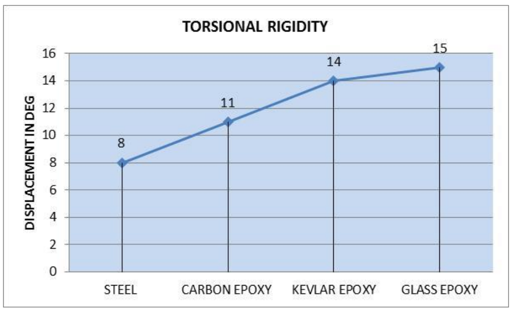

Figure 15: Torsional rigidity graph of composite material

From the Figure 13 to 15 we can observe that the deflection is within the range compared to IS 7827 (Part 3/Section 1):1993

V.CONCLUSION

A composite wiper arm with modified thickness has been developed. These wiper arms are analyzed in ANSYS software with different composite materials along with the steel. A comparative study has been made between different composite materials and with the steel in respect of weight, deflection. It can be observed that composite materials are the best suitable materials for replacing the steel in manufacturing of wiper arm. The savings in the weight is 76%

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