Analysis of Glass/epoxy composite Sulcated Spring

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Abstract: Composites materials have been using in various defence applications and now there demand has extended to automobile applications. The present work focuses of design a composite GFRP sulcated spring which could perform the same operations as that of the conventional coil spring. A four element sulcated spring was analysed in-order to determine the variation of the stiffness of the spring with respect to the fiber orientation. A considerable effect of which is observed, moreover large variation of stress along the thickness direction is observed indicating an opening mode of failure.

Keywords: Sulcated spring, GFRP Spring, FEA, Stiffness variation.

1. INTRODUCTION

The expeditious development in the usage of composite materials for the structures can be imputed by the replacement of the existing conventional materials for those applications in aerospace and other engineering applications. This is due to their specific properties which have attained prime focus so as use them in applications which require high performance and tailoring ability. Supplementary the considerable expansion of these materials in the commercial application has also been noticed due to the high strength to weight ratios along with the structural potency [1]. Significant amount of research efforts are presently in progress all the way through the automotive industry to demonstrate the feasibility of these materials in automotive applications and also so as to develop suitable fabrication dealings which would lead to high production rates [2].
In the automobile industry, attempts have been carried out in order to replace the conventional steel springs with the Fiber reinforced composite springs [3]. The automobile manufactures in an attempt of reducing the overall weight of the vehicle conducted experimentation on replacement of conventional leaf springs with the composite one [4, 5]. These springs were tested both in laboratory and on a full scale by actually installing on the vehicle (Ford Econoline Van and Chevrolet corvette). The Liteflex spring could completely replace the font and rare suspicions in a Chevrolet Corvette, however, the fatigue results for the suspensions system in Ford Econoline van were in an acceptable range.
Fiber reinforced plastic composites when compared to steel have higher energy storage capacity but, indicates deprived response against shear stresses. Consequently, the direct use of these materials in applications where shear stress is predominant such as coil springs would thus require increasing in the coil diameter. However, by doing it may override the prime advantage of weight saving. In view of overcoming the above said disadvantage, the ‘‘Sulcated Spring’’ were introduced and were subjected to test which highlighted their application in suspicion [6, 7]. In the interim, the performances of elliptic springs made from composite were studied [8]. Various constructions of elliptic spring made from unidirectional E-glass fiber reinforced epoxy tapes were connected in a series and were tested under quasi-static compression, where the primary failure was observed due to inter-laminar shear [9]. Later on much work was focused on evaluating the performance of elliptical springs [10-14].
The present work focuses on studding the performance of glass/ epoxy sulcated composite spring, and the effect of fiber orientations on the stiffness of the spring. The spring with $[0]_4$, $[10]_4$, $[20]_4$, $[30]_4$, $[45]_4$, $[55]_4$, $[58]_4$, $[60]_4$, $[70]_4$, $[80]_4$ and $[90]_4$ were considered for the present study.

2.METHODOLOGY

An FRP sulcated spring is classically a type of bump stop member which largely bears uneven and impact loads. Thus, the material used for these springs must possess high strength, high strain energy, restricted percentage elongation in the material, high fatigue and impact resistance. The fig 1 details the arrangement of the sulcated spring which could be used to replace the conventional steel coil spring. The compression molding, RTM and Pultrusion are the common manufacturing and processing techniques which could be used to produce the geometry of the sulcated spring.

The sulcated spring is a flexible member with a wide range of variations to be considered based on the geometry and the geometric arrangement. In the present case of study the spring comprises of four flexible sulcated members. The overall diameter of the spring is 60 mm and the effective length of the spring is 75 mm. the sulcated spring is designed which would perform the same functions of the steel coil spring with above said dimensions. The sulcated spring in this case comprises of four sulcated elements of same dimensions and stiffness. The thickness of the each element is 4 mm and the corrugations of 25 mm diameter and 25 mm width.

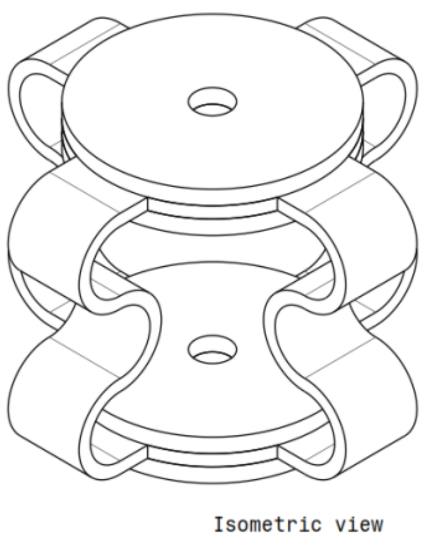

Fig1: The arrangement of FRP Sulcated Spring.

3. FEA OF SULCATED SPRING

The commercially available finite element tool ANSYS is used to carry out analysis. In-order to reduce the computational time only one element of the spring is modeled in ANSYS and a 2D layered element is selected for the analysis. The material properties required for the anisotropic glass/epoxy composite published else ware is used in this case [15]. The element of the sulcated spring is a corrugated part with 25 mm diameter and 25 mm thick. The component comprises a flange of 25 mm height so that it could be holed in the position. The fig 2 represents the meshed model of the sulcated spring where the bottom flange is fixed and a pressure is applied on the upper flange.

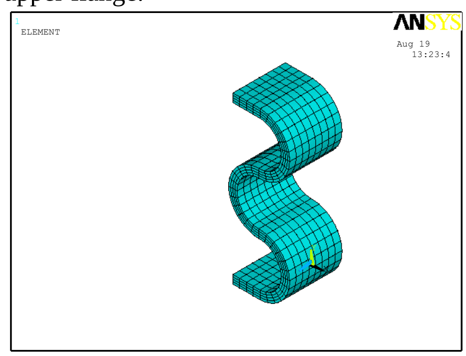

Fig 2: Meshed model of sulcated spring.

4. RESULTS AND DISCUSSION

The spring is subjected to a pressure of 4.8 MPa under static condition and the corresponding results for all the above said orientations are recoded. The fig 3 represents the defection of the spring element under the applied pressure. As the base of the element is fixed, a minimum deflection is observed at and the value of deflection is high at the flange where the load is being applied.

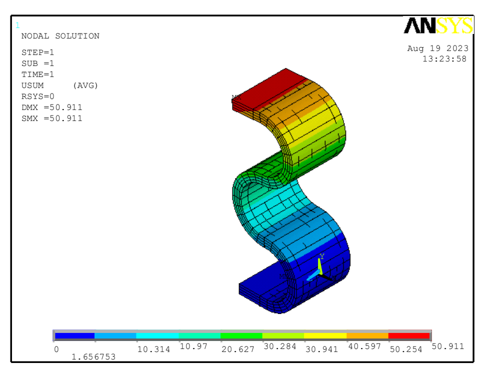

Fig 3: Deflection of the spring element.

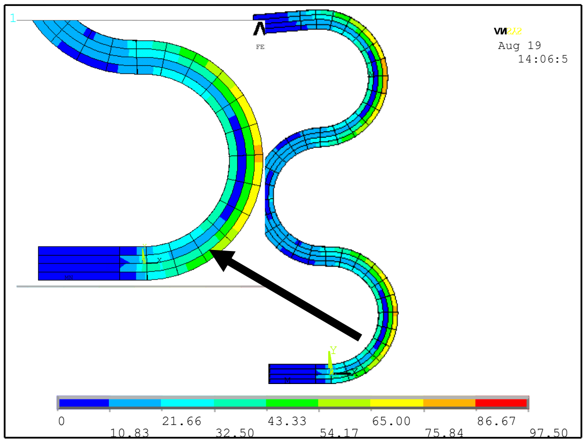

Fig 4: stress distribution along the thickness of the spring.

The fig 4 represents the variation of stress along the thickness direction of the spring element. It is clear that the outer layer of the spring element s subjected to maximum stress when a compressive force is applied. However along the thickness direction the variation of the stress is very high. The second layer from bottom experiences no stress indicating a mode – I failure mode.

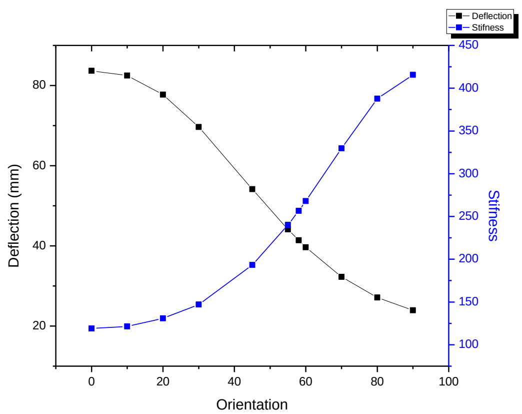

Fig 5: Variation of deflection and spring stiffness with respect to fiber orientation.

The fig5 and 6 represents the variation of deflection, spring stiffness, stress and strain with respect to variation of the fiber orientation. An increase in stiffness with decreased defection is observed with increase in fiber angle. The induced stress increase up to 30 fiber orientation and decreased from 45 fiber orientation. However the strain reduces along the increased fiber orientation.

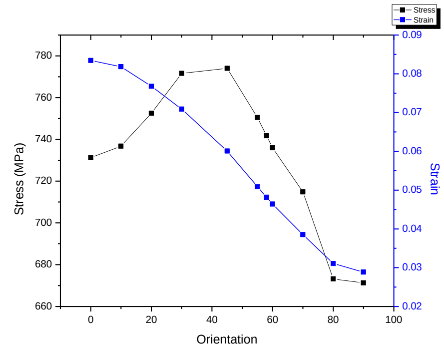

Fig 6: Variation of Stress and Strain with respect to fiber orientation.

5. CONCLUSIONS

A four element glass/epoxy sulcated spring was effectively analysed using the conventional FEA tool in-view of determining the effect of fiber orientation on the stiffness of the spring. The fallowing conclusion could be highlighted from the work:

a. The Sulcated spring could be effectively used instead of a FRP composite coil spring, as these springs are not subjected to shear stress.

b. A considerable affect of fiber orientation is determined with respect to the stiffness of the spring. The fiber orientations from 0 – 30 offers very low stiffness and from 45 – 60 a moderate stiffness could be observed, however the stiffness is very high for the fiber orientations 80 and 90.

c. The variation of the stress along the thickness direction is very high indication an opening mode of failure due to variation of stress.

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