Analysis and Designing of Diaphragm Spring Washers

P Umesh [1], Purushottam Kumar Sahu[2]

[1]BM College of Technology, RGPV, Bhopal Indore, Research Scholar, Dept. of Mechanical Engineering, BM College, MP, Indore
[2]First BM College of Technology, RGPV, Indore, Professor, Dept. of Mechanical Engineering, BM College, MP, Indore

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Abstract - *In present work a standard Belleville spring is considered for numerical analysis of force with respect to its maximum displacement of twice that of its height the results obtained are quite satisfying the one which are proposed by Almen J O [1] in 1936 and is modelled in CATIA v5r12 software and then further analysed in ANSYS 14.0 simulation software. For validation 4 different cases of different height to thickness ratio are considered which are h/t=0.4, h/t=0.7, h/t=1.04, h/t-1.4, h/t = 2.83 respectively. It is then concluded that FEA results are in good agreement with the numerically obtained data and can be considered for this kind of application in future too. Different graphs representing load-deflection curves are drawn and percentage deviation of FEA results with respect to numerical results are studied and summarized in conclusion.*

Key Words: Belleville Spring, FEA, CATIA, ANSYS, Load deflection curves, h/t ratio

1. INTRODUCTION

The Belleville spring is usually loaded only at its edges by circumferentially uniform loads, axial in direction and with a sense such that they tend to reduce the cone angle. In most cases the edges are completely free to move. However, certain applications require that either the outer edge be restrained from radial expansion, as would be the case if the spring were inserted in a cylinder, or that the inner edge be restrained from radial contraction, as would be the case if a shaft were inserted through the spring. Some applications may require that both of these restrictions be imposed.

1.1Characteristics of Belleville Springs

The simplest type of spring, a prismatic tension specimen, exhibits a characteristic which is typical of structural members in the elastic range: a linear load deflection curve. Accordingly, the helical spring, the volute spring, the ring spring, and most common springs have a straight relationship between load and deflection. On the other hand, Belleville spring usual1y have a nonlinear relationship between load and deflection, and it is possible to design Belleville springs with many differently shaped load deflection curves. By varying the fundamental parameters, it is possible to obtain positive, zero, and even negative spring rates in given portions of the load deflection curve.

The clutch provides a temporary connection between the engine and the gearbox by transmitting engine torque and engine speed in addition to the comfort function of the clutch. One of the com- fort tasks is to damp the vibration while transmitting torque and speed towards the gearbox. The clutch compensates for vibrations through radial and axial springs. The friction force is obtained by a com-press Belleville spring to the disc assembly. Absorption of vibration is a key according to the characteristic of the engine of the vehicle, and the required torque is calculated. In this study, the load calculation of Belleville spring was done and optimized, and then the results were investigated.

Studies on the Belleville spring are limited in the literature and only a few studies have been found about Belleville washer's FEA modeling. No study has been done on the clutch Belleville spring regarding the behavior of stress and deflection compared to the Belleville spring, but the parameter optimization to obtain the required load and stress values.

The performance of the Belleville spring under com- press load was compared between the simulation and experimental results. He investigated Belleville spring stress and deflaction among experimental Method and FEA method. They reduced the deviation between the results by changing the element formation [1]. Friction clutch design was done with dual Belleville Springs and Friction Plates. They reduced the number of components required by using a Belleville spring as a friction plate [2]. The method was developed to predict the deformation behavior of the Belleville spring under axial load using minimum potential energy theory. The classical thin shell theory in a conical coordinate system was used to prepare Belleville Springs by strain energy and function. Their method brings more precise results between the pre-assumptions and the finite element method than the Almen and Lezlo equation [3]. Composite material was applied to Belleville springs instead of steel and the composite material provides similar load and deflection characteristics with steel.

Belleville Spring has been shown to be of little interest as clutch elements, with no studies about the shape adaptation of Belleville Spring to be the target curve under stress constrained. The shape of the Belleville spring has been optimized in this study. Load and stress results were obtained by the finite element method. The design of the experiment was applied to the Latin hypercube sampling method. An evolutionist

1.2 Function of diaphragm spring

The diaphragm spring can be a steel disc with a hole in the middle, and therefore the inner part of the disc is moved sequentially to form a variety of inductive (release-lever) fingers. The outer end of the slotted square measurement is given enlarged blunting holes, which distribute the concentrated stresses created during finger deflection, and in addition provide a way of finding rivets of the body part that pin rings. Controls. Landed, it is a shapely shape. As the pressure plate cowl tightens, it pivots on its pin rings, and the dead set exerts a force on the flat pressure plate, and also the facings. The transmission input shaft passes through the pressure plate. Its parallel splines interact with the internal division of the central disc on the friction disc. With engine rotation, the force current will be transmitted from the regulator disc, through the friction disc, to the central hub and transmission. When the foot lever is depressed, the operation is transferred to the operation fork through the operation mechanism as well as an uncontrollable bearing. The release bearing moves forward and the diaphragm pushes the middle of the spring toward the regulator. The diaphragm on its pin ring stimulates pivots that maneuver incorrectly and act on a pressure-plate retention clip. The pressure plate disintegrates, and the drive is no longer transmitted. Releasing the paddle allows the diaphragm to reapply its clamping force and has a clutch interaction, and the drive is rebuilt.

Research Objective:

1) To study the importance of Diaphragm spring in clutch assembly.
2) To study the boundary conditions involved in actual working condition of Diaphragm spring and to study how load and deformation is related to one another by drawing load deformation curves with suitable scale.
3) To Analyse the Characteristic curve between load and deformation values at different h/t ratios.
4) To simulate the Diaphragm geometry in ANSYS workbench and to compare the same with that of theoretically obtained results.
5) To achieve at the best geometry in terms of h/t ratio.

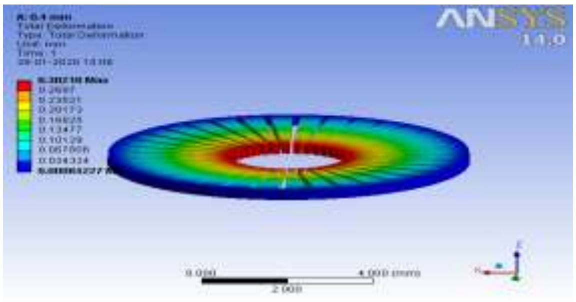

Figure-1 Deformation for h/t ratio of 0.4

Above figure represents the deformation values for height to thickness ratio of 0.4 for diaphragm spring. The observed maximum value of deformation is 0.3 mm. The deformation value is double the height of the spring.

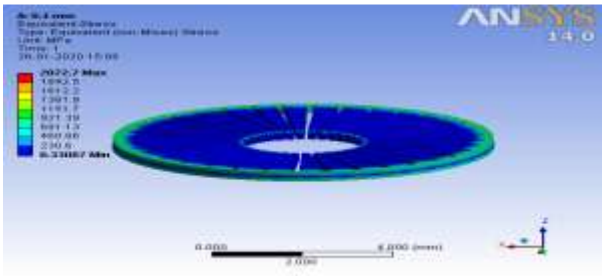

Figure-2 Stress for h/t ratio of 0.4

Above figure represents the stress values for height to thickness ratio of 0.4 for diaphragm spring. The observed maximum value of equivalent stress is found as 2072.7 MPa.

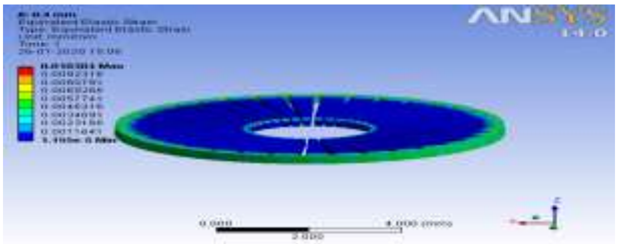

Figure-3 Strain for h/t ratio of 0.4

Above figure represents the strain values for height to thickness ratio of 0.4 for diaphragm spring. The observed maximum value of equivalent elastic strain is found as 0.010384.

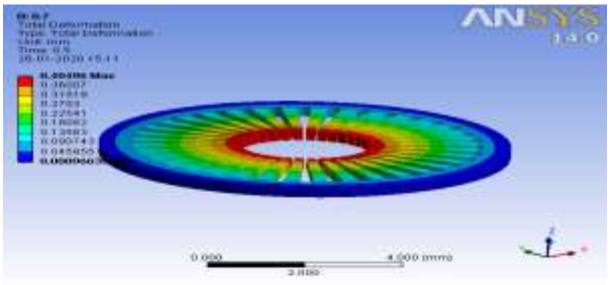

Figure-4 Deformation for h/t ratio of 0.7

Above figure represents the deformation values for height to thickness ratio of 0.7 for diaphragm spring. The observed maximum value of deformation is found as 0.40496.

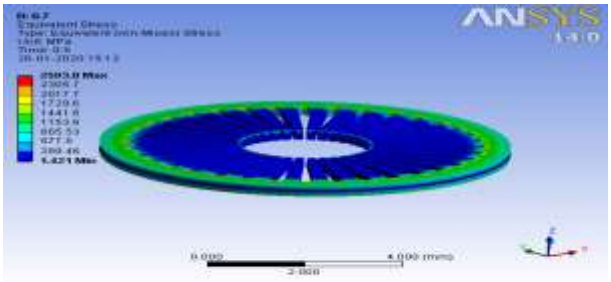

Figure-5 Stress for h/t ratio of 0.7

Above figure represents the stress values for height to thickness ratio of 0.7 for diaphragm spring. The observed maximum value of equivalent stress is found as 2593.8 MPa

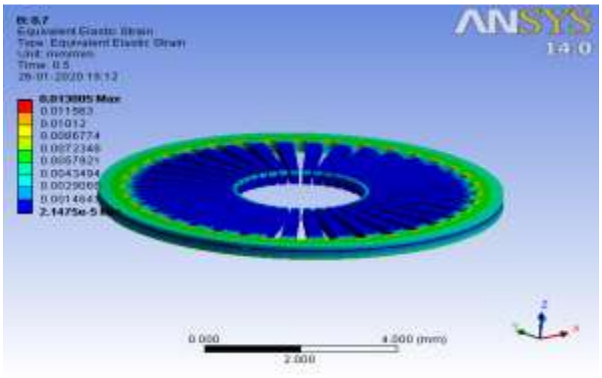

Figure-6 Strain in h/t of 0.7

Above figure represents the Strain value for height to thickness ratio of 0.7 for diaphragm spring. The observed maximum value of equivalent elastic strain is found as 0.013005.

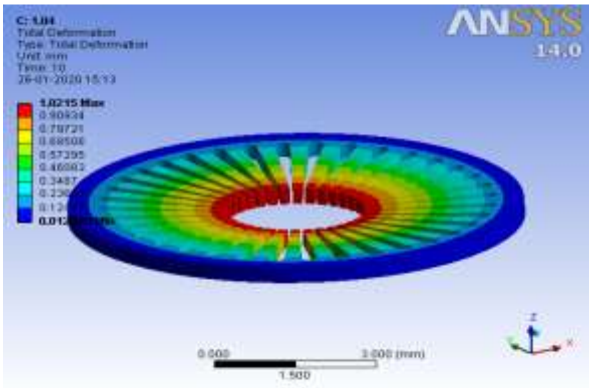

Figure-7 Deformation for h/t ratio of 1.04

Above figure represents the Deformation value for height to thickness ratio of 1.04 for diaphragm spring. The observed maximum value of maximum deformation is found as 1.0215 mm.

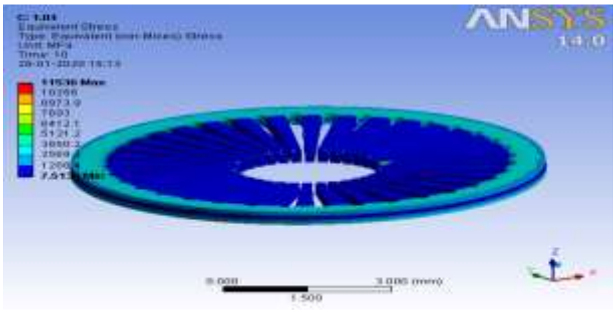

Figure-8 Stress for h/t ratio of 1.04

Above figure represents the stress value for height to thickness ratio of 1.04 for diaphragm spring. The observed maximum value of equivalent stress is found as 11536 MPa.

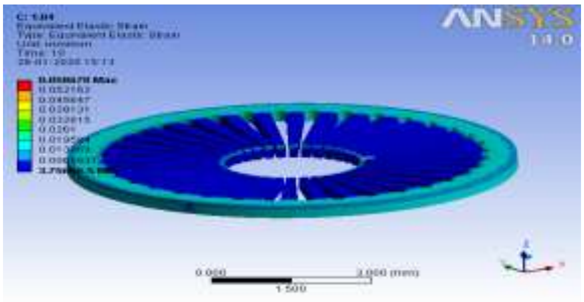

Figure-9 Strain for h/t of 1.04

Above figure represents the strain value for height to thickness ratio of 1.04 for diaphragm spring. The observed maximum value of equivalent elastic strain is found as 0.058678.

Table-4 Values of deformation, strain, stress and force for height to thickness ratio of 1.4

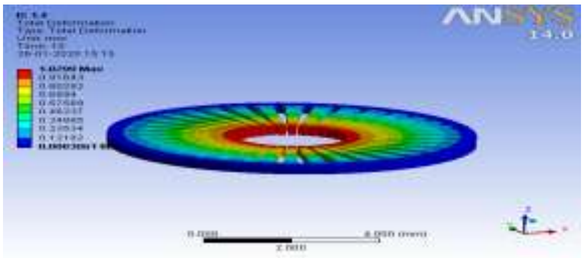

Figure-10 Deformation for h/t ratio of 1.4

Above figure represents the total deformation for height to thickness ratio of 1.4 for diaphragm spring. The observed maximum value of equivalent stress is found as 1.0299 mm.

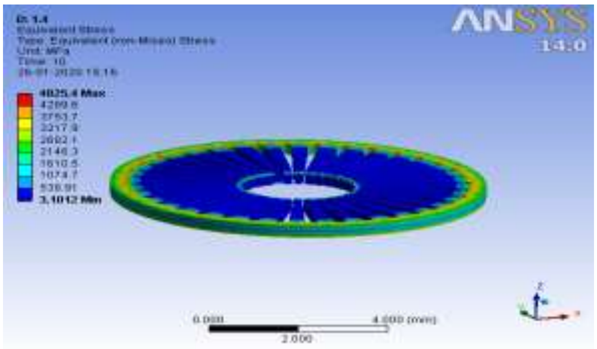

Figure-11 Stress for h/t ratio of 1.4

Above figure represents the stress value for height to thickness ratio of 1.4 for diaphragm spring. The observed maximum value of equivalent stress is found as 4825.4 MPa.

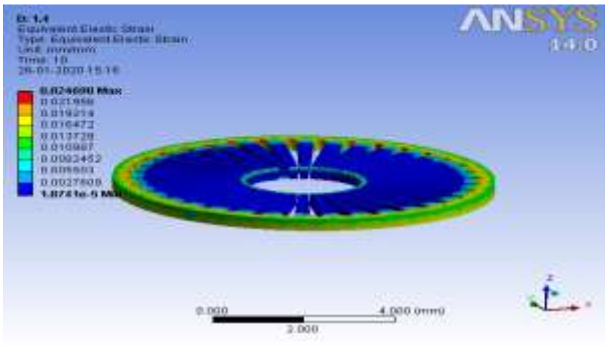

Figure-12 Strain for h/t of 1.4

Above figure represents the strain value for height to thickness ratio of 1.4 for diaphragm spring. The observed maximum value of equivalent elastic strain is found as 0.024698.

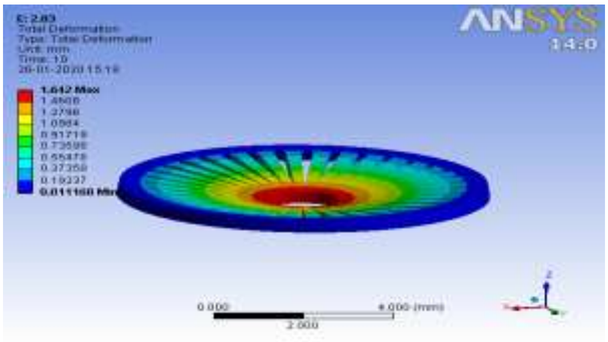

Figure-13 Deformation for h/t ratio of 2.83

Above figure represents the total deformation for height to thickness ratio of 2.83 for diaphragm spring. The observed maximum value of equivalent stress is found as 1.642 mm.

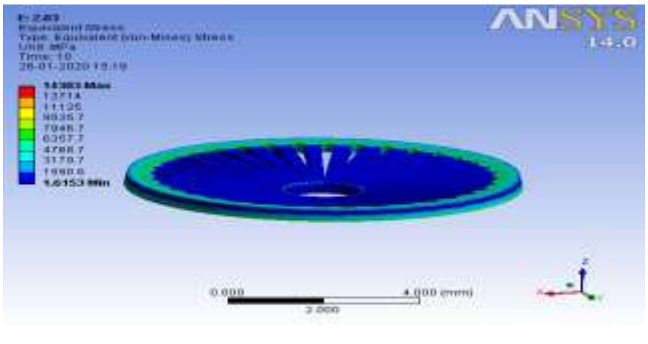

Figure-14 Stress for h/t ratio of 2.83

Above figure represents the stress value for height to thickness ratio of 2.83 for diaphragm spring. The observed maximum value of equivalent stress is found as 14303 MPa.

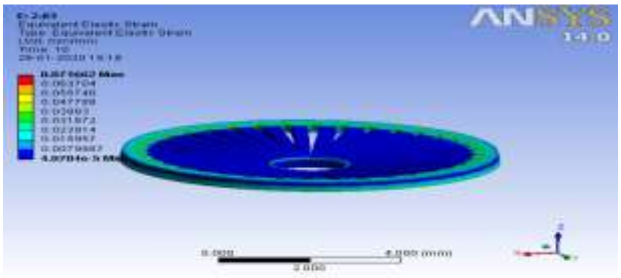

Figure-15 Strain for h/t of 2.83

Above figure represents the strain value for height to thickness ratio of 2.83 for diaphragm spring. The observed maximum value of equivalent elastic strain is found as 0.071662.

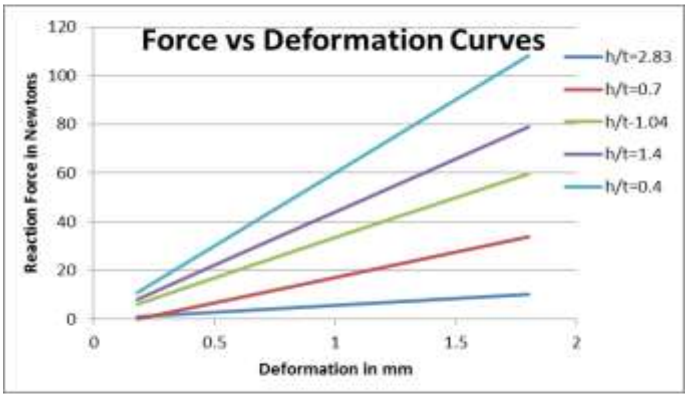

Figure-16 Force vs. deformation curves for different h/t ratios

Above figure represents the force vs. deformation curves for various height-to-thickness (h/t) ratios for modified Belleville spring (Diaphragm washer). It is found that as the h/t ratio increases the maximum force required is also increased.

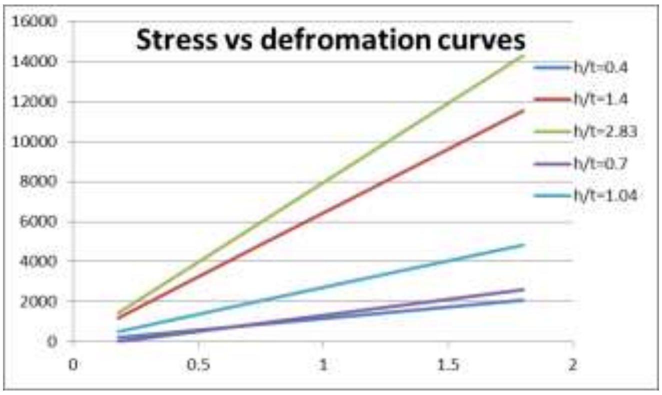

Figure-17 Stress vs. deformation curves for different h/t ratios

Above figure represents the Stress vs. deformation curves for various height-to-thickness (h/t) ratios for modified Belleville spring (Diaphragm washer). It is found that as the h/t ratio increases the maximum stress generated is also increased.

Conclusions:

1. The modified Belleville spring is lighter in weight and more effective than the existing one.
2. The Belleville spring has a disadvantage as the load increases beyond certain limits; it reverses its characteristic curve of load-deflection or stress-deflection so it is highly non-linear. But this is not the case with the diaphragm spring.
3. The maximum value of the reaction force observed from Table 1 to Table 5 in any of the models taken here is 100N which is much lower than the same H / T ratio as the Belleville spring and is therefore more effective in clutch applications.
4. The maximum value of stress obtained from Table 1 to Table 5 in any model obtained here is 14000 MPa which is much lower than the same H / T ratio as the Belleville spring and therefore proves to be more effective again.
5. It is seen from both figure 16 and figure 17 that the H / T ratio is very low range of reaction force and generated stress up to 1 (approx.) and should be preferred over large H / T ratios.
6. It is being observed from the deviation results from Table 1 to Table 5 that despite the model of the diaphragm spring the values of the forces in each time step are so low that the Belleville spring and hence to thicken the ratio, we can say That the modified model we are able to reduce the force required to compress the spring. It can also be concluded that for a small amount of h/t ratios the diaphragm spring shows better results than Belleville spring.

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