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Relation between Shore Hardness and Stress Induced in Engine Isolators

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Abstract

The relationship between the shore hardness and the stress induced in the engine isolators is generally established on the basis of exhaustive NVH testing and thereby the shore value for an isolator is established. However, no theoretical relation exists between the two. The author has tried to find a relationship between the stresses induced and the shore hardness of the engine isolator which gives an estimate of the values of the shore hardness. Using the concept of forces acting on bolted joint in a perpendicular to the direction of application and a logarithmic relationship between the Young's modulus and shore hardness the author arrived at the values which were in +10% variations of the actual values of the engine isolator. Using this relationship the number of iterations can be significantly reduced resulting in a shorter product development lead time.

Keywords: Shore Hardness;Stress Induced;Engine Isolators; Young's Modulus.

1. Introduction

The engine isolator is used to isolate the vibration generated in the Engine and the Frame. It protects the engine from the vibrations that are generated by the stresses induced in the frame due to several external factors also; it protects the frame from the vibrations generated by the engine due to the rotating and reciprocating components. The engine isolator is very basic in construction and has two plates separated by rubber body which acts like a damper to these vibrations generated. These engine isolators commonly referred to as rubber mounts have a very important property of rubber which effect the vibration isolation known as Shore Hardness. The author has tried to find a relationship between the stress induced and the shore hardness of the mount using a simple concept. The results obtained were in 10% variation to the actual mount being used in the production.

2. Methodology

2.1 Stress Determination

The shore hardness of the mounts are found based on the stresses generated, which are obtained from the case where the maximum force is generated, as a practice the following conditions are considered to induce the maximum forces on any engine isolator.

- Heavy braking
- Cornering
- Engagement of the 1st gear or reverse gear from static conditions

Considering the above mentioned cases stress generations the authors found that the maximum stresses were generated on the mounts during heavy braking as the change in momentum generated the maximum force.

2.2 Main Ideology

The conventional method of calculating the shore hardness is to use the above mentioned conditions and use the NVH analysis for the same to generate the value of shore hardness, the method is very cumbersome and time consuming with a very wide range of iterations to be carried.

Instead the authors have employed a new approach by considering the mounts to be in a plane perpendicular to the action of the force and hence considering the mounts to be as bolted joints in a perpendicular plane the author has approached the calculations.

After the computation of the stresses the author computed linear strain onto the mount which helped to get to the modulus of rigidity for the mounts. The young's modulus was computed from the modulus of rigidity using the basic equations.

The shore hardness was hence computed using logarithmic reaction between the Young's modulus and the shore hardness, the usage of the logarithmic approach was found to closest to the actual values and so it was the one employed to compute the values for 1G,3G and 5G loading conditions.

2.2 Calculations

The following data was taken from the mount under analysis and its parameters are reported as follows

1. Maximum speed of the vehicle: 100 km/hr
2. Time of braking to come to a standstill from top speed: 30secs
3. Linear Strain=0.0681818
4. Poisson's Ratio for rubber υ=0.5
5. Area of front mount Af= 0.00848 m2
6. Area of rear mount Ar= 0.0116 m2
7. Eccentricity of front mount e1=82.5mm

8. Eccentricity of rear mount e2=157.5mm
9. Distance from force of application for front mount L1=-97mm
10. Distance from force of application for rear mount L2=900mm

The total force was calculated on the basis of change in momentum formula giving the total load,L=674.8148148 N

The shear force was calculated on the basis of the reaction force, $F_S = (\frac{L}{4})$

The shear stress was calculated using the following formula, $\tau = (\frac{F_S}{Area\ of\ mount})$

Using the above loading, the weight per unit length (w) was calculated using the following formula, $\mathrm{w} = \frac{\mathrm{L}(\mathrm{e}_1+\mathrm{e}_2)}{\mathrm{L}_1^2+\mathrm{L}_2^2}$

Giving the tangential force as,

$$F_T = (w * distance\ of\ mount\ from\ point\ of\ application\ of\ force)$$

Giving the stress at the mounts as, $\sigma = (\frac{F_T}{Area\ of\ mount})$

The maximum shear stress on a mount was calculated by, $\tau_{MAX} = \sqrt{(\sigma/2)^2 + \tau^2}$

Now the modulus of rigidity is given by, $G = (\frac{\tau_{MAX}}{Shear\ Strain})$

The Young's modulus was calculated as follows, $E = G * 2 * (1 + \upsilon)$

Using the logarithmic relation between shore hardness and young's modulus we have

$$lnE = (0.0235 * S) - .6403$$

Where E= young's modulus in MPa and S= shore hardness

3. Results

Table 1: Shore Hardness Result.

Shear stress front(N/m2)	19894.30468	Shear stress rear(N/m2)	14543.42273
Tangential force front(N)	57.5159251	Tangential force front(N)	533.6529133
Stress front(N/m2)	6782.538337	Stress rear(N/m2)	46004.56149
Shear stress max (N/m2)	20181.28007	Shear stress max(N/m2)	27214.26215
Modulus of rigidity front (Pa)	591984.2155	Modulus of rigidity rear(Pa)	798285.023
Young's modulus front(Pa)	1775952.646	Young's modulus rear(Pa)	2394855.069
Young's modulus in MPa	1.775952646	Young's modulus in MPa	2.394855069
Shore hardness(SHORE A) 1G	51.1458	Shore hardness (SHORE A) 1G	42.9623
Shore hardness(SHORE A) 3G	51.6866	Shore hardness (SHORE A) 3G	64.4094
Shore hardness(SHORE A) 5G	52.7288	Shore hardness (SHORE A) 5G	81.8522

4. Conclusions

The authors would like to report the following conclusions,

1. The shore hardness was calculated using a logarithmic approach.
2. The values selected were that of 3G loading since they offer the best results. As the results obtained at the #G loading condition meet the present values of 55 (SHORE A) for the front mount and 60(SHORE A) for the rear mounts
3. The calculated and actual values are in the range of -6.02% for the front mount and 7.3% for the rear mount which are within the ±10% range.

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