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Research Article

Dynamic Analysis on Hammer of a Coal-Hammer Mill Crusher

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Abstract

The Paper deals with the Static and Dynamic (Modal, Harmonic) analyses for analyzing the hammer used for crushing coal. The size of the coal received is 200 mm and has to be crushed as per the desired sizes (30mm) . The hammers are made of Manganese Steel (SA – 105). Deformation under static analysis is found. Maximum strain value is obtained. The maximum induced stresses and the frequency at which the hammer is to be operated is analyzed. The Hammer is modeled in CATIA and is analyzed by ANSYS software.

Keywords: *Hammer mill crusher, Tramp iron, Vibratory Motion, Modal, Harmonic and Dynamic analysis.*

1. Introduction

A crusher is a machine used to reduce size or form such that the crushed materials can be reduced to the required size or recycled or easily disposed off.

Crushing is the process of transferring a force amplified by mechanical advantage through a material that resists deformation, more.

The crushing method uses any or a combination of the following four basic ways: Impact, Attrition, Shear and Compression.

Impact crushing has two variations: Gravity impact and Dynamic impact. Coal is dropped onto a hard surface (gravity impact) and is given a blow by hammer (dynamic impact).

Attrition method has the material scrubbed between the hammers and the screen bars. Attrition consumes more power and causes heavier wear on hammers and screen bars.

Shear method has trimming or cleaving action. It is usually combined with impact and compression methods.
Compression method has the material compressed between two surfaces.

In mining industry crushers are used either as Primary or secondary. Primary crushers are used for fragmenting the starting material. Secondary crushers are used for handling coarse materials. Ternary crushers and Quaternary crushers are also used to reduce ore particles to finer gradations.

In a Hammer Mill crusher, the coal (app. 200 mm sizes) enters from the top and is violently thrown against the breaker blocks by the hammers. The final crushing is done between the hammer faces and the screen bars (sizes of ¼ inch or lesser). Then the crushed coal goes to the conveyors below and is carried to the storage bunkers. Tramp iron or material that does not go out between the screen bars is dropped into the iron pockets for removal.
Hammer Mills crushers operate with close tolerances between the hammers and the screen bars. They reduce the material size by attrition combined with shear and impact reduction methods.

Hammer Mill crushers finish product to desired sizes by and sizes are controlled by grates. They have high rate of production and have easy access for maintenance and grate changes. Hammer Mill crushers are made of heavy duty Cast Iron or have Carbon Steel for construction.
Hammer Mill crushers are used for crushing Minerals, Stone, Ceramics, Lime Stone, Glass recycling industries.

2. Problem Formulation

The Hammer Mill Hammer is used to crush coal of 200 mm size to a crush size of 30 mm. Hammer is modeled in CATIA Software and is analyzed by ANSYS software. Material used for Hammer is SA-105 Carbon Steel, which has an allowable stress of 96.5 N/mm^2.

Modal Analysis: This is used to determine the vibration characteristics, i.e., natural frequencies and mode shapes of a linear structure. It is also used as a starting point for other dynamic analysis.

Harmonic Response Analysis: This is used to determine the steady state response of a structure to loads that vary harmonically with time. Any sustained cyclic load will cause resonance and other harmful effects of forced vibrations.

Dynamic Analysis: This is used to determine the response of the structure under the action of any general time dependent loads.

3. Parameters to be considered for Design

1. Type of material being crushed.

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2. Size of material to be taken and to be crushed.
3. Capacity / thorough put
4. Type of feeding
5. Motor rotational speed
6. Overall dimensions of Crusher and its weight.

4. Data considered for Design

1. Type of material being crushed - coal
2. Size of material – 200 mm taken to 30 mm crush size
3. Capacity / thorough put – 16 to25 ton/hour
4. Type of feeding – from top
5. Motor rotational speed – 970 rpm
6. Overall dimensions of Crusher – 980*890*570 mm and weight – 1.05 ton.

Static Analysis – Hammer

Table: 1 Data given as Input

Material	
Assignment	Structural Steel SA-105
Non Linear Effects	Yes
Thermal Strain Effects	Yes
Bounding Box (Hammer Size)	
Length X	90.0 mm
Length Y	191.0 mm
Length Z	55.0 mm
Properties	
Volume	5.8234e+005 mm^3
Mass	4.5714 kg
Statistics	
Nodes	1956
Elements	980

Table: 2 Structural Steel (SA-105) Constants

Density	7.85e-006 kg / mm^3
Co-eff. Of Thermal Expansion	1.2e-005 / ^{0} C
Specific Heat	4.34 e+005 mJ/ kg / ^{0} C
Thermal Conductivity	6.05e-002 W/ mm / ^{0} C
Resistivity	1.7e-004 ohm mm

Table: 3 Static Analysis Results

	Total Deformation (mm)	Max. Principle Elastic Strain (mm / mm)
Minimum	0	0.0002373
Maximum	0.97051	0.007295

Table: 4 Modal Analysis Results

Mode	Natural Frequency (Hz)	Strain (mm/mm)
1	713.36	0.1078
2	1408.2	0.1047
3	2470.2	0.2556
4	6276.3	0.4435
5	6386.8	0.6428
6	7655.4	0.5509

Harmonic Analysis Results

Table: 5 Deformation (mm)

Mode	Forced Frequency (Hz)	Deformation (mm)
1	916.67	0.033118
2	1733.3	0.029407
3	2550	0.031728
4	3366.7	0.036436
5	4183.3	0.045731
6	5000	0.067863

Table: 6 Stress Values (N/mm2)

Mode	Forced Frequency (Hz)	Stress (N/mm^2)
1	916.67	29.08
2	1733.3	37.29
3	2550	34.9
4	3366.7	41.52
5	4183.3	54.44
6	5000	85.24

5. Figures

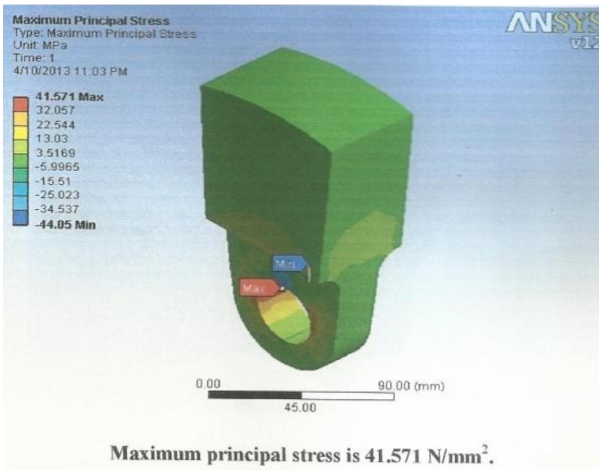


Fig. 1 Maximum Principal Stress is 41.571 N/mm^2

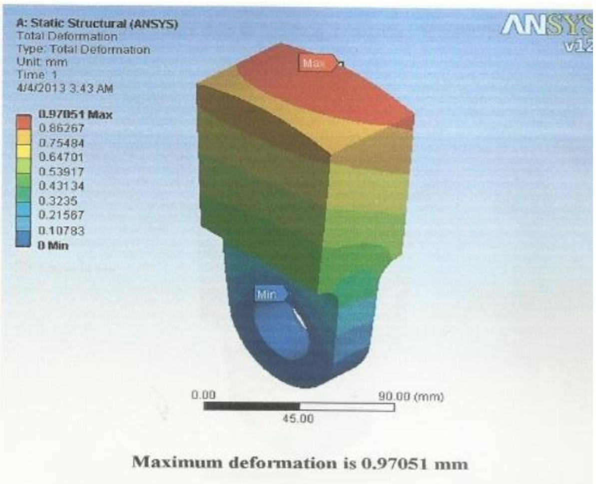
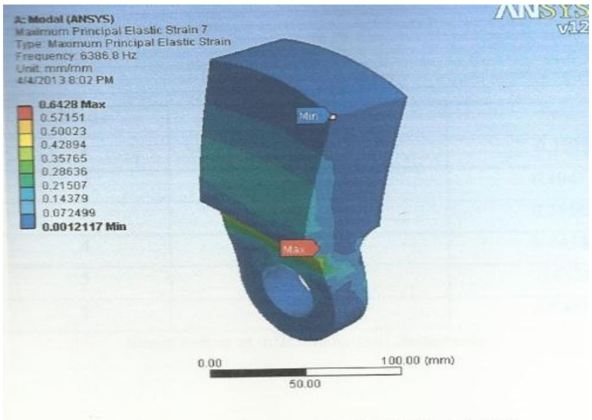
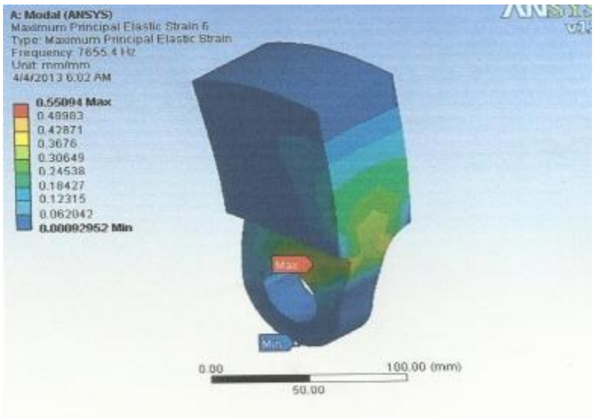


Fig.2 Maximum deformation is 0.97051 mm



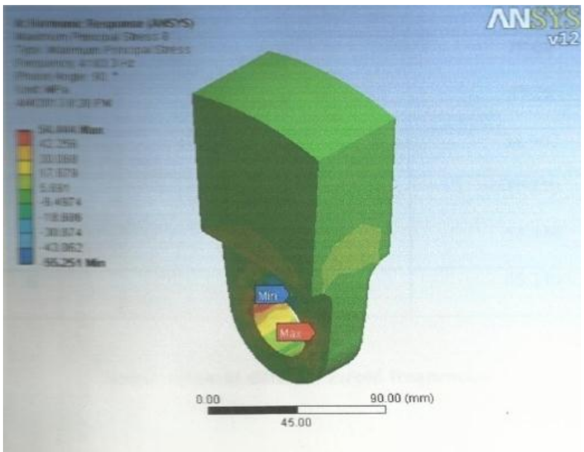
Maximum principal strain at 6386.8 Hz is 0.6428

Fig.3 Maximum Principal Strain at 6386.8 Hz is 0.6428



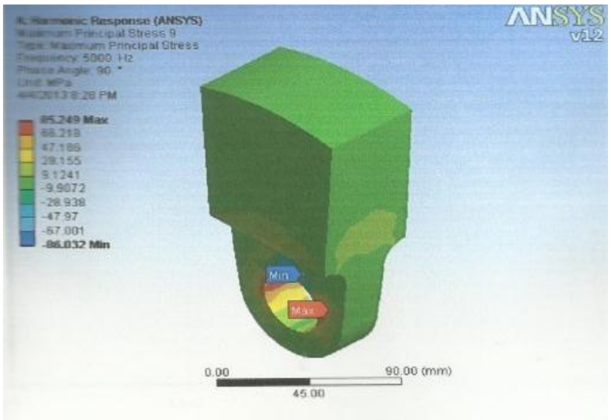
Maximum principal strain at 7655.4 Hz is 0.55094

Fig. 4 Maximum Principal Strain at 7655.4 Hz is 0.55094



Stress induced is 54.444 N/mm^2 at 4183.3 Hz

Fig. 5 Stress induced at 4183.3 Hz is 54.444 N/mm^2



Stress induced is 85.249 N/mm^2 at 5000 Hz

Fig. 6 Stress induced at 5000 Hz is 85.249 N/mm^2

Conclusions

1) Material considered for the Hammer is SA-105. The allowable stress is 96.5 N/mm^2.
2) Maximum deformation is found to be 0.9705 mm.
3) Natural frequency of hammer is found to be in the frequency range of 100 – 10000 Hz.
4) Maximum Strain value is 0.6428 at a natural frequency of 6386.8 Hz.
5) Maximum deformation of 0.067863 mm is observed at 5000 Hz.
6) Maximum stress at 5000 Hz is found as 85.249 N/ mm^2.
7) The induced stress of 85.249 N/ mm^2 is less than the allowable stress of 96.5 N/ mm^2.
8) From the result obtained, it could be deduced that the component is in safe zone for the above working conditions up to a frequency of 5000 Hz.
9) The effect on the production/thorough put at different frequencies can be studied. And, analysis on tramp iron can be done.

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