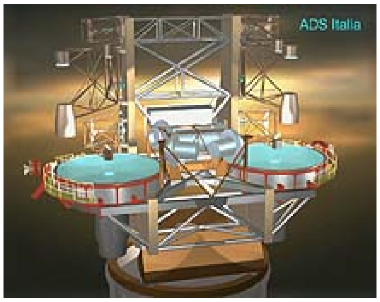
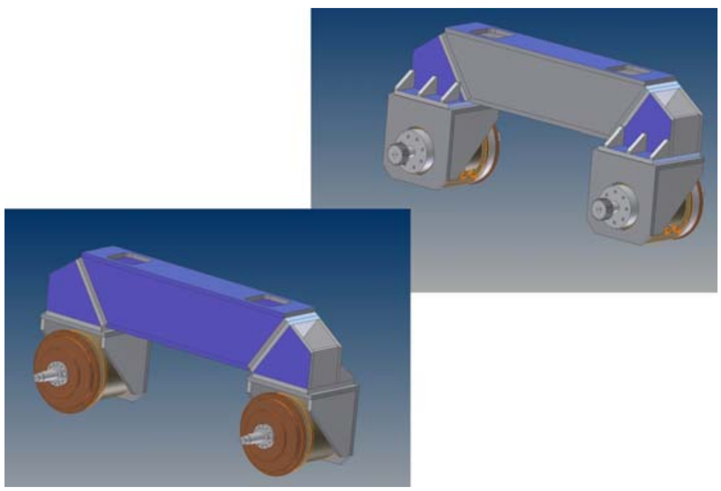


LBT PROJECT 2x8.4m TELESCOPE
Doc.No. : 671s009 Issue : a Date : 28 February 2007

LBT PROJECT

2 X 8.4m OPTICAL TELESCOPE



Instrument Rotator and Cable Chain
Bent Gregorian Rotator

Motor Mount Analysis

	Signature	Date
Prepared	Thomas Hair	02/28/2007
Reviewed	Robert Meeks	
Approved		

1 Revision History

Issue	Date	Changes	Responsible
a	28 February 07	First issue	T.Hair, R.Meeks

2 Table of Contents

3 About this document

3.1 Purpose

This document is to describe the analysis results from ANSYS about the deflection and stiffness of the Rotator Gallery motor mounts.

The results from the ANSYS analysis contribute to changes in the overall design of the motor mount to increase stiffness and minimize any twisting or unwanted deformation.

3.2 Analysis results summary

The resultant maximum deformation of the entire motor mount assembly is 11.5 microns. The calculated stiffness is 87.0 N/micron.

The following two results are an analysis of a “Ring” region (shown Figure 1). The “Ring” region is an area displaying the deformation of the motor mount most affectively.

The resultant maximum deformation of the interior mount “Ring” specific region is 10.4 microns. The calculated stiffness is 96.4 N/micron.

The following analysis is the average deformation of the 882 nodes that make up the “Ring” region. The calculated average deformation of the interior mount “Ring” region is 5.98 microns. The calculated average stiffness is 167.1 N/micron.

The average deformation of the individual nodes in the “Ring” region has higher accuracy of the mount plate stiffness than the prior results. This is due to the localization of the node deformation allowing a more accurate analysis of the pinion gear displacement is possible.

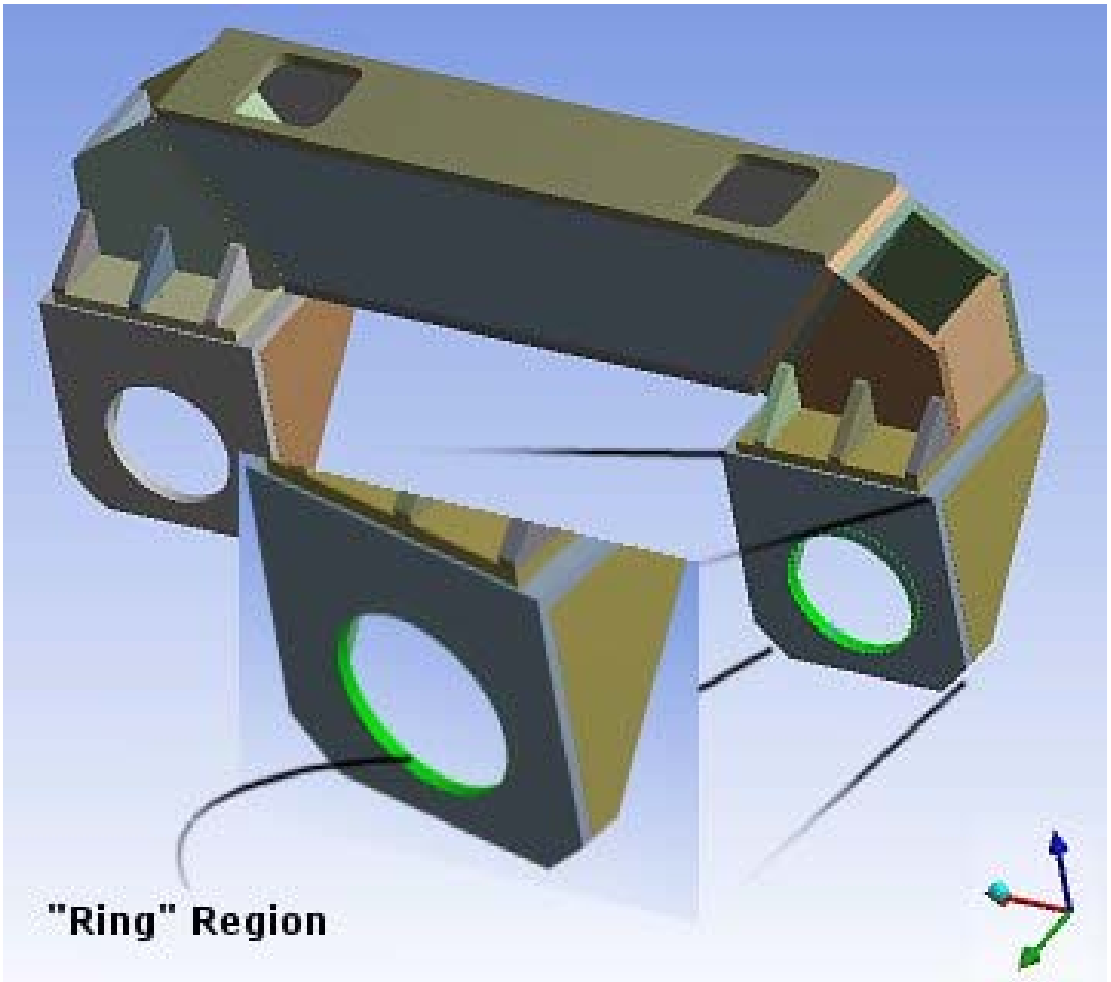


Figure 1 - Selected "Ring" Region

3.3 Reference Documents

[RD1] 670s004a – Instrument Rotator and Cable Chain Conceptual Design Description
[RD2] 671s120 – Nasmyth Rotator Motor Mount.iam
[RD3] 671s120a – Nasmyth Rotator Motor Mount.idw

4 Model Description

4.1 Mesh

Construction of an appropriate mesh accommodates applicable loads and supports giving results conducive of the actual assembly deformation.

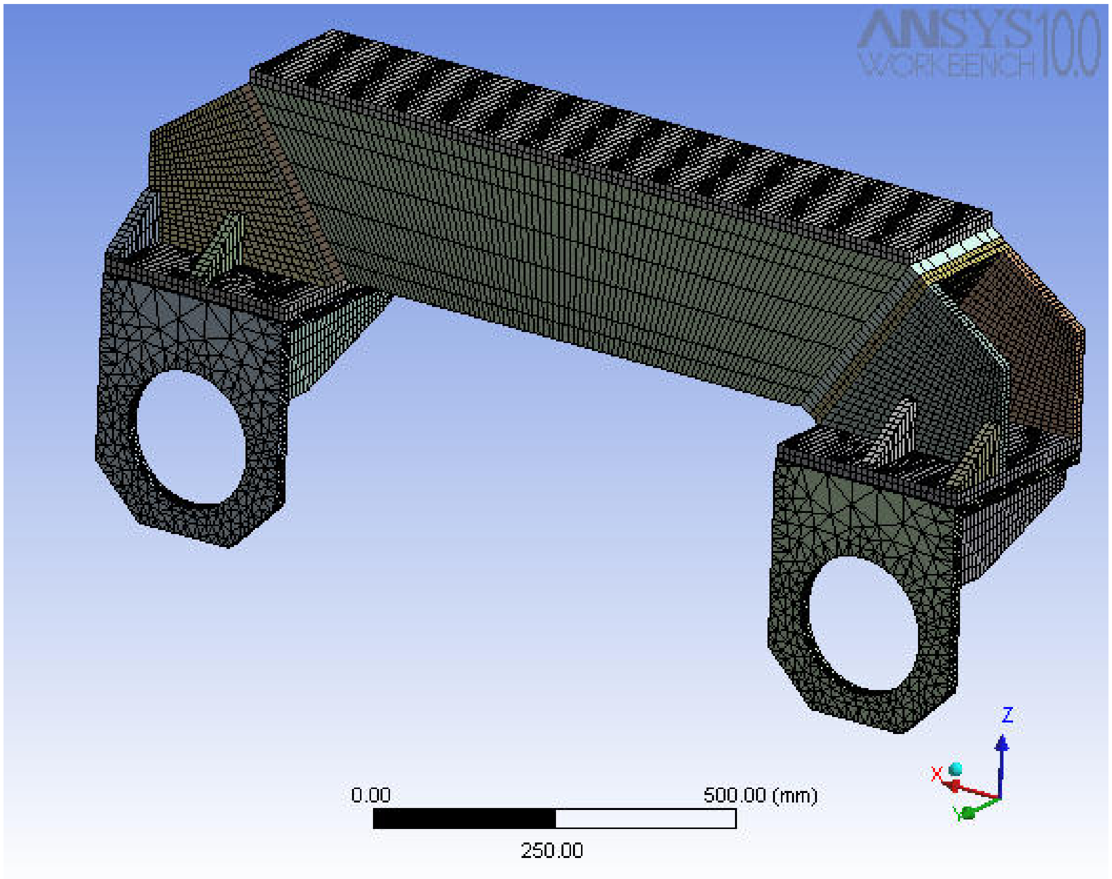


Figure 2 - Nasmyth Rotator Motor Mount Assembly Mesh

There are 29360 solid elements, 19208 contact elements, and 137612 nodes in the mesh seen in Figure 2. The solid elements are primarily quadratic tetrahedrons and secondarily quadratic wedges. All parts in the assembly are "Structural Steel". Definitions of "Structural Steel" are in section 6.6.

4.2 Loads and Support

"Remote Force" loads were applied to the assembly model according to a configuration that they would most likely occur on the rotator gallery.

The loads are 1000 N at 35 degrees to the X-Axis (according to the local coordinate system), displaced a distance approximately 130 mm from the mount face of the plate the motors are assembled to, as seen in Figures 3 and 4.

Any load could have been used instead of 1000 N. This is due to the linear relationship between load and deformation shown in Equation 1.

$$k = \frac{F}{\delta}$$

Equation 1 - Stiffness Calculation (stiffness is k, load is F, and deformation is δ)

The 35 degree angle of the load is the pressure angle between the pinion and rotator gears.

The displacement of the loads is necessary to correctly simulate the force reactions between the pinion gears and the rotator gear.

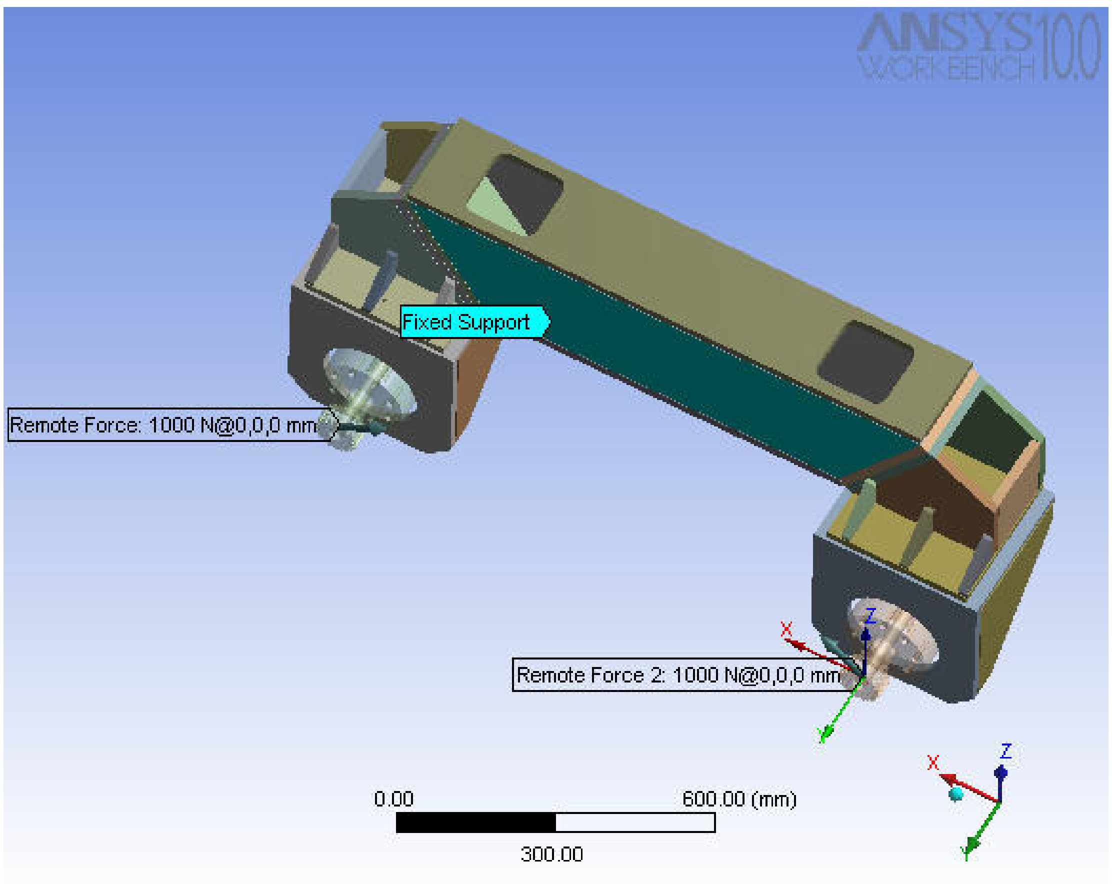


Figure 3 - Applied Loads and Supports

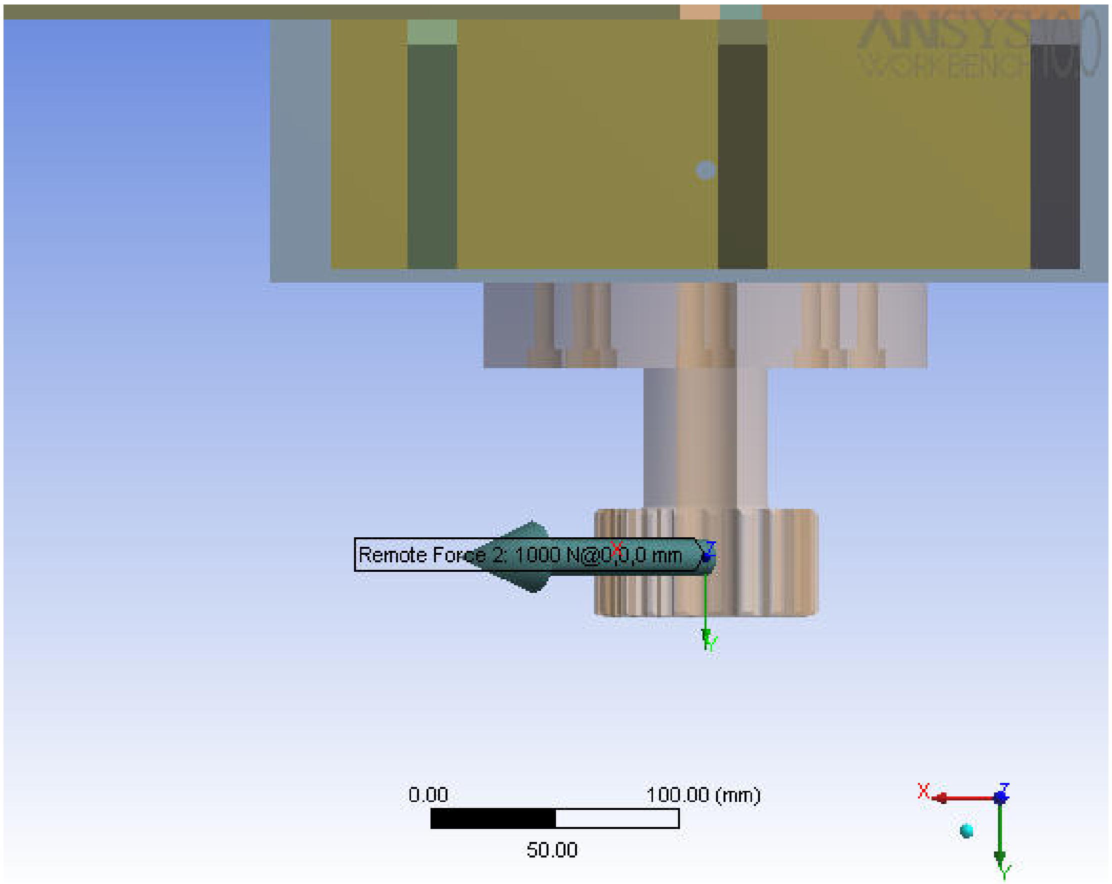


Figure 4 - Applied Load Close Up

The motor mount assembly is supported by the face of the plate indicated as a "Fixed Support" shown in Figure 3. The face of the plate (shown in Figure 5), is selected as the support because that is the location that the motor mount assembly is to be mounted to the rotator gallery.

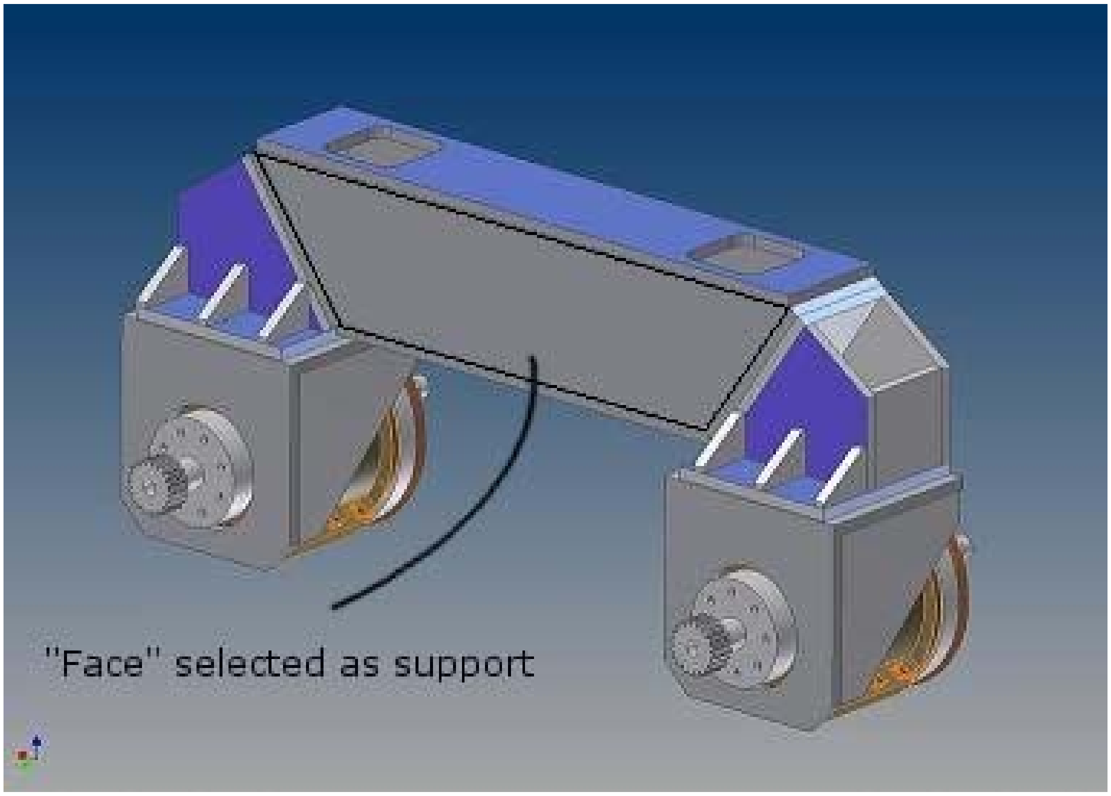


Figure 5 - Fixed Support Selection

5 Results

The results obtained are from the calculations and analyses of the stiffness of the entire motor mount assembly, the localized "Ring", and the nodes of the "Ring". The "Ring" region is where the motor is mounted.

The completed analysis returns information on the deformation of the specified model, assembly or region. Stiffness is calculated by using Equation 1, the maximum deformation acquired from the completed analysis, and knowing that the Load applied is 1000 N. This is shown in as an example Equation 2 using the results of the analysis of the entire model.

$$k = \frac{F}{\delta} = \frac{1000N}{11.5\mu m} = 87\frac{N}{\mu m}$$

Equation 2 - Stiffness of Entire Model

A stiffness exceeding 8,000 N·m/radian [RD1] is necessary for sufficient stiffness between the pinion and rotator gears.

5.1 Entire Model Deformation Results

Deformation of the entire model indicates a maximum deformation of 11.5 microns as seen in Figures 6 and 7. This corresponds to a stiffness of 87 N/micron.

The 11.5 micron deformation shown in Figures 6 and 7 is a highly localized result. This result is the maximum deflection that is possible for the small region that the maximum deformation occurs. However, this is not specifically pertaining to the deflection to that of the pinion gear or the entire model.

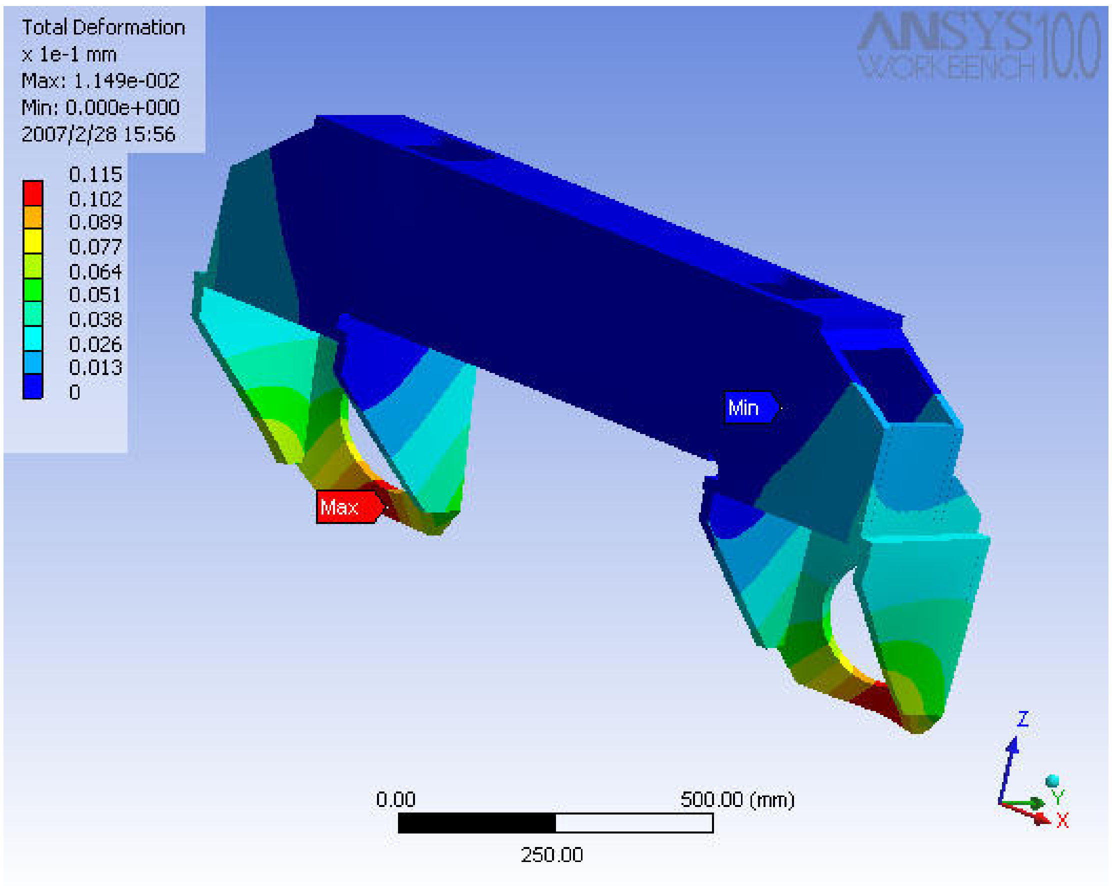


Figure 6 – ISO View Deformation of Motor Mount Assembly

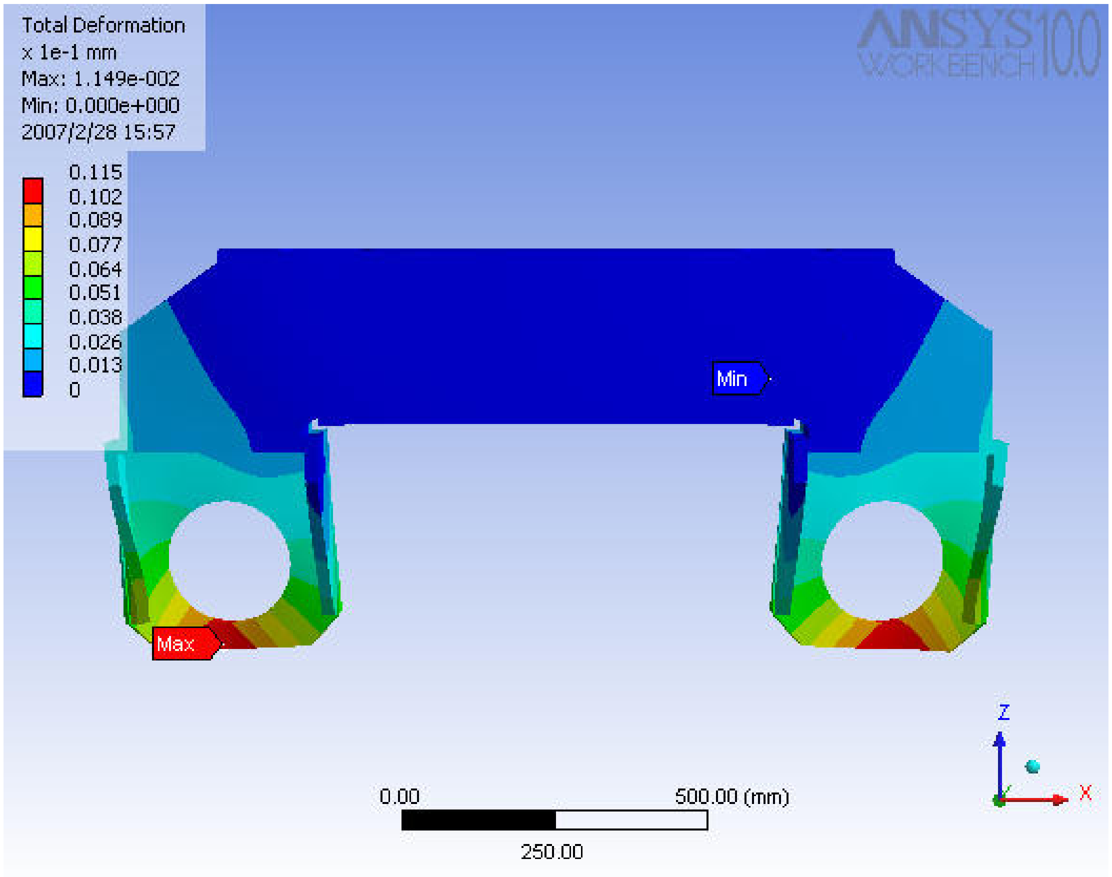


Figure 7 – Front View Deformation of Motor Mount Assembly

5.2 Motor Flange Interior "Ring" Region Deformation Results

The deformation of the "Ring" region, seen in Figures 8 and 9, indicates a maximum deformation of10.4 microns. This corresponds to a stiffness of 96 N/micron.

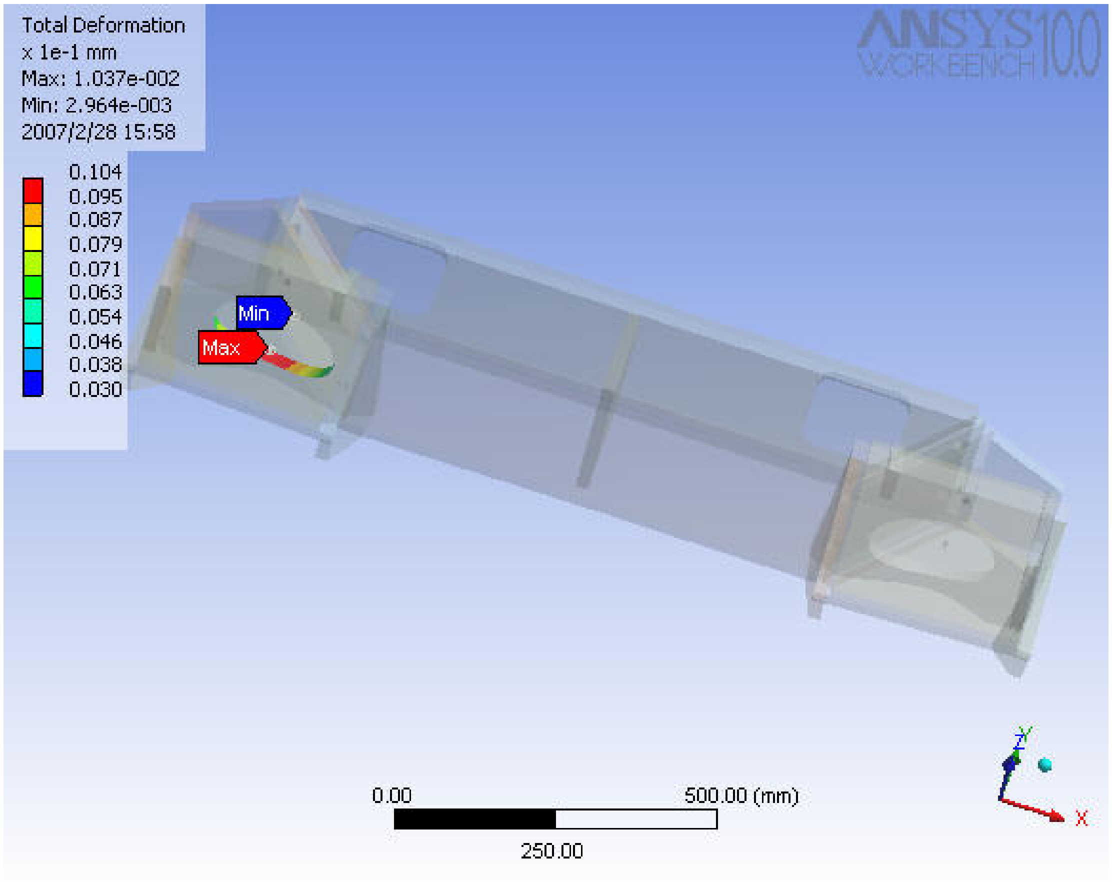


Figure 8 - "Ring" Region Deformation

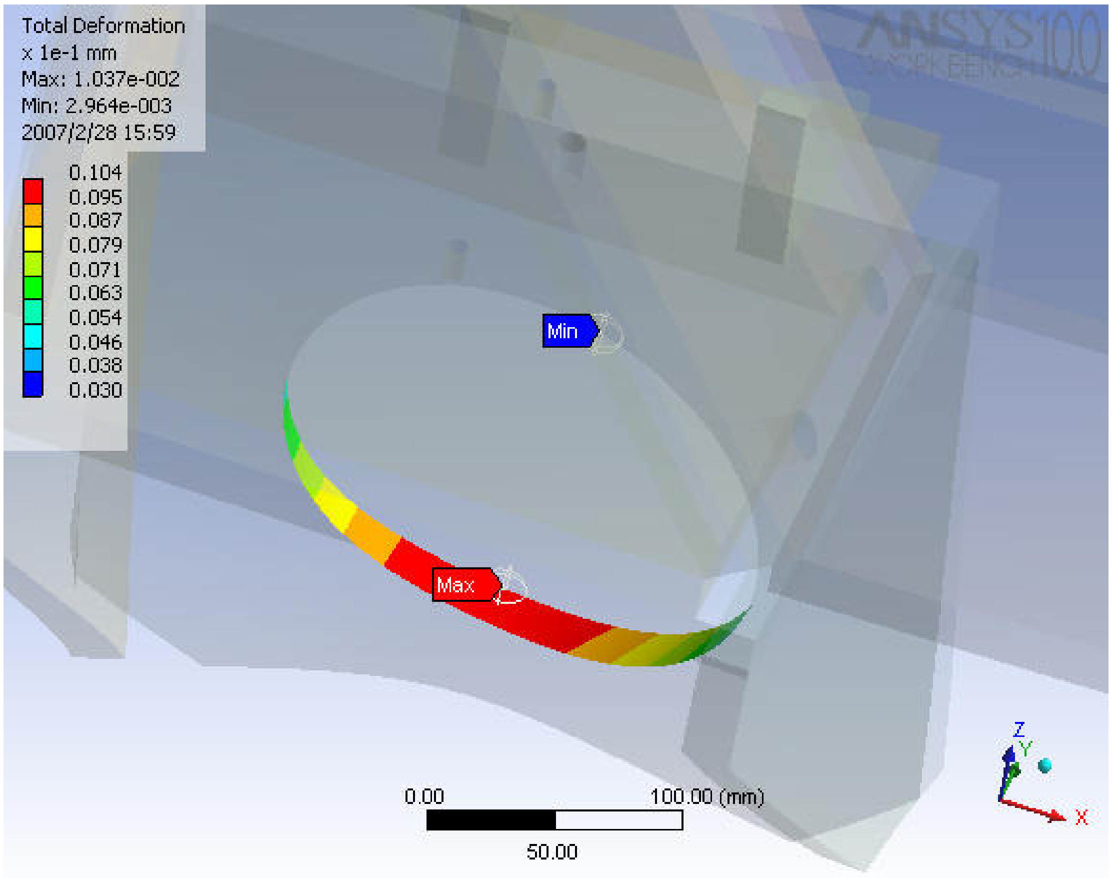


Figure 9 - "Ring" Region Deformation Close Up View

5.3 Average Results of “Ring” Region

A better deformation and stiffness is available by exporting the amount of deformation by each node within the “Ring” region and taking the average of that sum total. The average deformation is 5.98 microns of 882 nodes. The calculated stiffness is 167.1 N/micron.

The results obtained from averaging the deformations of the individual nodes in the “Ring” region are more relevant to the deflection of the pinion gear. This is because the “Ring” region will deform (deflect) in a similar manner to the pinion shaft.

The average nodal deformation is more relevant than the maximum deformation of the “Ring”, because the maximum deformation of the “Ring” is another localized result similar to the localized result of the deformation of the entire model.

The average nodal deformation indicates a stiffness well exceeding 8,000 N·m/radian.

6 Generated ANSYS Report

Large Binocular Telescope Observatory

ANSYS Report

Author

T.Hair

Subject

Rotator Gallery Motor Mount

Project Created

Tuesday, February 27, 2007 at 9:36:16 AM

Project Last Modified

Wednesday, February 28, 2007 at 2:45:55 PM

Report Created

Wednesday, February 28, 2007 at 3:52:49 PM

Software Used

ANSYS 10.0

6.1 Summary

This report documents design and analysis information created and maintained using the ANSYS® engineering software program. The scenario listed below represents one complete engineering simulation.

- Based on the Inventor assembly *"\\Lbtdw102\LBTO Home\thair\My Documents\Vault Working Folder\Projects\671 Nasmyth Rotator\NewMotorMount 3.iam"*.
- Considered the effect of body-to-body contact, structural loads and structural supports.
- Calculated structural results.
- No convergence criteria defined.
- No alert criteria defined.
- See Scenario 2 below for supporting details and Appendix A2 for corresponding figures.

6.2 Introduction

The ANSYS CAE (Computer-Aided Engineering) software program was used in conjunction with 3D CAD (Computer-Aided Design) solid geometry to simulate the behavior of mechanical bodies under thermal/structural loading conditions. ANSYS automated FEA (Finite Element Analysis) technologies from ANSYS, Inc. to generate the results listed in this report.

Each scenario presented below represents one complete engineering simulation. The definition of a simulation includes known factors about a design such as material properties per body, contact behavior between bodies (in an assembly), and types and magnitudes of loading conditions. The results of a simulation provide insight into how the bodies may perform and how the design might be improved. Multiple scenarios allow comparison of results given different loading conditions, materials or geometric configurations.

Convergence and alert criteria may be defined for any of the results and can serve as guides for evaluating the quality of calculated results and the acceptability of values in the context of known design requirements.

- *Solution history* provides a means of assessing the quality of results by examining how values change during successive iterations of solution refinement. *Convergence criteria* sets a specific limit on the allowable change in a result between iterations. A result meeting this criteria is said to be "converged".
- *Alert criteria* define "allowable" ranges for result values. Alert ranges typically represent known aspects of the design specification.

All values are presented in the *"Metric (mm, kg, N, °C, s, mV, mA)"* unit system.

Notice

Do not accept or reject a design based solely on the data presented in this report. Evaluate designs by considering this information in conjunction with experimental test data and the practical experience of design engineers and analysts. A quality approach to engineering design usually mandates physical testing as the final means of validating structural integrity to a measured precision.

6.3 Nasmyth Rotator Motor Mount

6.3.1 Geometry

Geometry from the Inventor assembly *"\\Lbtdw102\LBTO Home\thair\My Documents\Vault Working Folder\Projects\671 Nasmyth Rotator\NewMotorMount 3.iam"*.

- *"nasmyth rotator pinion 3:1"* , *"nasmyth rotator pinion 3:2"* , *"0100 Freni Brake:1"* , *"0100 Freni Brake:2"* , *"Brake to Motor Mount Plate:1"* , *"Brake to Motor Mount Plate:2"* , *"Brake To Shaft Bracket:1"* and *"Brake To Shaft Bracket:2"* were suppressed. Suppressed parts do not affect the results in this scenario in any way.
- The bounding box for all positioned bodies in the model measures 1,570.97 by 305.16 by 658.69 mm along the global x, y and z axes, respectively.
- The model has a total mass of 328.83 kg.
- The model has a total volume of 4.19×10^{7} mm^3.

6.3.2 Contact

- *"Contact"* uses a tolerance of 0.0 for automatic detection.

6.3.3 Mesh

- *"Mesh"*, has an overall relevance of 0.
- *"Mesh"* contains 137610 nodes and 29360 elements.

6.4 Environment

Simulation Type is set to Static

Analysis Type is set to Static Structural

6.4.1 Structural Loading

Table 4.2.1.1. Structural Loads

Name	Coordinate System	Type	Magnitude	Vector	Reaction Force	Reaction Force Vector	Reaction Moment	Reaction Moment Vector
"Remote Force"	Coordinate System	Remote Force	1,000.0 N	[-819.15 N x, 0.0 N y,573.58 N z]	N/A	N/A	N/A	N/A
"Remote Force 2"	Coordinate System 2	Remote Force	1,000.0 N	[819.15 N x, 0.0 N y,573.58 N z]	N/A	N/A	N/A	N/A

6.4.2 Structural Supports

Table 4.2.2.1. Structural Supports

Name	Type	Reaction Force	Reaction Force Vector	Reaction Moment	Reaction Moment Vector	Associated Bodies
"Fixed Support"	Fixed Surface	1,147.16 N	[-1.68×10^{-4} N x, -8.09×10^{-4} N y, -1,147.16 N z]	246,925.5 N·mm	[-246,925.5 N·mm x, 2.93 N·mm y, -0.74 N·mm z]	*"NewMotorMount_SupportBlockWeb 3:2"*

6.5 Solution

Solver Type is set to Program Controlled

Weak Springs is set to Program Controlled

Large Deflection is set to Off

6.5.1 Structural Results

Table 4.3.1.1. Values

Name	Scope	Minimum	Maximum	Minimum Occurs On	Maximum Occurs On
"Total Deformation"	All Bodies	0.0 mm	1.15×10^{-2} mm	NewMotorMount_SupportBlockWeb 3:2	NewMotorMount_MotorBracket 3:2
"X-Deformation"	All Bodies	-6.46×10^{-3} mm	6.44×10^{-3} mm	Wedge Gusset 2:1	Wedge Gusset 2:4
"Y-Deformation"	All Bodies	-1.81×10^{-4} mm	0.01 mm	NewMotorMount_SupportBlockTop 3:1	NewMotorMount_MotorBracket 3:2
"Z-Deformation"	All Bodies	-1.4×10^{-3} mm	2.02×10^{-3} mm	Wedge Gusset 2:1	NewMotorMount_MotorBracket 3:2
"Equivalent Stress"	All Bodies	7.91×10^{-4} MPa	4.38 MPa	NewMotorMount_SupportBlockWeb 3:2	NewMotorMount_WedgeFace 3:1
"Total Deformation on NewMotorMount_MotorBracket 3:2"	Face(s) on *"NewMotorMount_MotorBracket 3:2"*	2.96×10^{-3} mm	1.04×10^{-2} mm	NewMotorMount_MotorBracket 3:2	NewMotorMount_MotorBracket 3:2

- Convergence tracking not enabled.

6.6 *Definition of "Structural Steel"*

Table A3.1. *"Structural Steel"* Constant Properties

Name	Value
Compressive Ultimate Strength	0.0 MPa
Compressive Yield Strength	250.0 MPa
Density	7.85×10^{-6} kg/mm³
Poisson's Ratio	0.3
Tensile Yield Strength	250.0 MPa
Tensile Ultimate Strength	460.0 MPa
Young's Modulus	200,000.0 MPa
Thermal Expansion	1.2×10^{-5} 1/°C
Specific Heat	434.0 J/kg·°C
Thermal Conductivity	0.06 W/mm·°C
Relative Permeability	10,000.0
Resistivity	1.7×10^{-4} Ohm·mm

7 Doc_info_start

Title: *Instrument Rotator and Cable Chain Bent Gregorian Rotator Motor Mount Analysis*
Document Type: Report
Source: Steward Observatory
Issued by: Thomas Hair
Date_of_Issue: *28 Feb 2007*
Revised by:
Date_of_Revision:
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Accepted by:
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Date_of_Release:
File Type: MS Word
Local Name: *Rotator Motor Mount Analysis*
Category: *600*
Sub-Category: *670*
Assembly: *671*
Sub-Assembly:
Part Name:
CAN Designation: *671s009*
Revision: *a*
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