Fermilab

Particle Physics Division
Mechanical Department Engineering Note

Number: MD-ENG-320 Date: 2 May 2011

Project Internal Reference:

Project: NOVA

Title: Ash River Pivoter Free Body Diagrams

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Reviewer(s):

Key Words:

Applicable Codes: AISC 9th Edition

Abstract Summary:

This note shows describes calculations on the structure of the NOvA Ash River Pivoter. It is a more complete revision to the calculations documented in engineering note 304 which addresses the heavier modules and the anticipated heavier table.

Refer to drawing 3929.220-ME-486942 which shows the lower portion of the block pivoter for use at Ash River. This drawing (and those called out in the bill of material on this drawing) is available at:

http://www-admscad.fnal.gov/MSDMain/cgi-bin/TP_PPDifind-web.pl

Discussion:

Engineering note 184 dated 21 April 2009 was originated to document and calculate the NOvA Ash River Pivoter loads. This engineering note 320 is based on that earlier work, but includes new values for the weights of the extrusions, new values for the weight of the Ash River pivoter table (table design is nearing the end of the fabrication drawing production effort, so the weight is better known than it was previously) and several additional calculations prepared as the FHEP pivoter was built.

Loads calculated in this engineering note are used as design inputs for individual components examined with FEA and documented in other engineering notes including numbers 321, 322, 323 and others.

The excel spread sheet where the calculations are made for the Ash River Pivoter is divided into several sections as listed below:

Section 1) List the inputs to the design driven by the detector geometry.

Section 2) List the center of gravity of the three major loads seen by the pivoter table during rotation and the moments resulting from each load.

Section 3) Sums the rotation moments from each major component and calculates a location for the combined center of gravity of the block, table and pallet.

Section 4) List the geometry choices made for the ends of the pivot cylinders.

Section 5) Calculates the geometry of the cylinders when the Table is horizontal and again when the Table is vertical. This section includes hand drawn sketches to show each distance and angle used in the calculations.

Section 6) Repeats the calculations in Section 5, but at many rotation angles; from the table rotated 2 degrees past horizontal to vertical. These calculations are used to generate the cylinder load and pressure as a function of table rotation angle.

- Table 1) Calculates cylinder geometry at each angle
- Table 2) Calculates moments from the Table, Block and Pallet at each rotation angle.

Table 3) Calculates the combined cylinder load (load exerted by both cylinders together) needed to balance the moments calculated in Table 2

Table 4) Provide the same calculations as in table 3, but for each cylinder and assumes the load is shared equally by each cylinder.

Graph 1) Graphs the cylinder load and extension values calculated in Table 4.

Section 7) List the key dimensions of the pivot cylinders manufactured by Phelps Industries, Inc.

Section 8) List the key dimensions of the Upper Frame Weldment. Fabrication drawing for the Upper Frame Weldment is 3929.000-ME-486361.

Sketch 6) Show the key dimensions of the Upper Frame and the reactions at the Table Pivot and Cylinder Stationary Pivot.

Table 5) Calculate the horizontal and vertical reactions at the table pivot and cylinder stationary connection.

Table 6) Hydraulic Cylinder pressure as a function of table rotations for loading due to the block and for the bare table with a pallet.

Section 9) List the geometry data from the Upper Frame Rear Pin to the Center of Gravity for the Block, Table, Pallet and Upper Frame.

Section 10) Calculate the reactions on the Forward and Rear Pins connecting the Upper and Lower Frames.

Section 11) List key Lower Frame dimensions and calculates the required moment of inertia to keep the bending stresses below the AISC ASD allowable values.

Section 12) Section 12a calculates the moment of inertia of the forward portion of the lower frame by hand. Section 12b shows the results of using Ideas beam properties to calculate the same moment of inertia. Results match.

Section 13 Rear Pin Support Bracket Mounting Bolt Sizing

Section 14 Rear Pin Support Bracket Weld Sizing

Section 15 Calculation of the Upper Frame Rotation due to Kneeling Cylinder Motion

Section 16 Loads on the Lower Frame Roller and Drive Traction Requirements

Section 17 Lateral Loads on the Ash River Pivoter

The calculations were performed in MS Excel.

Drawings were made in Ideas and PDF versions posted on the ADMS I-find website as mentioned above.

Because of formatting problems inserting PDF documents into MS word (drawings are often missing most of the information and excel spread sheets do not maintain page breaks) this engineering note has been assembled as a PDF document using Adobe Acrobat.