Fermilab

Particle Physics Division
Mechanical Department Engineering Note

Number: MD-ENG-158 Date: 03 June 2008

Project Internal Reference:

Project: Lab 5 Extruder Die Support Installation

Title: Die Support and Installation Tooling Analysis

Author(s): Dave Pushka

Reviewer(s): 6/9/08

Key Words: Lab 5, Extruder, Die Installation,

Abstract Summary:

A new die approximately eight inches in diameter by nine inches long (estimated weight of 130 pounds) is being installed on the plastic extrusion machine. This engineering note addresses the loading and procedures to be used during this die installation.

Applicable Codes: AISC 9th Edition. Aluminum Association Specification for Aluminum Structures No. 30, Table 3.3.27

Description:
The die has been supplied with a 1 inch deep, blind tapped hole (1-12 thread size) located over the center of gravity. Since standard eyebolts are not available in this size, a 1-8 threaded eye bolt was modified by having its shank cut off and a 1 inch long portion of 1-12 threaded material welded on using a 3/16 fillet weld performed using a TIG process. The weld length is

equal to π * d; L = 3.14 * 1 = 3.14 inches. Allowable weld stress is 0.3 Fy of the filler metal. Fy is 30,000 psi; allowable weld stress is 10,000 psi. Weld area is 0.707 * fillet size * length; Weld area is 0.4165 square inches. Allowable axial load is the weld area * allowable stress; = 0.4165 in^2*10,000 psi = 4165 pounds. This allowable load exceeds the actual load of 130 pounds by about 30 times. The modified eye bolt used to lift this die is acceptable.

A commercial, hand operated, worm gear driven strap winch with a nameplate capacity of 1500 pounds will be used to lift the die. The worm gear drive prevents the winch from releasing the load. The hand operated winch is acceptable for lifting the die weight of 130 pounds.

The winch is suspended with a 1000 pound capacity polyester sling used in a upside down basket configuration. Allowable load is therefore 2000 pounds. This exceeds the die weight by a factor of about 15. This sling is acceptable.

The upper end of the sling is supported by a section of aluminum box section. Box section dimensions 2 inches by 2 inches with a ¼ inch thick wall. Box sections spans 72 inches and the load is located 12 inches from one end. Material is 6061-T6. Span, L_b is 72 inches, Moment of inertia, I_{yy} = 0.91 in^4; Section modulus, S_c = 0.911 in^3. From table 3.3.27 of the referenced Aluminum Association publication, the Slenderness, S = L_b * S_c / I_{yy} = 72. For S < 146, the allowable stress is 21 ksi.

Bending stress in the aluminum box section is M_{max} = P* a * b / L. M_{max} = 200 pounds (weight of the die and the hoist and sling) * 12 inches * 60 inches / 72 inches. M_{max} = 2000 inch pounds. Bending stress, σ = My/I. Bending stress, σ = 2000 inch pounds * 1inch / 0.91 inch^4 = 2197 psi. The allowable bending stress is about 10 times the actual bending stress, so the box section is acceptable.

The two inch square box section is supported by a sistered pair of 5 inch deep by 1.25 inch wide hollow aluminum extrusions salvaged by Hans Jostlein and used to support the utilities over the extruder. Analysis of these members is addressed in Rafael Silva's engineering note MSD -03-06 from several years ago. Assuming the full load of 200 pounds goes into one horizontal member and a temporary unistrut column is located eighteen inches from the box section attachment, the cantilever load on the sistered

pair of aluminum box sections with 1/8 inch thick wall, (I = 17 inch ^4), the bending moment is 3600 inch pounds and the resulting bending stress is about 525 psi. This value is well below any allowable stress.

The temporary unistrut support column is a P3001 channel, approximately 84 inches tall. The allowable axial load on this is 4230 pounds per the unistrut general engineering catalog number 12. This capacity exceeds the applied load.

So, all elements in the load path from the new die, the eyebolt, the hand operated winch, the lifting sling, the 2 inch square aluminum box section, the existing cantilevered utility support extrusions, and the temporary unistrut column have all been shown to have structural capabilities in excess of the applied load.

Once the die is mounted to the extruder, the technicians wish to avoid taking the gravity load of the die solely with the mounting braces. So, an adapter to mount the tapped hole located on the bottom of the die (right below the center of gravity) has been made to allow a ¾-10 section of all thread rod. Rod length is about 18 inches and it is designed to sit into the center of a ¾ inch nominal diameter pipe welded to a base plate. (typically used for support pipe while welding or cutting).

Since the die will be rigidly bolted to the extruder, motion in the transverse direction will be prevented. Refer to AISC 9th edition Chapter E on page 5-42 for the formulas used below. This means the theoretical "K" value is 0.5. For a ¾ inch nominal diameter steel rod, r = R/2 = 3/16. KL/r = 0.5 * 36" / 3/16" = 96. C_c = SQRT (2* π^2 * E / F_y). F_y = 36 ksi, E = 2900 ksi; C_c = 39.87. Therefore, KL/r > C_c, so F_a = 12* π^2 * E / (23*KI/r)^2 = 1.62 ksi. Actual stress is 200 pounds / (π/4)*(.75)^2 = 452 psi (0.452 ksi).

So, the auxiliary support, although not needed, is sufficient to support the vertical load.

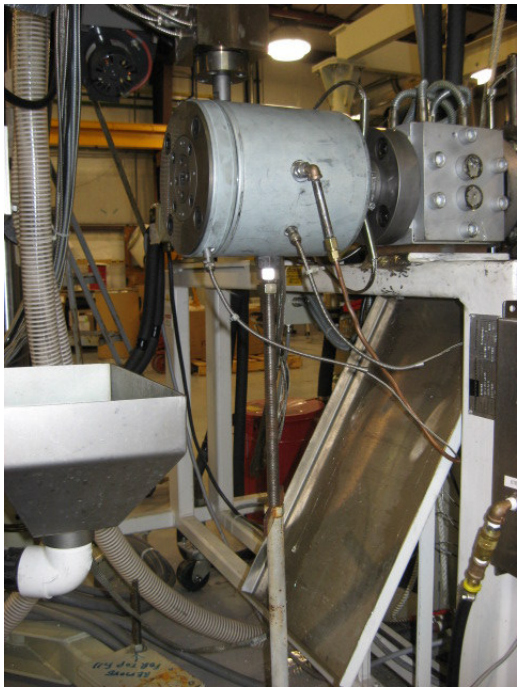

Image 1; Elevation view showing new die installed and supported on the threaded rod.

Image 2; Shows 2 inch square aluminum box section above the die.

Also shows the 5 inch deep recycled aluminum extrusions.

Unistrut column has been removed prior to this photograph being taken.