Crane Project: Design Review 1

Group 34

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1 Annotated Picture

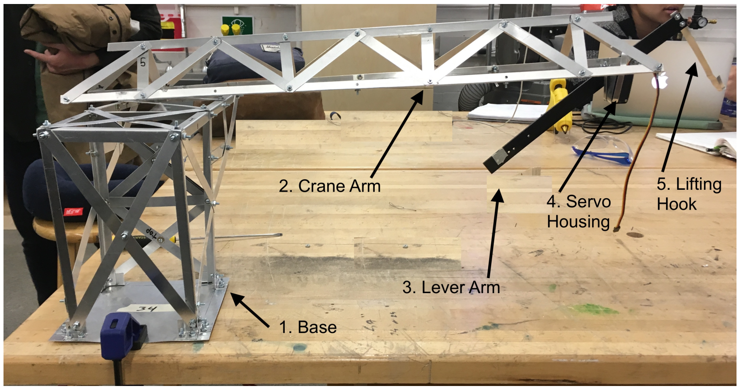

Figure 1: Side view of full crane.

1. Base: Our design featured a $5 \times 5 \times 8$ inch rectangular base with a 6 inch overhang. The front and back of the base were supported by X-shaped trusses. The sides use a V-shaped truss to support both the rectangular portion as well as the overhang. (see Figure 2)
2. Crane Arm: The crane arm was a 28 inch long triangular truss. The sides of the truss had vertical supports approximately every 6.8 inches, with diagonal supports in between. In order to reduce weight the bottom had only vertical supports.
3. Lever Arm: The lever arm was constructed using the delrin strip. The servo motor was attached approximately 8 inches from the left. (See fig. 3)
4. Servo Housing: The servo motor was held in place with several strips of aluminum screwed into the bottom of the crane arm. (see fig. 4)
5. Lifting Hook: The lifting hook extends about 2 inches downwards from the end of the lever arm. (see fig. 3)

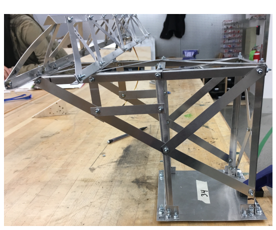

Figure 2: Side view of base

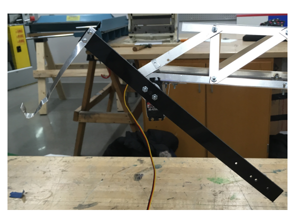

Figure 3: Lever arm and hook

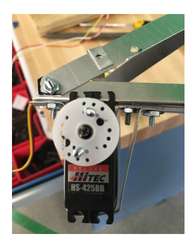

Figure 4: Servo housing

2 Theoretical Servo Torque Calculation

Note: These calculations were originally done with the intention of adding a counterweight to the opposite end of the lever arm. After construction the crane, the motor was unable to move with the counterweight attached, so we removed it for testing. The first set of calculations below does not include the counterweight; the latter does.

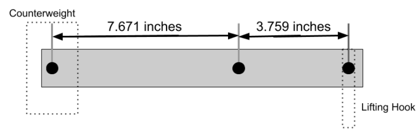

Figure 5: Diagram of lever arm.

Assumption: $M_{servo,max} = 57$ oz-in

Without Counterweight:
$\Sigma M_c = R_1 * W_{counterweight} - R_2 * W_{weight} + M_{servo} = 0$
$(7.671) * (0lbs) - (3.759in) * (1lb) + M_{servo} = 0$
$M_{servo} = 3.759$ lb-in $M_{servo} = 60.144$ oz-in
$\frac{60.144*100}{57} = 105.5\%$

This exceeds $M_{servo,max}$

With Counterweight:
$\Sigma M_c = R_1 * W_{counterweight} - R_2 * W_{weight} + M_{servo} = 0$
$(8.74409in) * (.26lbs) - (2.75591in) * (1lb) + M_{servo} = 0$
$M_{servo} = .482$ lb-in
$M_{servo} = 7.719$ oz-in
$\frac{7.719*100}{57} = 13.54\%$

3 Theoretical Lift Distance Calculation

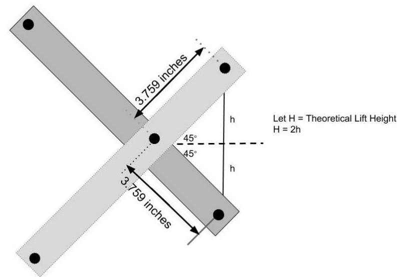

Figure 6: Diagram of lever arm after rotation.

Assumptions: $\theta_{servo} = 90°$, using theoretical torque (with counterweight) calculated in part 2

$\frac{T_{max}}{\theta_{max}} = \frac{T_{servo}}{\theta}$
$\frac{57}{90} = \frac{7.7199°}{\theta}$
$\theta = 12.188°$

$sin(12.188°) = h/2.756$
$h = 2.756 * sin(12.188°)$
$h = .582$ in
$H = 2h$
$H = 1.164in$

4 Discussion

According to the calculations, the servo motor should have been able to lift the weight with the added torque of the counterweight. However, the motor was unable to turn with the counterweight attached. In order for the motor to turn, we removed the counterweight for Design Review 1 in order to receive credit for lifting without weight. Without the counterweight, the required torque to lift the 1 lb weight exceeded the maximum torque of the servo motor, as seen in part 2. Thus, no lift was achieved.

In the calculations above, it was assumed that the maximum torque of the motor was 57 oz-in. However, if this were the case, the motor and counterweight should have provided more than enough torque to rotate the lever arm, even without trying to lift the 1 lb weight. Since this did not prove to be true, we can conclude that the servo motor may have provided less torque than originally assumed.
Additionally, when doing the calculations, we assumed the lever arm would start rotated 45° clockwise from a horizontal position. In reality, the lever arm

begins parallel to the ground, which would make the theoretical lift distance shorter than previously calculated. Another assumption we made for the second calculation was that the servo rotated exactly 90 degrees. However, if the angle of rotation was less than 90°, then our calculation overestimates the lift distance. For the final design review, some redesigning will be required in order to increase the torque. We will try switching out our servo for a new motor, to increase the amount of torque produced. We will try shortening the lifting side of the lever arm to reduce the amount of torque required to lift the weight. Additionally, we can lengthen the opposite side and add a heavier weight to increase the torque in the direction needed.