MTSU BAJA

College of Basic And Applied Science

Engineering Technology Department

Abstract

Baja SAE is an intercollegiate design competition hosted by the Society of Automotive Engineers (SAE). Students from universities on a global level will demonstrate their teamwork, education and innovative skills to design, fabricate, build, test and compete a vehicle within a years' time while adhering to the strict specifications of the SAE rulebook. The goal of the MTSU SAE is to manufacture safe and affordable recreational off-road vehicles, in a cost and time efficient manner, which can withstand and perform under the harsh elements of rough terrain. The experience that transpires from the innovative task of improving the design of the previous year's model simulates engineering in a real-world scenario for students to excel in their area of study. The team will resource innovative ideas through brainstorming, feedback from testing, and trends in competition. The team will fabricate custom parts and perform the entire build in-house while considering all achievements as well as failures as learning opportunities.

Chassis Design

The chassis is designed within the specifications of SAE rulebook. It is based on the previous year design while making several weight saving changes. Last year we used our 2018 design and built with a lighter grade steel that proved to be strong and reliable, so we decided to keep that design and only make changes to accommodate the 2020 rules. This only required us to change the rear compartment to fit a spec fuel cell that is now required. The chassis is constructed of two different sizes of 4130 chromoly tubing. The primary being 1.125 inch by 0.083 inches thick, the secondary being 1.00 inch by 0.065 inches thick.

Bending Stiffness:

Definitions

E = Modulus of Elasticity (205GPa for all steels)

I = Second Moment of Area for the structural cross section

Design Definition: 1.125 x 0.083, 4130 steel

D_O = 1.125in = 28.6mm

D_I = 1.125in-2(0.083in) = 0.959in = 24.4mm

$I = (D_O^4 - D_i^4) = (28.6^4 - 24.4^4)$

I = 15443mm^4

K_b = E * I = (205GPa * 15443mm^4)

$K_{b,des}$ = 3,165,815 N * mm^2

Bending Strength:

Definitions:

Sy = Yield Strength

C = Distance from neutral axis

Design Definitions: 1.125 x 0.083, 4130 steel

S_y = 435GPa

C = 1.125/2 = 0.5625 = 14.3mm

S_b = = $S_{b,des}$ = 469,770 N*mm

Baja Assembly

Suspension

Replacing the three-link trailing arm with a triangulated single swing arm design we implemented last year proved to be a successful change and was carried over into our 2020 build. The single swing arm is constructed out of 1.25 inch chromoly tubing with a 0.065-inch-thick wall. The only change in the suspension system this year was a new size shock absorber for the front end. We increased the length of the front shock absorbers by 4" to improve two condidtions. The first condition is that the larger shock offers more adjustability in the performance of the vehicle. This is important since the tracks we compete on have such a wide array of obstacles and jumps that need to be considered when setting up the vehicle, this can be properly accomodated when there are multiple ways to adjust the handling of the chassis for any scenario. The second condition is a longer shock will introduce a softer landing, by having more adjustability in the dampening of the shock, which is important being that the front of the car lands first. This change will mainly benefit the driver, decreasing any abuse he or she may experience during a lentghy run. Our competitioin consists of a 4-hour endurance race split between 4 drivers for an hour each. The rough terrain of a baja track can fatigue the driver towards the end of their run which may cost us valuable points and positions. The softer landing will help ease the abuse the driver has to persevere through and keep running strong throughout the course of the event.

Chassis Tubing Strength:

C = 1.25/2 = 0.625 = 15.9mm

$S_b = \frac{Sy * I}{C} = \frac{435MPa * 17812mm^4}{15.9mm}$

$S_{b,des}$ = 487,309 N*mm

Drivetrain

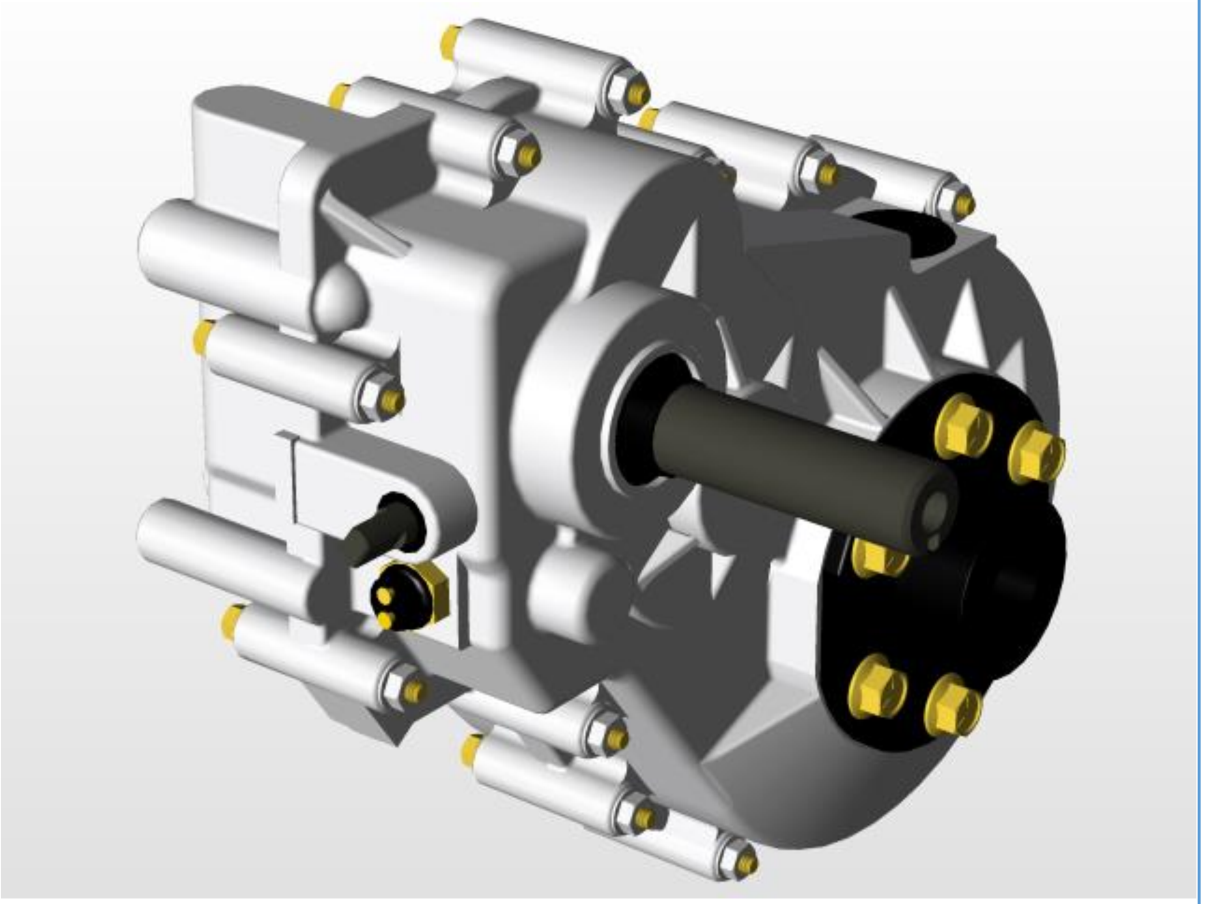
We will continue use the popular dana H-12 FNR transfer case as it has proven over the years to be a reliable means of strength and performance. Most of our competition uses the Dana h-12 without having any mechanical issues proving the reliability of the product. This is a product we can reverse engineer when we design our own transfer case in the future. It has a forward gear ratio of 10.15:1 To transfer the power from the engine to the FNR we use a Comet 790 series CVT that has a drive ratio of 3.3:1 and 0.5:1. Taking into account all the drivetrain factors for a 400 pound Baja as well as a 150 pound adult using a 10hp motor at 3600rpm our tested top speed still reaches an impressive 30 mph on rough open terrain.

Theoretical Speed Calculation

Power(P) = 9.51hp = 5.231x103 ft · lbf s 44

Significant Area (Afire) = 1ft2 144in2 · [22.95in · 30in + 2(18in · 14in + 6in · 14in)] = 9.448in2

Maximum Theoretical speed (vmax) = √ 2 · P · ηg · ηb pair · (Afire·cd) 3 = 49.583mph



Brake Rotors

Weight reduction is crucial for speed without neglecting the safety features of the vehicle. We used engineering calculations to find the smallest brake rotor possible without sacrificing its function. Using these engineer formulas below we were able to that the factory rotors found on a Yamaha Banshee were more than adequate. This example shows how the size of the front disc brakes needed to be at least 5" in in diameter. A rotor with a 3"(76.2mm) radius was used as a starting point.

Actuation force at master cylinder for front brakes = 900 x .7 = 630 N

Pressure inside master cylinder (Force / Area) 630 / .00078 = 8.07 MPa
Force applied by caliper (Pressure x Area) 8.07 x 10^7 x .00078 = 6294.6 N
Clamping force =6294.6 x 2(# of brake pads per rotar) = 12589.2 N

Frictional force applied by brake pads on the rotor= 12589.2 x .7 = 8812.44
Braking torque (Frictional force x Effective Radius of a 3" rotor) 8812.44 x 76.2 = 67.15 mm (2.5") radius or 5" diameter

Team Members

Captain: Brandon Stahl

Team Advisor: Sam Fassnacht,

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Team Members: Kris Schwiebert, Miles Sizeroe, Sam Porterfeild, Tamir Hussain, Morgan Olsen, Bryon Mcmillian,