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Variable Speed Flapping Wing Micro Air Vehicle using a Continuous Variable Transmission Design

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Variable Speed Flapping Wing Micro Air Vehicle using a Continuous Variable Transmission Design

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By

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I HEREBY RECOMMEND THAT THE THESIS PREPARED UNDER MY SUPERVISION BY Jason CD Chuang ENTITLED Variable Speed Flapping Wing Micro Air Vehicle using a Continuous Variable Transmission Design BE ACCEPT IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF Master of Science in Engineering.

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ABSTRACT

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Flapping wing micro air vehicles (FWMAV) have very unique flight mechanics in two-wing orientation. Many challenges arise with two wing configuration: lift production, design construction, and control systems. Control surfaces used in fixed wings can be used but at low Reynolds numbers they become less effective. In order to truly mimic insects with two wings, control mechanisms must be developed. Since MAVs are designed to navigate through confined spaces they need to have many degrees of freedom in motion. One way is to use a continuous variable transmission (CVT) mechanism, by integrating its infinite gear ratios to change the flapping frequency of each wing independently it will be able to generate a roll maneuver. In previous work, two motor designs were used; by using a CVT design an additional motor weight can be neglected. The work completed was the development of a cone CVT design for MAV use that could produce variable frequency in each wing. Testing and analysis of the prototype model shows the design as possible control method in MAVs.

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CHAPTER 1

INTRODUCTION

1.1 Flapping Wing Micro Air Vehicle

Flapping Wing Micro Air Vehicle (FWMAV) mimics the flight mechanisms of insects in an attempt to gain their flight performances. This idea of flight was developed as a method for military and civilian surveillance missions. The challenges of using Unmanned Air Vehicles or UAVs were their large bodies which could not sustain stealth in urban environments. The situation asks for a new type of vehicle that could be dispatched in urban missions to obtain target locations but for a successful mission a micro air vehicle or MAV would have to sustain flight for long durations. This posed a large development gap in research. Research turned to specifically the well-studied insect flight -- Dragonflies or Ornithopters. Ornithopters have the ability to take off from standing, hover, glide and maneuver with great agility. They can cruise at 54 km/h, perform sharp turns, fly knife edge and capture their pray with great accuracy.[6] The bio inspired dragonfly lead to the development of the Wright State's Four Wing Flapper, Delfly's Delfly I and II. These four wing FWMAVs use the flight mechanism of a two-fixed wing structure, the flapping wings generate the thrust, a rudder and elevator controls the pitch and yaw actuated by a control board and controlled by remote control. These methods for MAVs have shown very limited flight durations of 10 to 20 minutes of flight and have very limited ability to perform vertical take offs and landings and hovering. These problems produce a need for development of methods for actuation mechanisms and control techniques.[2]

Other insects have also been studied for their flight mechanism, bumble bees, cicadas and ladybugs for their two wing designs. In evolution their second wing was adapted into halters, which are club like structures that function as a sensor that acts like a gyroscope. [7] This makes two wing flights reliant on control systems and fast response time. Similarly in FWMAV moving from four wing flappers to two wing flappers, new control systems have to be implemented with the change similar to the insects they are derived from.

When designing FWMAV many factors must be accounted for, they include: wing property, flapping frequency, flapping angle, amplitude, size, weight, endurance, lift, control, and maneuverability. Of these factors the focus of this thesis will be in manipulating the flapping frequency for control in a design that can reduce the weight of the vehicle instead of using two motors to perform the same task.

1.2 Biomimetic

Biomimetic is the biologically inspired approach in designing based on adaptations made through natural selection as a form of design solutions. The design optimization would be specific to the organism's environment. By studying the method of locomotion they use, bio inspired design can be formulated, the creative design by nature can be implemented in human made creations. Robotics has featured some bio inspired designs like gait transition, the transition from swimming to walking in salamanders. [11] When looking at the behavior of insects, they use multiple sensor convergence, the use of more than one sensory organ to determine the flight path. Some insects exhibit a stimulus based control over the direction of flight. In retrospect micro air vehicles need the ability to autonomously control their actuators manipulating the degrees of freedom in their flight. To get a better understanding of how they move their wings can be important.

There are many challenges when designing two- wing FWMAVs, because they lack control surfaces they need alternative methods of control mechanisms. In insects, they are able to manipulate their wings by using their muscles. The two methods they use are synchronous and asynchronous. In synchronous flight mechanism they use two sets of muscle contractions, the first set contracts to raise the wings and the second set lowers the wings, the two sets of muscles alternate contraction and relaxation. Notably the more primitive insects use direct flight mechanisms like the dragonfly [1].

Asynchronous flight is categorized by the distortion of their thorax section of their body to move their wings. These mechanisms are found in more advanced insects like flies, which are evolutionarily advanced for smaller more agile flight. Asynchronous flight has higher flapping frequencies than synchronous because it uses a resonant mechanical load on the body structure generating more strokes cycles for each stimulus to the muscle. However this method of flight does not allow the insect to control lift and thrust. The wings angle of attack control the lift and thrust. The wing movement allows the insect to increase lift and reduce drag.[1] This wing movement was implemented in Wright States two-wing flapper.

1.3 Aerodynamics of Flapping Wings

There are three sections that build the framework of flapping wing micro air vehicles: flapping kinematics, aerodynamic modeling, and body dynamics, according to Taha.[8] Flapping kinematics is based on Euler angles, in conventional fixed wings Euler angles are for yaw, roll and pitch, but for flapping wings use flapping, plunging and pitching. In flapping wings the flapping angle and flapping frequency in symmetry produce upward thrust only. Doman et al. proposed an asymmetrical flapping method by using one actuator per wing, instead of using one actuator to control symmetrical flapping.[9,10] This asymmetrical method allowed them to develop control for six degrees of freedom, by controlling the speed of upstroke and down stroke and the flapping frequency in each wing. This design was the source for research for an alternative method to produce independent flapping frequency in each wing without the use of two motors. Doman's group used a mechanism of split cycle which controls the speed of the two motors to control the flapping frequency in each wing.

Aerodynamic modeling for FWMAVs has been mainly done in quasi-steady models after insect flight from their wing motion. The wing motion data from the kinematics go through aerodynamic modeling in quasi-steady/unsteady analytic approaches, unsteady vortex lattice simulations and different models to the Navier-Stokes equations. The loads from the model can then be put into the body dynamics to understand the body motions of the MAV.

1.4 Purpose

Many studies have been able to model and simulate insect control mechanisms and grasp an understanding of the aerodynamics behind the flight mechanism but very few have designed methods of controls in mechanical design.[1] Therefore there is a need for mechanical designs for control mechanisms in FWMAVs. Practicality is also an issue, many prototypes that are small in size but require an external power source, without the ability to fly independently and without control they cannot fly effectively and efficiently.[3] The weight of the vehicle must be small enough to be lifted by the thrust force, design in reduction of weight is significant. The current method of variable flapping in MAVs is using two motors to control each wing independently. Since weight is significant, designing for one motor can reduce the vehicle's weight.

1.5 Continuous Variable Transmission

The design for a control mechanism in FWMAVs has to simple, compact and miniturizable, when designing a complex mechanism it becomes a disadvantage, having more moving parts, more mass, more build intensive. In motor vehicles, continuous variable transimissions (CVT) has been popular for it's high efficiency and stepless shifting between speed ratios. There are multiple types of CVTs: Cone CVT, Toroidal CVT, Spherial CVT, Disk CVT, and Magnetic CVT. The most basic and simplistic CVTs are the cone, disk and toroidal (Figure 1). CVT drives have the capabilty of having infinite speed ratios and function without the use of clutches to change the ratios. Many CVTs are friction based mechanisms

thus the applications for them have to account for the wear level. The transmission becomes less efficient depending on the wear of the part which causes non linear dynamics according to the time spent at a given speed ratio. [4] The simple CVT designs are all friction based mechanism thus when using a CVT design the wear must be accounted for. The wear relates to all types of CVTs that are friction based, accounting for the fatigue and wear on the materials that increase the friction coefficients, like rubber to rubber, to transfer the torque force. These types of CVTs transmit power through the contact between two rotating elements with a drive ratio varied by controlling the effective contact points at a specific radius. Traction or friction drives have the capability of being compact and offering more flexiblity in terms of their design and range of applications and can be positioned precisely without consequence.[5] The simple types of CVT use either circular or conical parts to change the speed ratios, the ratios are changed when the counter rotor, or the part inbetween the two conical parts, moves its position changing the ratio based on the radius of the conical part.

Types of Simple CVTs

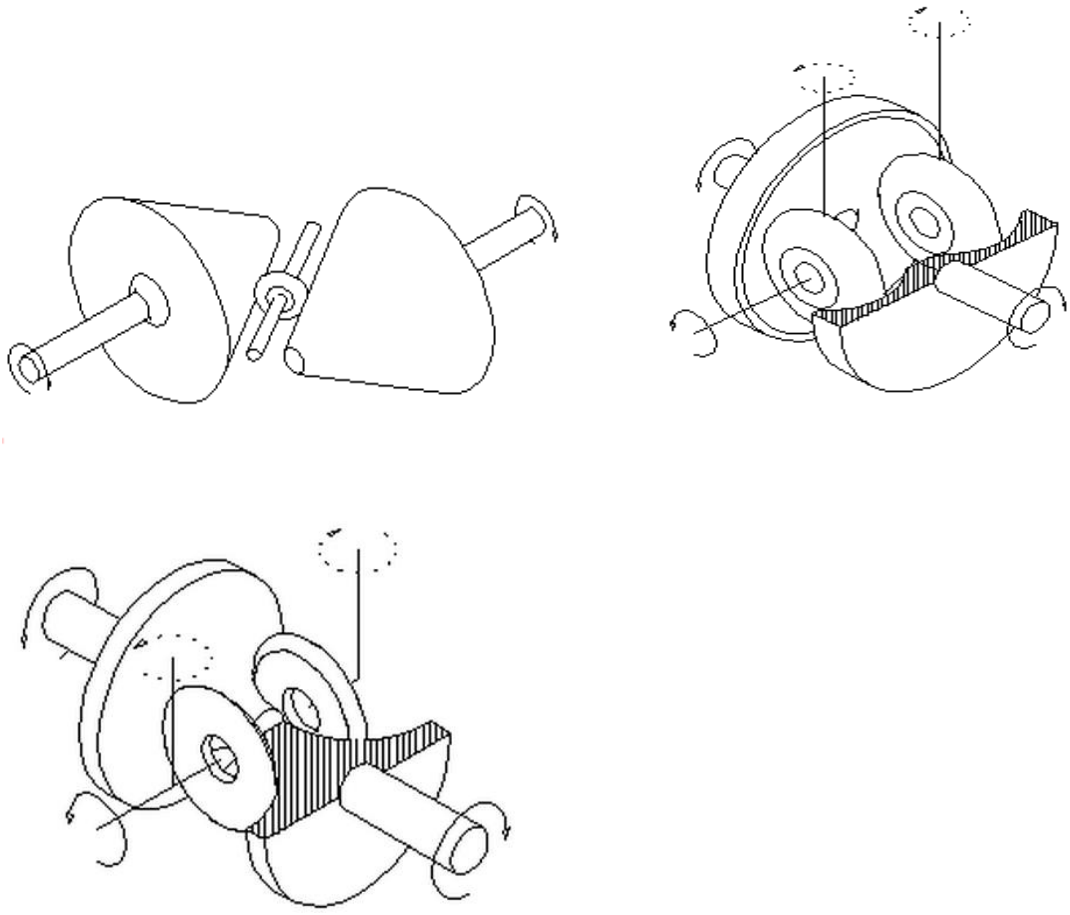


Figure 1: Different types of CVT mechanism: Cone, Disk and Toroidal.

The abiltiy of CVT drives to change speed ratios can be adapted into a FWMAV drive system to produce variable frequency flapping wings. The CVT mechanism would need two output shafts to manipulate the two wings separately, thus the challenge is modifying the design of a simple CVT mechanism to produce two output shafts.

1.6 Control Mechanism

Control using independently controlled wings is by changing the amount of thrust generated in each wing. In order to roll to the left, more thrust would be generated in the right wing than the left. In order to roll to the right, more thrust would be generated in the left wing than the right wing (Figure 2). This control allows for one degree of freedom in flight.

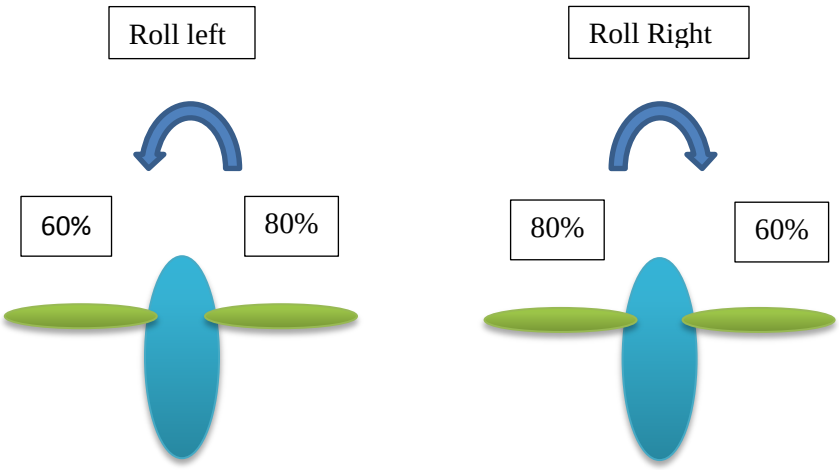


Figure 2: The control mechanism for rolling in a two wing MAV using the CVT design.

CHAPTER 2

Design and Manufacturing

2.1 3D Printing

Plastic parts are made using a Rapid Prototyping Machine, Projet™ HD 3000 by 3D systems. The Projet HD 3000 uses UV Curable Acrylic based plastic, the VisiJet® EX200 was used in all micro air vehicles at Wright State University for its highest tensile strength of 42.4 MPa. It uses VisiJet® S100 support material which is non-toxic and can melt away. The ProJet™ HD 3000 has a resolution of 656 x 656 x 800 DPI (xyz) and accuracy of 0.001- 0.002 in per inch of part on Ultra High Definition setting. The 3D printer client software uses stl files format for input data and lays out layers of liquid plastic and support based on the cross section of the part. When the part is complete it is then removed from the machine and placed in an oven to 75^{o}C to melt the support material. The remainder support material can be placed in hot vegetable oil for no longer than 5 minutes to remove support from the small crevices, and then cleaned using soap and cool water to remove the oil.

2.2 Wire EDM

Metal parts are made using an AccuteX AU-300A Wire EDM, electric discharge machine. The part file from CAD can be used in the post processor, PEPS Wire EDM software for programing wire EDMs. Billet material used was 7075 Aluminum for their light weight and high tensile strength. The EDM uses HBZ- K0.010 Hitachi wire 0.25 mm diameter.

2.3 Flexible Wing Structure

FWMAV wings were designed with biomimetics in consideration. The vein structure in cicadas and bumble bees were investigated to design a wing that most replicates the flexible structure of their wings. The vein position shows areas of more stiff parts of the wings where blood can circulate make that portion of the wing more rigid. The final design was based off of more than one insect wing only the consistent vein structure was residual in the design. The wings were designed and manufactured by Mervat Elhindi at the Wright Patterson Air force Base Research Labs. The ones used on the prototype was a modified version of their original design, made smaller for the prototype vehicle. The wings were made by printing a positive plastic mold using the ProJet HD 3000 3D printer. The positive mold was then used to make a negative mold out of silicone. The negative mold would then be used to place carbon fiber strips and then held together using resin. Two layers of PET sheets would be adhered to the top and bottom of the carbon fiber skeleton using 3M spray adhesive. Lastly the outline of the wing was cut out of the PET sheet.

2.4 Research Design

The design CVT mechanism would take the place of a two motor design. The complications of using two motors on a FWMAV could cost in weight. Therefore the CVT mechanism must have two output shafts that would act as having two motors and function similarly. The most feasible mechanism to alter was the cone CVT, it was simple in construction and had room for expansion. A normal cone CVT consisted of a driven cone, counter rotor and a driving cone. In order to replicate a two motor design a second driven cone must be installed to play the role of the second output shaft.

The initial design of a dual CVT design was drafted, an outer rectangular frame precisely positioned the single driving cone, dual driven cones, and the two counter rotors (Figure 3). The distance between the cones and counter rotors would determine the pressure between the surfaces. The surface contact transfers the torque forces between the driving and driven cones. Manipulating the counter rotors position changes the driving and driven cone's pitch radius ratio (Figure 4).

The equation:

$$v = r_A w_A = r_B w_B \quad (1)$$

where v is velocity, r_A is the radius of input cone and w_A is the angular velocity of the input cone, and r_B is the radius of output cone and w_B is the angular velocity of the output cone.

Thus the ratio, R:

$$\frac{w_A}{w_B} = \frac{r_B}{r_A} = R \quad (2)$$

The lowest speed ratio gives the fastest output speed and the highest speed ratio gives the slowest output speed. The equation is equivalent for the two driven cones, producing two output shafts with variable speeds.

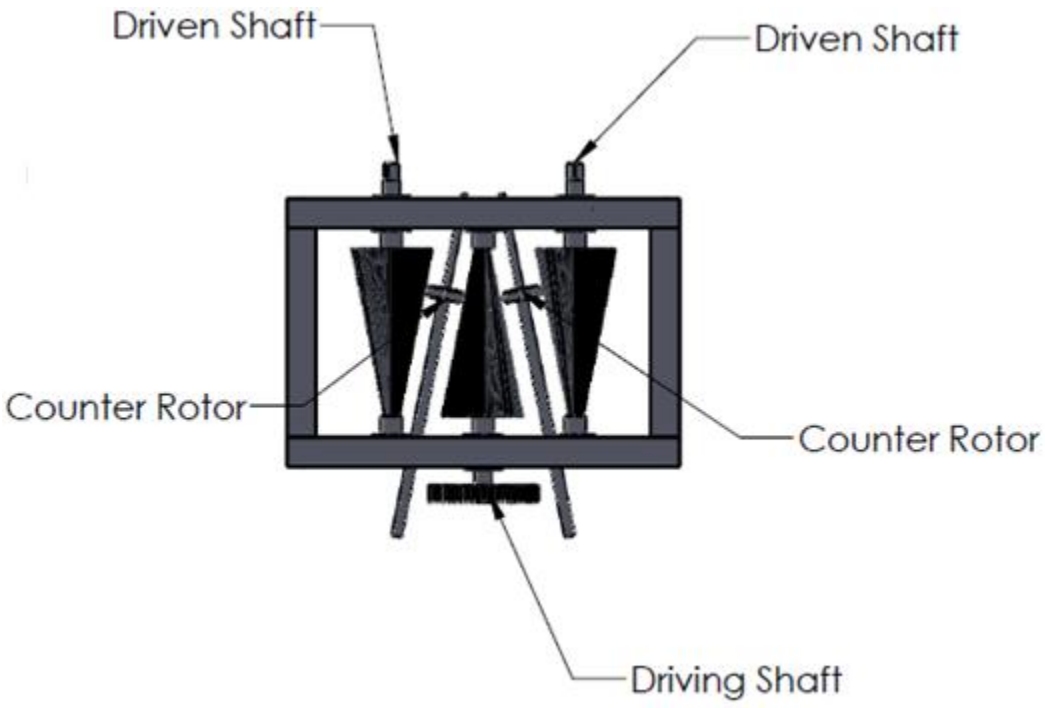


Figure 3: Prototype design for a cone CVT with two driven shafts.

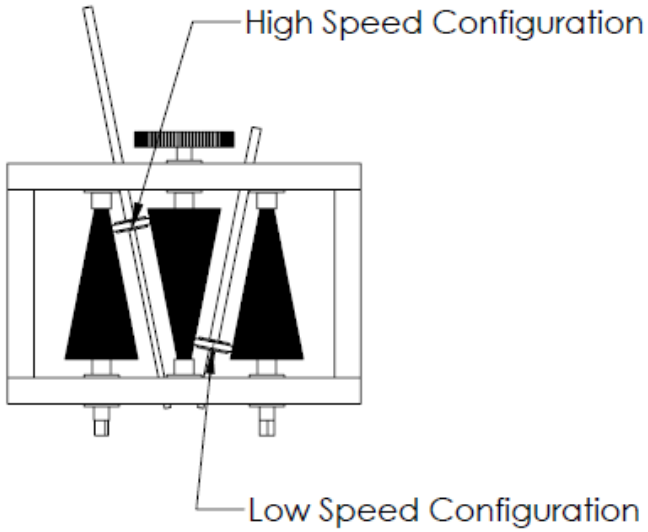


Figure 4: The prototype design for low and high speed configurations.

2.5 Manufacturing of Prototype

The initial prototype was to prove the concept, from a theoretical basis to mechanical feasibility. The size was not a factor for the first prototype; the purpose was to demonstrate the working mechanism. The 3D Systems Projet HD3000, rapid prototype printer was used to produce three cones, four piece rectangular frame, and a two holder pieces for the counter rotor. The counter rotors, that were in between the input and output cones, were fitted with a 7 mm inner diameter and 2 mm width Buna-N 70 Duro O-ring and a 2.5 mm thick, 4 mm outer diameter, and 2.5 mm inner diameter bearing from RcBearings.com. The counter rotor assembly would be placed on sliding rods which were made of hollow aluminum rods with 2.5 mm outer diameter and 1.5 mm inner diameter, and a 1.5 mm diameter rod. The hollow rod would be able to slide freely through the smaller diameter rod which would keep the alignment of the counter

rotor. The purpose for this was to avoid the conflicting intersecting shafts from having two counter rotors. The counter rotors were mated to the outer diameter of the hollow rod using Cyanoacrylate adhesive. The three cones and two counter rotors were positioned in their specific slot in the frame and locked in place by mating the four piece frame together using eight M3 machine screws (Figure 5). The cone shafts have 3 X 8 X 4 flanged bearings to reduce contact friction between the cone shaft and frame.

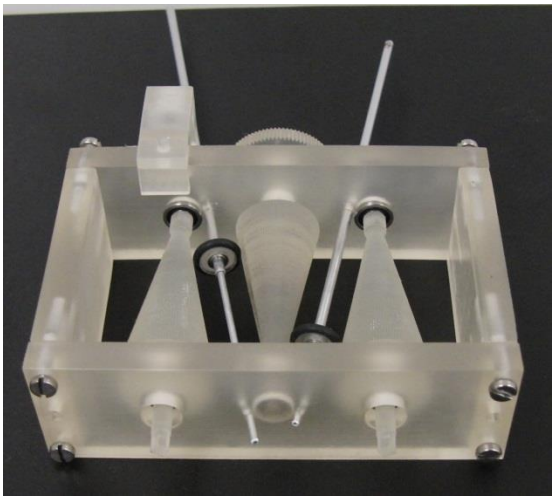


Figure 5: Prototype 1 design of a dual cone continuous variable transmission.

Slip was a major issue in friction based mechanisms; one of the major problems with the initial prototype was the smooth surface of the cones. The coefficient of friction between the cone and the rubber based counter rotor was too low causing slip to be a major factor in torque loss. The issue was solved by implementing treads on the cones surface to increase the surface area. A rubber coating was later applied to the cones treaded surface to increase the coefficient of friction with the counter rotor. The concept was proven to exhibit two outputs with variable speeds by controlling the counter rotor's positions.

2.6 Prototype Iterations

After the proof of concept was complete the mechanism had to be designed to be smaller and more applicable to MAV use. The 3D printer allowed for very small and feasible designs, the limiting factor would be off the shelf components, primarily the ball bearings and O- ring sizes. The smallest bearing that could be purchased through RCbearings.com was 1x2x1 mm bearings, and the smallest O-rings were 3x2 mm. The miniature prototype was designed around these conditions. The frame was reduced in size by using a triangular configuration as to a linear one. The prototype was reduced overall by the volume from 0.180 ccm to 0.011 ccm (Figure 6). The mass of the vehicle dropped significantly as well from 104 g to 5.91 g, excluding a control board and battery. The second prototype showed that it was feasible to create a much smaller working model. The design needed to be further modified to include durability and the torque required to rotate using a four bar mechanism and withstand the load of the wings.

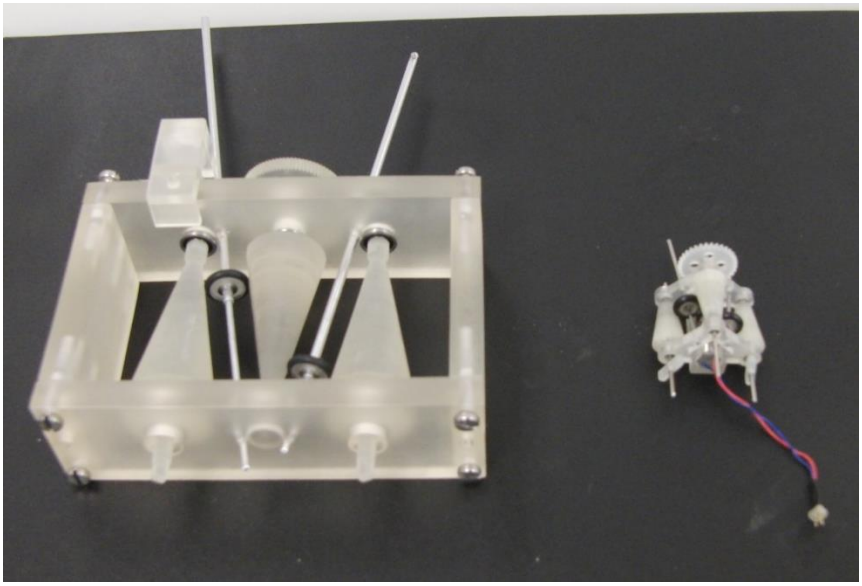


Figure 6: Prototype comparison between the first model and the second.

The big issue with the second prototype was the threads on the cone, when scaling the cone size down the threads became brittle and the pressure from the O-ring, counter rotor, would break the threads. The solution was to use a rubber coating either on treads or primarily on the cone surface disregarding the treads altogether. The next prototype would feature the change.

The third prototype modifications includes: a stronger frame, shorter cones, rubber coating for the cones, a flapping mechanism, a control board, and a larger motor. In order to test the model, the prototype had to be durable to withstand the wear of testing; increasing the frame size was a major factor (Figure 7). The shorter cones not only decreased the size but since only a small difference in speed can influence the direction of a MAV; large variable reductions were not needed. Less slip can be achieved by increasing the coefficient of friction by using a rubber to rubber coefficient. The larger motor was a Blade EFLH3003 coreless main motor with pinion purchased from Horizon Hobby USA. The motor would be connected to a power source at 3.7V. The torque was increased by implementing the larger motor required to rotate three cones and the wings.

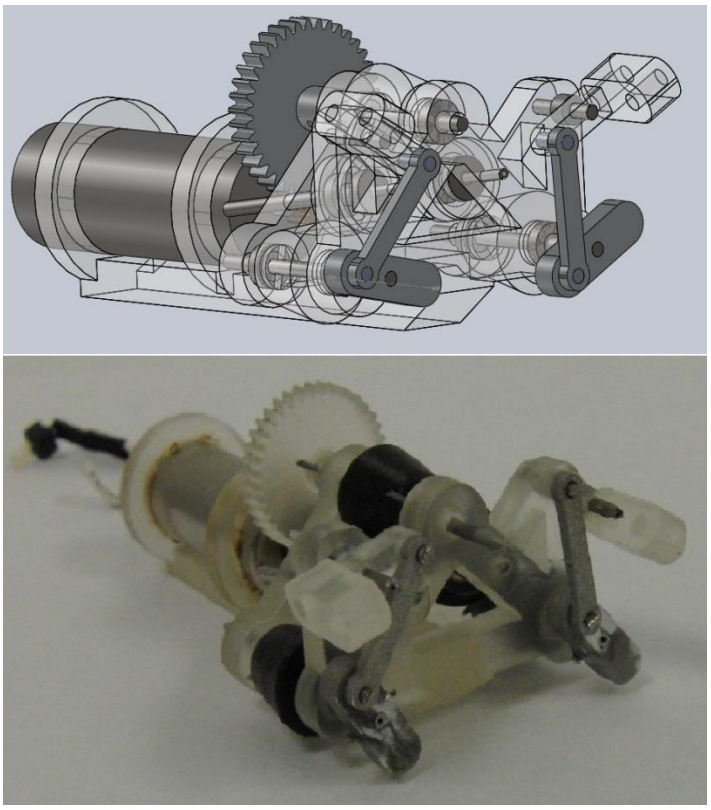


Figure 7: The third prototype rendered in Solidworks and produced using 3-D printing and wire EDM.

A four bar mechanism was used for the flapping mechanism. The four bar mechanism used a crank-rocker motion; the crank makes a full 360 degree rotation powered by the output shaft of the CVT would give motion to the rocker flapping the wing at a flapping angle of 118.45 degrees (Figure 8). Abiding by Grashof's law in joint limits, the condition states, "for a four-bar mechanism, the sum of the shortest and longest link lengths should not be greater than the sum of the remaining link lengths." The longest length was 13 mm and the shortest was 3 mm, with the remaining lengths 13 mm and 3.5 mm.

$L + S < P + Q$ (3) Equation for Grashof's law

L and S are the lengths of the longest and shortest links, while P and Q are the remaining lengths of links. The second crank-rocker was mirrored to the second output shaft allowing for

independent control. The two output shafts from the CVT rotate in the same direction this causes a slight jitter in the crank motion in one of the wing flaps. This does not change the symmetry of the flapping but was a notable observation.

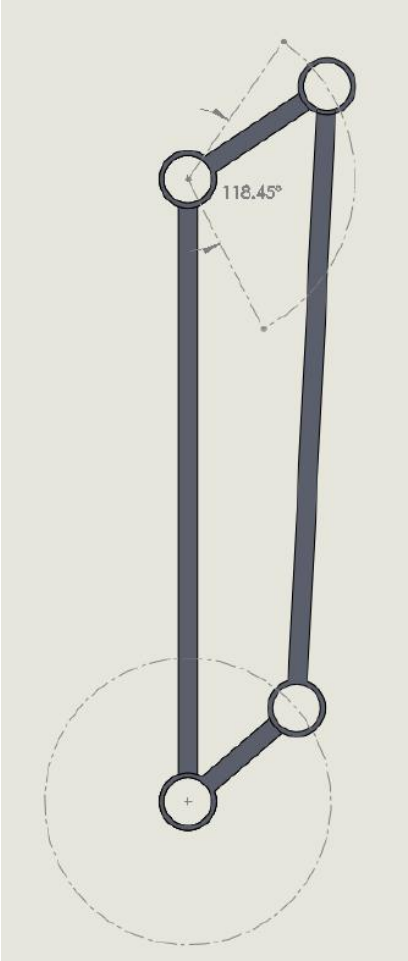


Figure 8: The four bar mechanism.

A major issue occurred with all the changes in the vehicle when testing the motor using a power source before attaching the control board, the torque required to move all the parts increased and for the motor to turn, required a large current draw, heating the motor and causing the plastic frame to deform thus causing system failure. The solution for this problem was to increase the primary reduction gear ratio.

The next prototype featured a gear ratio of 4 times the original. The implementation of a stepper gear increased the ratio to 1:28. The motor gear was 8 teeth with a gear modulus of 0.3. The stepper gear was 56 teeth stepped to 10 teeth with a gear modulus of 0.3. The input shaft gear, which was mated to the input cone, was as 40 teeth with a gear modulus of 0.3(Figure 9). This would reduce the current draw from the motor and prevent overheating. In addition to the final prototype, a stand was implemented to the frame for load cell testing, and control board for actuating the counter rotors position. The control board used was a Parkzone PKZ3352 from Horizon Hobby USA. A control board was used to control the position of the counter rotors by using the built-in actuators. The Parkzone control board would receive controls via remote control from the transmitter, a Spektrum™ DX6i. The wings were also installed to the four bar mechanism. Behind the transmission was a mount, made for the control board to be positioned in direct line of the counter rotor shafts for the actuators to control the speed ratios of each output cone (Figure 10).

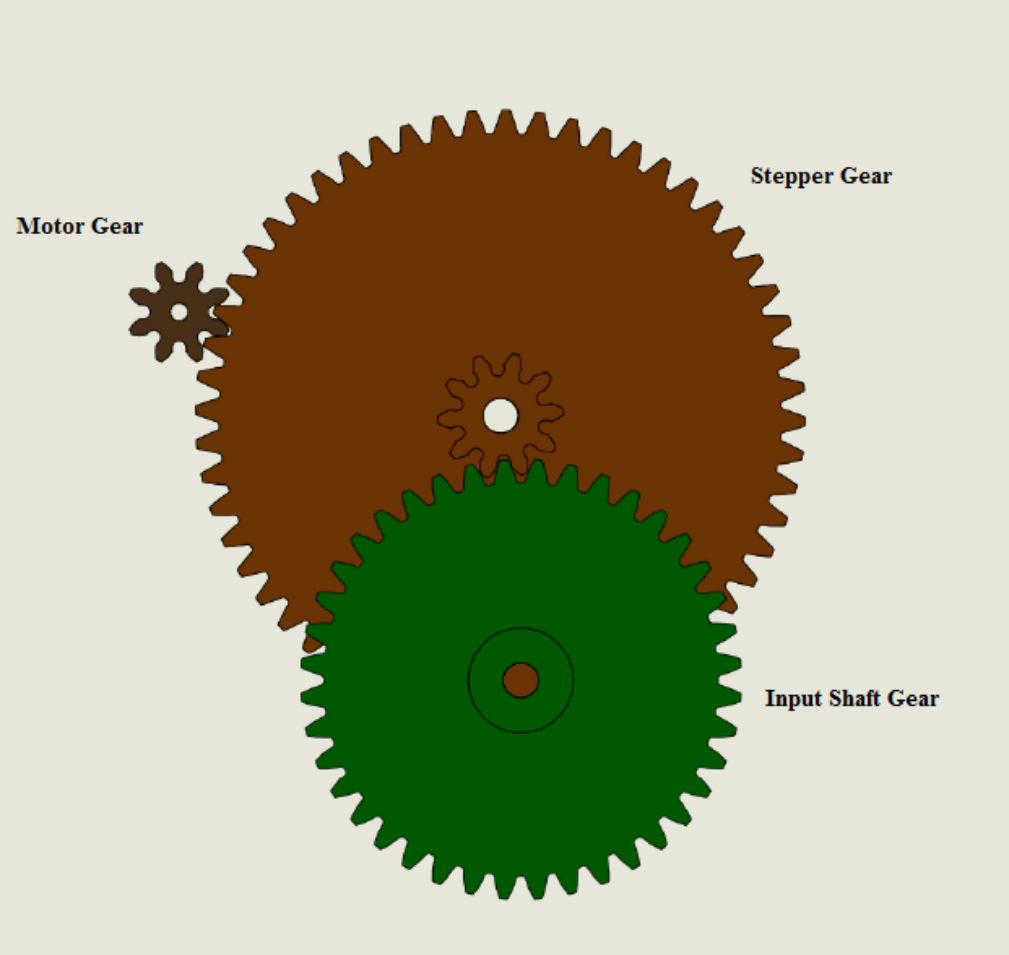


Figure 9: The final gear assembly for the testing prototype.

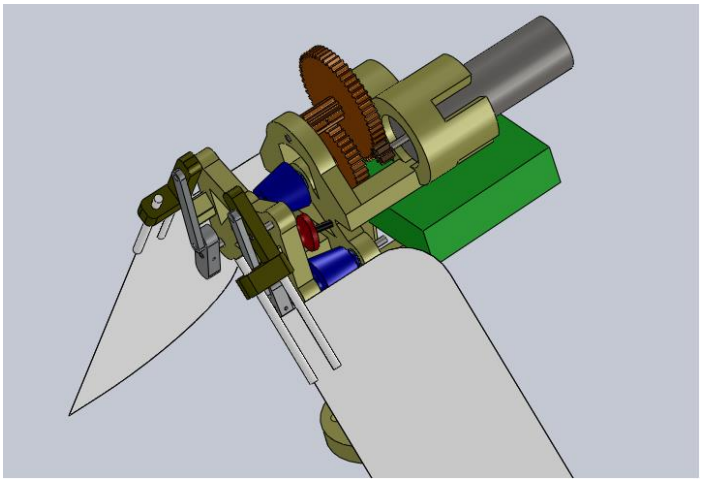


Figure 10: The final test prototype rendered in Solidworks.

The final prototype was built with all the additions previously mentioned. The result of this prototype would be to test the mechanism with wings and the forces generated from

controlling the flapping frequency difference produced in each wing. To test the forces a load cell was used to retrieve the data. Further the prototypes design would be simulated in Abaqus CAE to analyze the stress on the rotating cones with the different material properties and different overlapping distance between contacting surfaces.

CHAPTER 3

Method and Analysis

3.1 Load Cell

The load cell measured the forces in the X, Y and Z directions and the moment in the X, Y and Z direction. The testing prototype was mounted to the load cell. The control board was powered by a 3.4V Lithium polymer battery and controlled by remote control for the push rods that change the speed of the output shaft. The motor was powered by a power supply at 3.4 V. The control board was not used to power the motor because as the power drains in the battery the electric potential drops making it inconsistent. The initial test used a tachometer and reflective tape to measure the flapping frequency at the 3.4V power setting that the power source generates. The test was done for the different configurations, high speed and low speed, and the forces that were generated were recorded using the load cell.

3.2 Abaqus CAE

In order to analyze the kinematics of the dual cone CVT design to further the development, a model that could simulate the mechanism had to be made. Abaqus CAE, finite element analysis software was used to analyze the CVT portion of the design. Abaqus's software analysis results can be visualized. It is made up of 3 stages: pre-processing, processing, and post processing. In pre-processing it generates the input file which contains the design for a finite element analysis, the processing is where the output visual file is generated through the iteration

increments, and the post-process is the visual rendering of all the increments and variables reported. Abaqus uses the standard SI system of measurement for length, force, mass, density, time, pressure/stress, and energy.

The portion to be simulated would be two cones and one counter rotor. Prior to simulating the actual model, a test simulation was used as a control for consistency. The results from the test simulation were used to validate the modeling parameters to be used in the CVT model.

3.2.1 Abaqus Modules

Abaqus CAE consists of 7 modules for pre-process; they are the fundamentals to preprocessing a job. They are part, property, assembly, step, interaction, load, and mesh. The part module contains the parts for the assembly and features surfaces, skins that can be created based on the geometry of the part and section assignments can be made for the material properties. The property module manages the material properties ranging from general parameters of density to mechanical and thermal properties of material, for elasticity, plasticity, conductivity and heat generation. The material can also be sectioned in categories of solid, shell, or beam and types as homogeneous, generalized plane strain, Eulerian, or composite. The assembly module is made up of instances and features, the instances are the parts imported or made in Abaqus, and the features can be datums and reference points. In the assembly, instances can be manipulated with position constraints and similar to the parts module, sets and surfaces can be created for reference.

3.3 Test Simulation Model

The test simulation would involve the rolling cylindrical parts comparable to the CVT parts, the parts consisted of a large roller, small roller and a rod. The cylindrical parts were positioned parallel to each other in the assembly with the Y direction parallel to the axis (Figure 11). The points of contact between the parts surfaces were overlapping each other to account for the normal force.

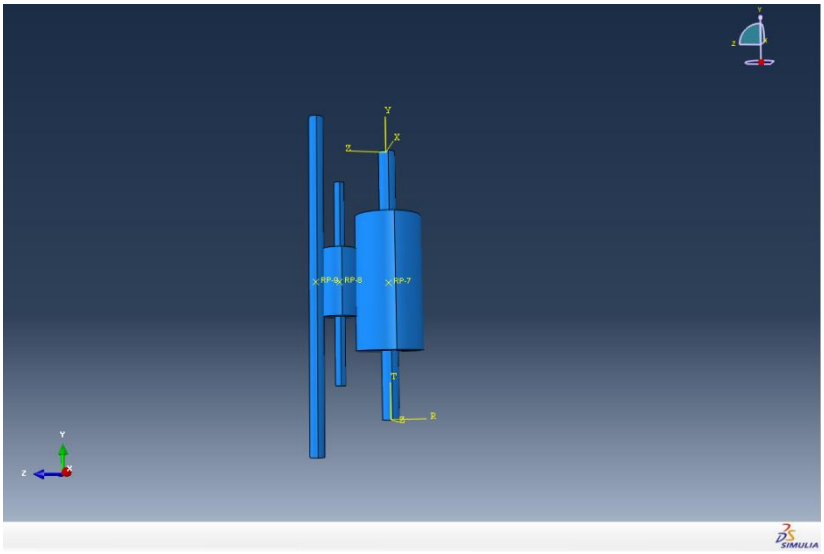


Figure 11: The assembly of the test simulation.

3.3.1 Material Properties

The materials properties used were plastic and rubber. Based on acrylic plastic the density used was 1220 kg/m^3, the Young's Modulus was 3.2 GPa, and the Poisson's ratio was 0.37. Rubber was given density of 1100 kg/m^3, elastic properties: Young's Modulus 0.1 GPa, and a Poisson's Ratio: 0.45 (Table 1). Reason behind not using hyperplastic property, was not

having a good material model of the rubber and could not base analysis using material testing data, the results would not simulate well. Attempts made using the built in Abaqus method for Neo-Hookean model resulted in many distorted elements and became unfeasible.

Table 1: Material Properties

Material	Young's Modulus (GPa)	Poisson's Ratio	Density (kg/m3)
Acrylic Plastic	3.2	0.37	1220
Rubber	0.1	0.4	1100

The parts were sectioned as a homogeneous material for plastic and rubber. The large roller and rod were given plastic properties and small roller was given rubber property. These materials would be similar to the ones used for the CVT simulation.

3.3.2 Assembly

The assembly of the test simulation, positions the cylindrical parts axis parallel to one another. The distance between the large roller and the small roller were given an overlap between the two contacting surfaces, in addition with the smaller roller and the rod were given an overlap as well. This overlap would allow the normal pressure of one part to another. The midpoints of the parts were aligned to their center of mass. The assembly was made so the cylindrical axis was parallel to the global y axis and would rotate along the global y axis direction. (Figure 11) In the assembly each instance or part was made to be independent of one another.

3.3.3 Steps

The steps used for the simulation were dynamic, explicit. The first step was to normalize the normal force in their position from the assembly they are aligned to. The first step was given a time period of 0.025 seconds with Nlgeom on for nonlinear geometries and incrementation was set to automatic with a maximum time increment of 0.1. The second step would implement the angular velocity of the large roller; this step's time period was set to 10 seconds for enough time to visualize the rotations and incrementation was set to automatic with a maximum time increment of 0.001.

3.3.4 Interactions

The interactions are the contact interactions between the parts in the simulation. These interactions would use contact properties from mechanical and thermal behaviors. For the test simulation and prototype simulation tangential and normal behavior were used. Tangential behavior accounts for the fiction coefficient and the normal behavior accounts for pressure-overclosure and constraint enforcement methods. The setting for tangential behavior valued the coefficient of friction to be 0.6 for plastic to rubber and would be compared to a higher coefficient of friction 1.16 for rubber to rubber. The first interaction in the test simulation was a surface to surface contact (explicit) between the large roller surface and the smaller roller surface using the contact interaction property of tangential and normal behavior for second step (Figure 12). The second interaction was also a surface to surface contact (explicit) between the smaller roller surface and the rod surface using the same contact interaction property as the first for the second step. The surface to surface interaction between a rigid body and a deformable body would use the kinematic contact method for the mechanical constraint formulation, whereas

interaction between two deformable bodies would use the penalty contact method for the mechanical constraint formulation.

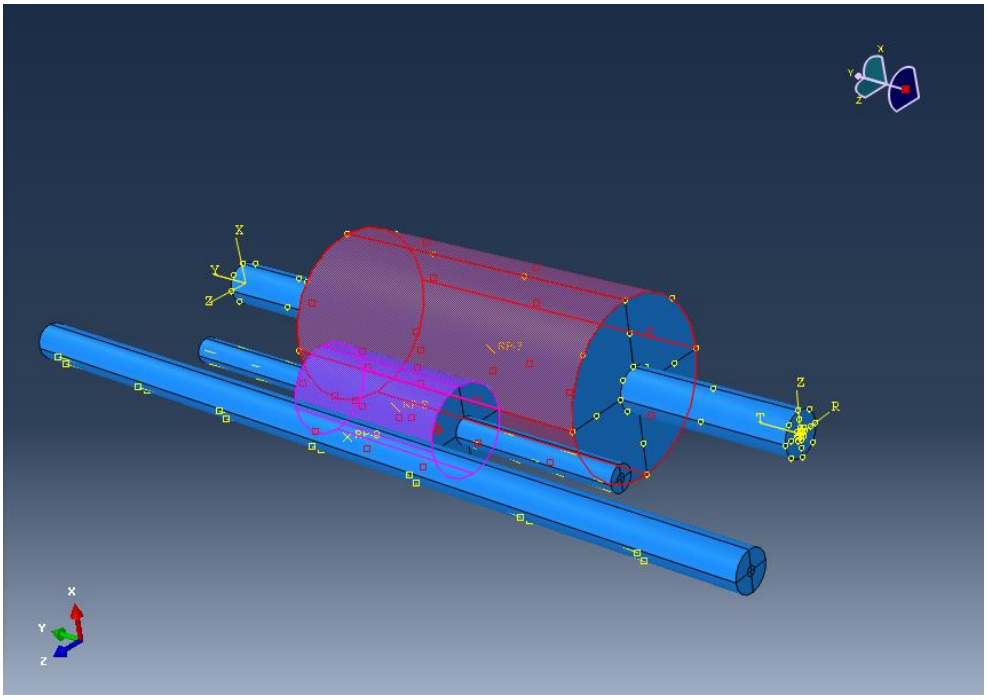


Figure 12: The large rollers surface interaction with the smaller roller.

3.3.5 Loads and Boundary Conditions

The loads in Abaqus account for concentrated forces, pressures, moments, surface traction, and etc. These properties work with constraints and boundary conditions. For the rotational simulation, no load is necessary. The model only needed constraints and boundary conditions to simulate the process. The constraint for the test simulation involved creating a rigid body and applying kinematic coupling. The rigid body was given to the larger roller with a reference point at the center of mass of the cylindrical part. The other two parts would be deformable bodies and would contain the stress and pressure contours to be visualized. The

smaller roller and the rod were individually given the kinematic coupling constraint, constraining the x, y, z directions and rotation on the x, y and z axis with the 6 degrees of freedoms constrained, and proper boundary conditions could be applied. The boundary conditions would set the controls for the simulation. The first boundary condition was to pin the center points of the top and bottom points of each cylindrical part so they could not move in the global x, y, and z directions, and only be able to rotate. This boundary condition was applied to step 2 in the model. Another pin boundary condition had to be made to control the center of mass of all cylindrical parts in the x , y , z directions applied to step 2 in the model. The last boundary condition was applied to step 2 for an angular velocity on the larger roller. For the test simulation it was given a value of 1 rad/s for the small incremental time steps.

3.3.6 Mesh

The mesh discretizes the parts into elements, the more elements the more accurate the solution for the simulation. A balance between mesh size and computation time is in careful consideration, accuracy is important but time is also essential; the larger the mesh time the longer the computation time. The test simulation parts had to be partitioned into mesh-able geometries. Valid element shapes for cylindrical parts are hex and tetrahedral, those could be changed in mesh controls but required there particular mesh geometry (Figure 14). In order to mesh the parts they were portioned into four quadrants and a circular edge sweep cell partition (Figure 13). Each part was partitioned in a similar method. The ends of the part were seeded for the mesh and then meshed according to the seed count (Figure 15).

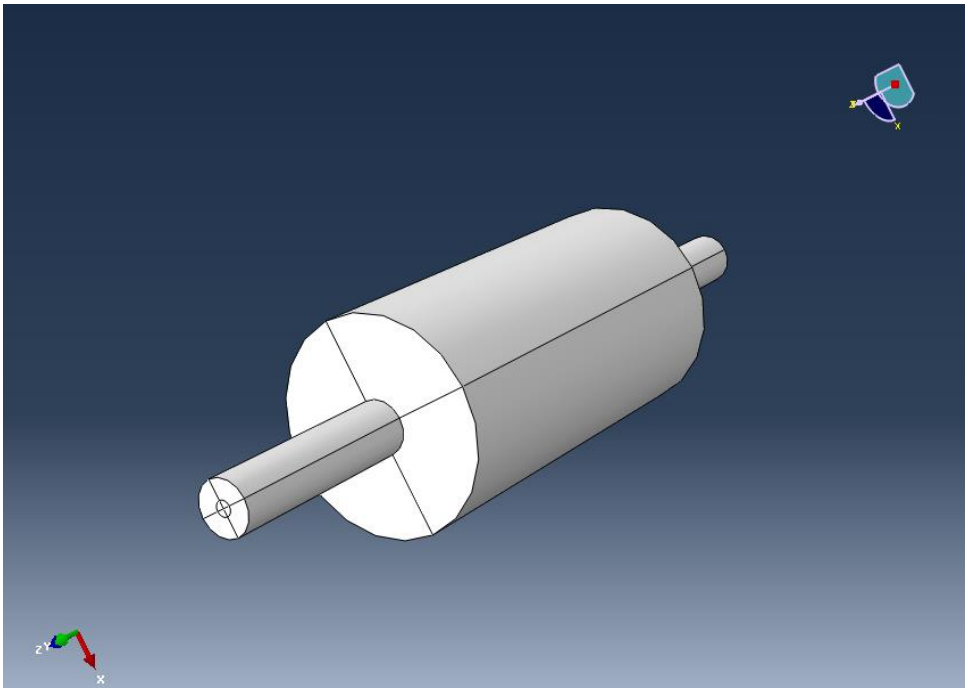


Figure 13: The partition of the cylindrical part into four quadrants.

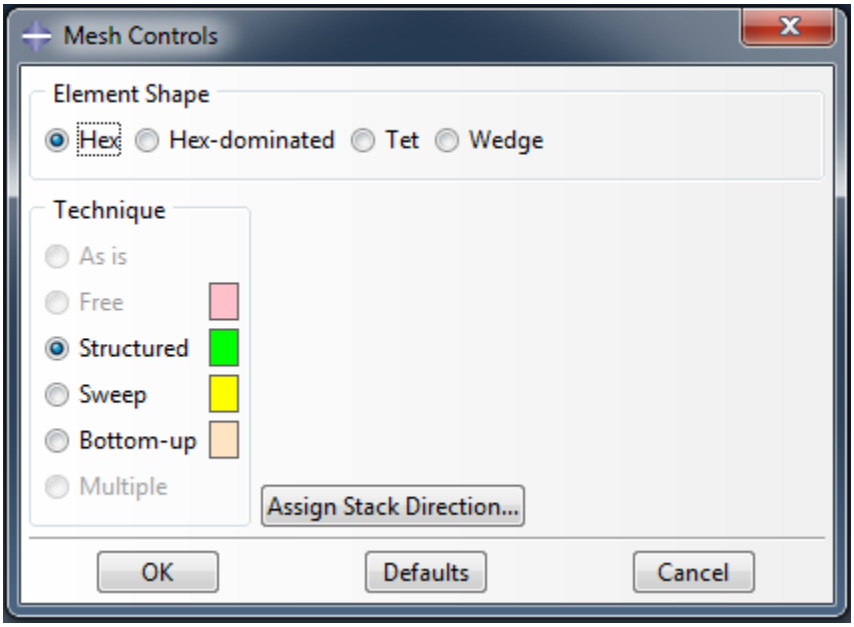


Figure 14: The mesh controls that control the shape of elements used in the mesh rule.

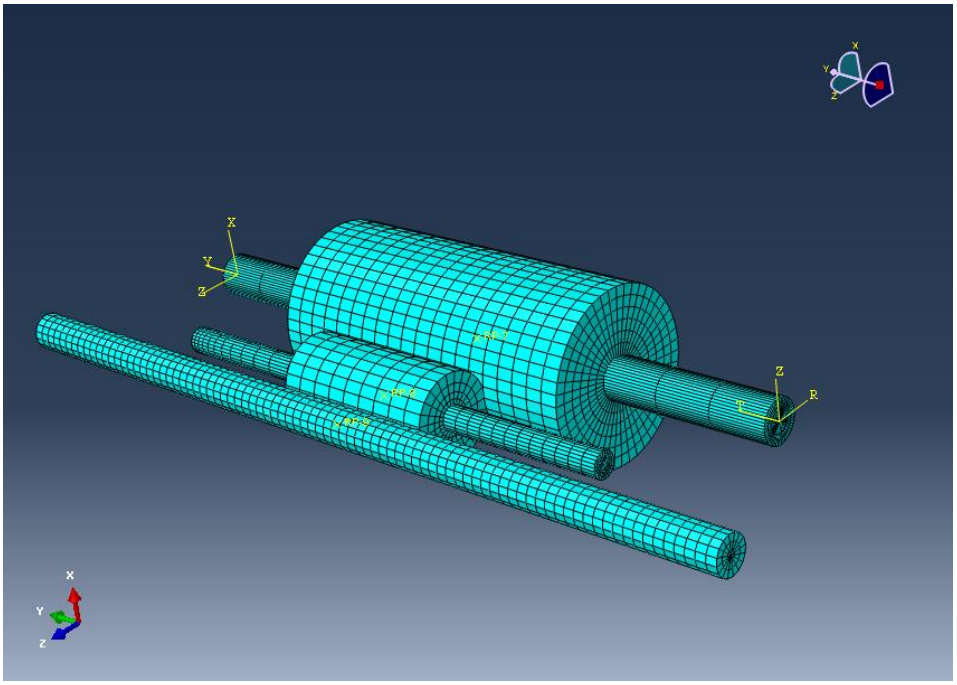


Figure 15: The meshed parts in assembly.

After all the pre-process parameters are finalized into the simulation the job can be created and data checked can be submitted before submitting the full job in order to find any pre-process errors that might come up. If any errors do occur, pre-process parameter might have to be changed or corrected to a valid value. The job can then be submitted, after computation time completes the results can be visualized and analyzed.

3.4 CVT Model

Before the CVT simulation was done, scaling using the Buckingham pi theorem was used to make the dimensions into dimensionless values for scaling into Abaqus.

3.4.1 Buckingham Pi Theorem

Based on the dimensions used in Solidworks, the material properties, and parameters used in Abaqus the dimensions are as followed:

ρ_1= plastic's density

ρ_2= rubber's density

E_1= plastic's Young's Modulus

E_2= rubber's Young's Modulus

D_1= Diameter of the cone

D_2= Diameter of the counter rotor

dx= overlap distance between surfaces

V_T= given tangential velocity

t= simulation time

In the Buckingham pi theorem we set the equation using the dimensions

$f(\rho_1, \rho_2, E_1, E_2, D_1, D_2, dx, V_T, t)= 0$

and

$F(\pi_1,\pi_2, \pi_3,\pi_4, \pi_5,\pi_6)= 0$

For every π symbolizes dimensionless parameters made from the dimensions in the previous function. The π functions are as follow:

$$\pi_1 = \frac{\rho 1}{\rho 2}$$

$$\pi_2 = \frac{D_1}{D_2}$$

$$\pi_3 = \Delta x / D_1$$

$$\pi_4 = E_1 / (\rho_1 V_T^2)$$

$$\pi_5 = E_2 / \rho_1 V_T^2$$

$$\pi_6 = t V_T^2 / D_1$$

Based on these dimensionless parameters a model in Abaqus was generated using the original design in Solidworks as a standard (Figure16 and 17). The parts made in Abaqus were scaled X1000.

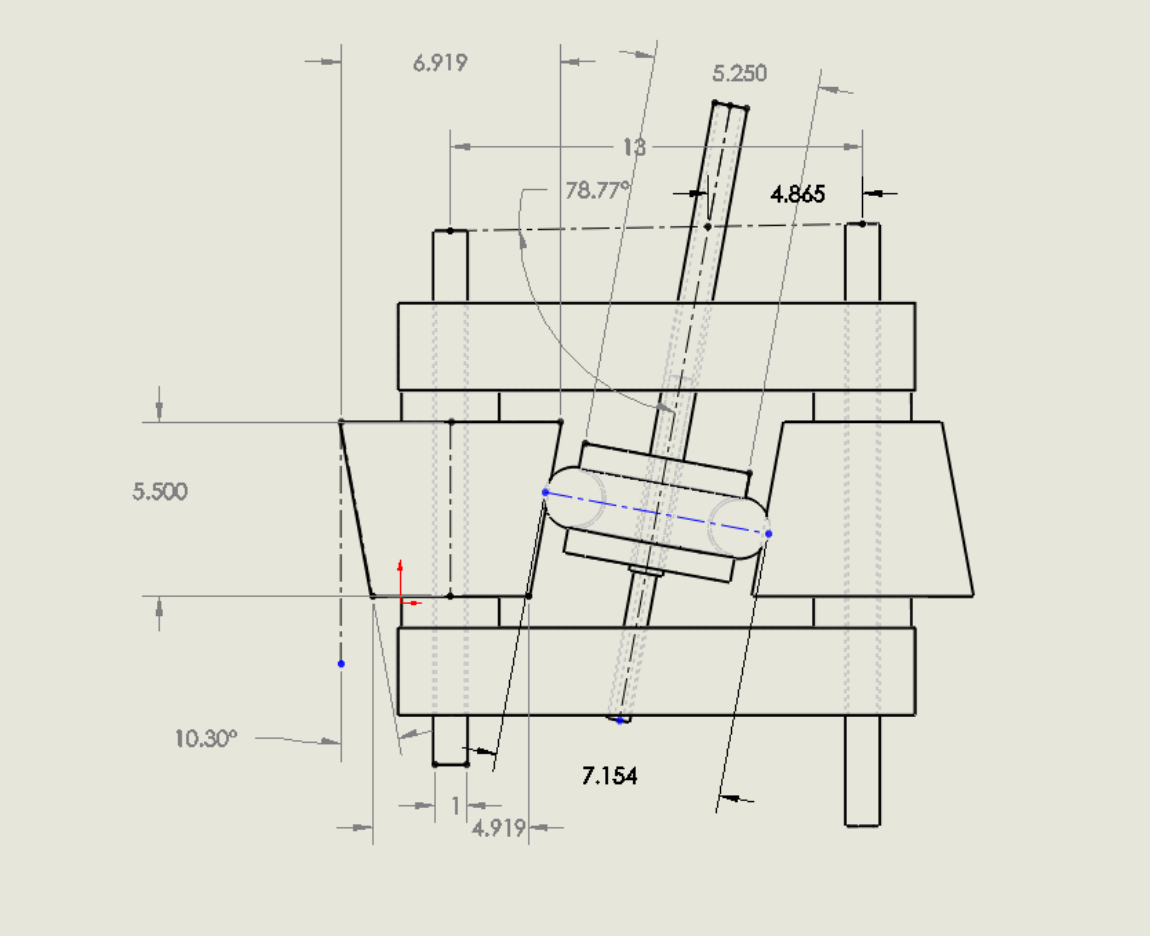


Figure 16: The original Solidworks dimensions in millimeters.

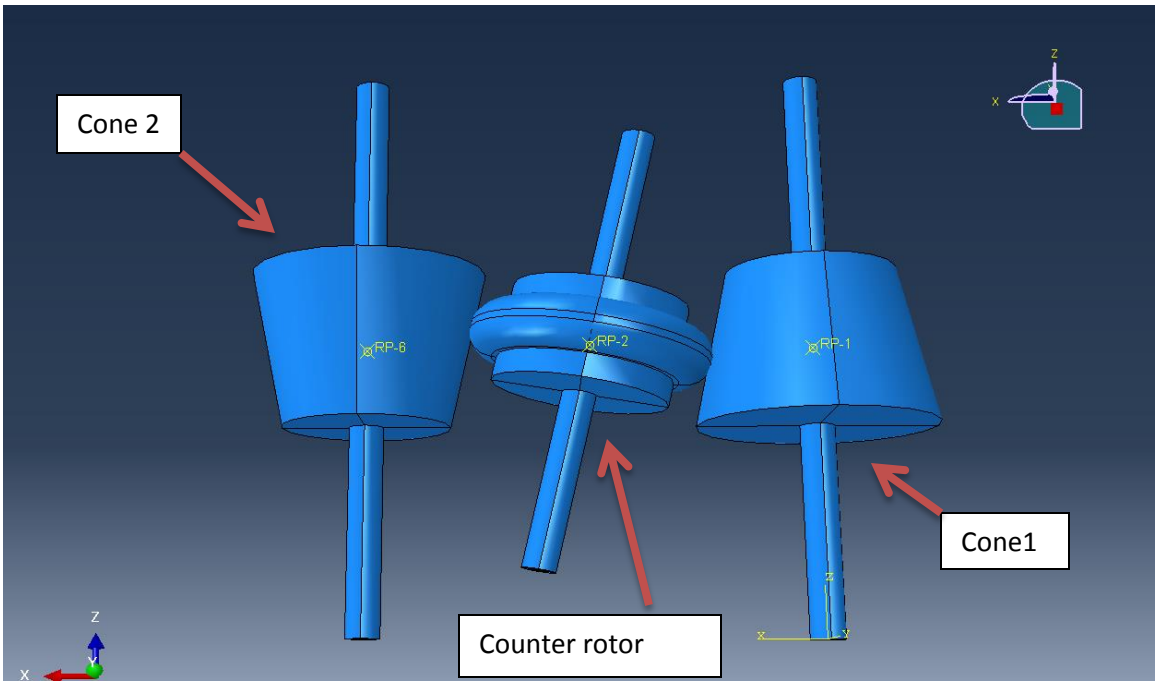


Figure 17: The model made in Abaqus.

3.4.2 Materials Properties

The CVT model simulated in Abaqus was similar to the test simulation. Additional materials tested to find the optimal one for the cone; the material properties for the CVT model are shown in Table 2.

Table 2: Material Properties for CVT Model

Material	Young's Modulus (GPa)	Poisson's Ratio	Density (kg/m3)
Acrylic Plastic	3.2	0.37	1220
Rubber	0.1	0.4	1100
Aluminum 6065	69	0.334	2700
Steel	180	0.305	8050
CarbonFiber	150	0.27	1800

3.4.3 Assembly and Steps

In the CVT case there are three parts, two cones and one counter rotor. The parts were partitioned with cylindrical geometries in mind, four quadrants and a circular sweep partition through the center. The assembly placed the cones in parallel to the global z axis and the initial driving cone was placed on the global origin. The counter rotor was translated in between the two cones and rotated so that the surface of the counter rotor would be normal to the surface of the cone.

The CVT simulation featured two steps, the initial step was set to the three instances in there assembly position and the second step were implemented the boundary conditions and constraints. The two interactions would be set to step 2, and were both be surface to surface contact for explicit solutions. The contact interaction property would include tangential and normal behaviors. The tangential behavior's friction coefficient would be different for each materials used. The coefficient of friction used for plastic and rubber was 0.6, rubber and rubber was 1.16, aluminum and rubber was 0.5, steel and rubber was 0.5 and carbon fiber and rubber was 0.5. The normal behavior was set to hard contact.

3.4.4 Boundary Conditions

A difference between the test simulation and the CVT simulation was in the constraints. The CVT simulation would use only deformable bodies as opposed to having one rigid body; the reason for this was the ability to see the stress contour contour on all parts of the simulation. All the parts were given a set reference point at their center of mass as a control point for a kinematic coupling constraint. The kinematic coupling constraint will allow boundary conditions to be applied to the ends of each cylindrical part. Similarly to the test simulation no load would be

applied to the model, but two boundary conditions would be set. The first was the angular velocity given to the first cone at the control point that was used for in the kinematic coupling constraint; the angular velocity was set for 1 radians/s rotating along the z-axis using the global coordinate system with instantaneous amplitude. The second boundary condition would pin 9 points, three on each part, this would set the translation in the x, y and z directions to zero in the global coordinate system (Figure 18).

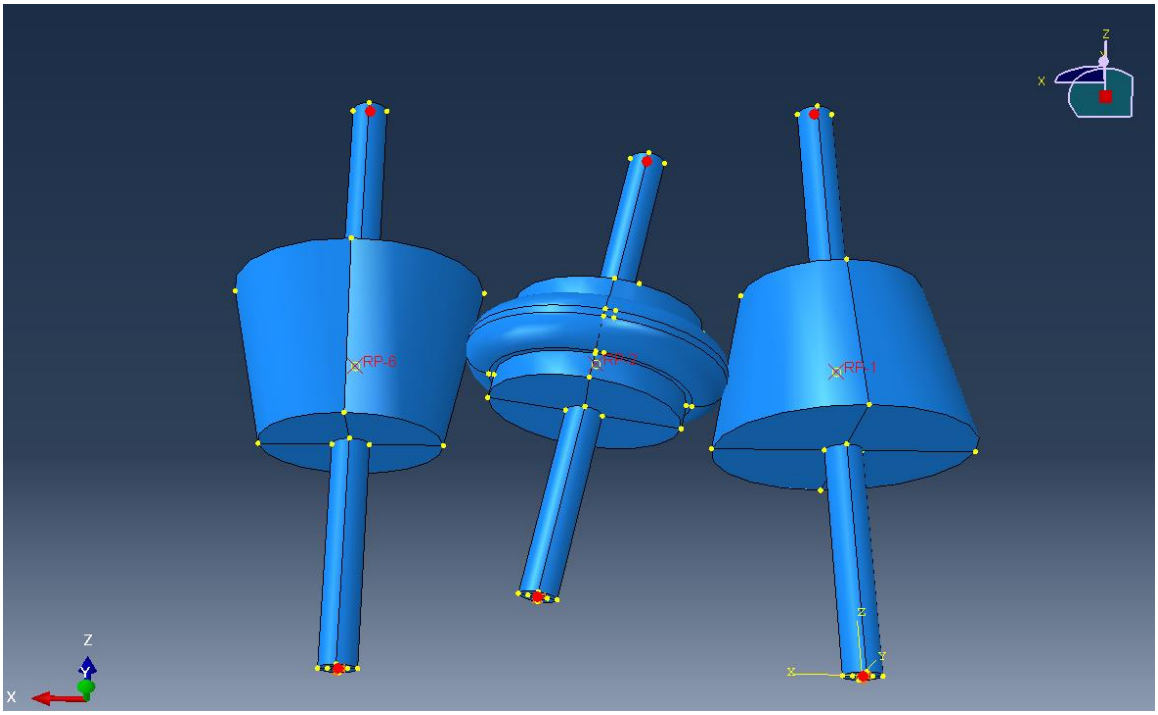


Figure 18: The 9 points pinned in the x , y and z translational directions indicated in red.

3.4.5 Mesh and Mesh Refinement

The mesh for each of the parts was done by using global seeding, a mesh refinement analysis was done to define a reasonable mesh size, and the variables for global seeding size were 0.3, 0.25, and 0.2. The mises were selected as measurements of mesh accuracy, the smaller

the mesh the more sensitive the measurement. The results from the mesh refinement analysis show that there was some deviation from the three different seeding, but because of computation time the larger seeding value of 0.3 was selected (Figure 19 and 20).

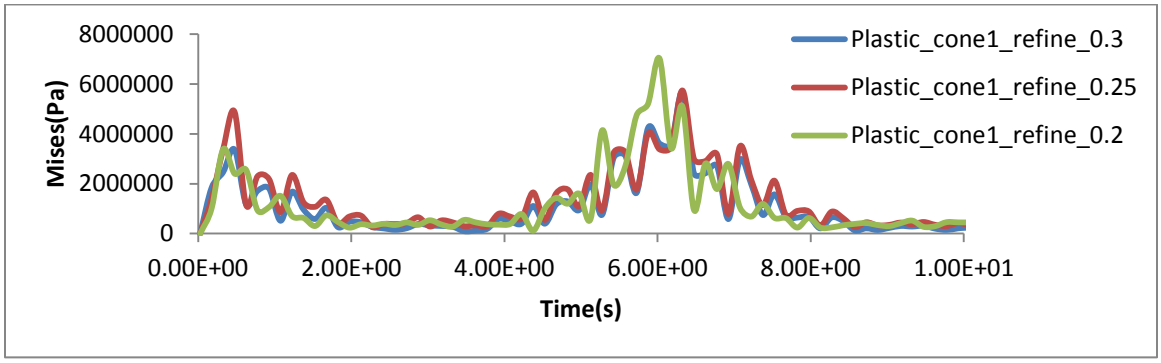


Figure 19: Mises over time for the 3 different mesh seeding for cone 1

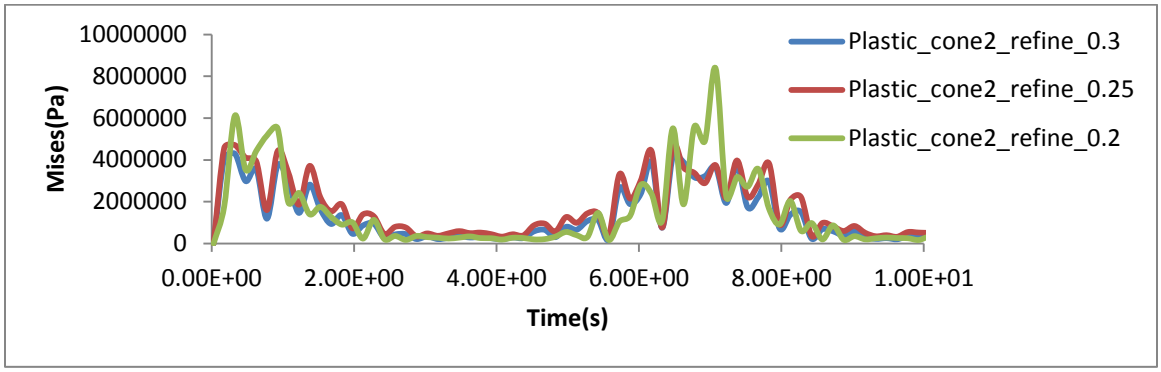


Figure 20: Mises over time for the 3 different mesh seeding for cone 2

The approximate global size was set to 0.3 with curvature control's maximum deviation factor of 0.1 and the minimum size control by fraction of global size of 0.1. The partitions featured in the assembly allowed for meshing elements of hex using sweep and hex using structured formats.

Once the mesh was finalized the simulation could be ran. After initial runs, specific history outputs can be created for specific sets of elements. Elements from the two cones were set for a history

output (Figure 21). These elements were selected for their nearest position to the surface contact region between the cone and counter rotor. The specific history output was set to extract the output variables for stress for those element sets. The variables would be comparable to cone 1 and cone 2, the different material properties and the overlapping distance between surfaces.

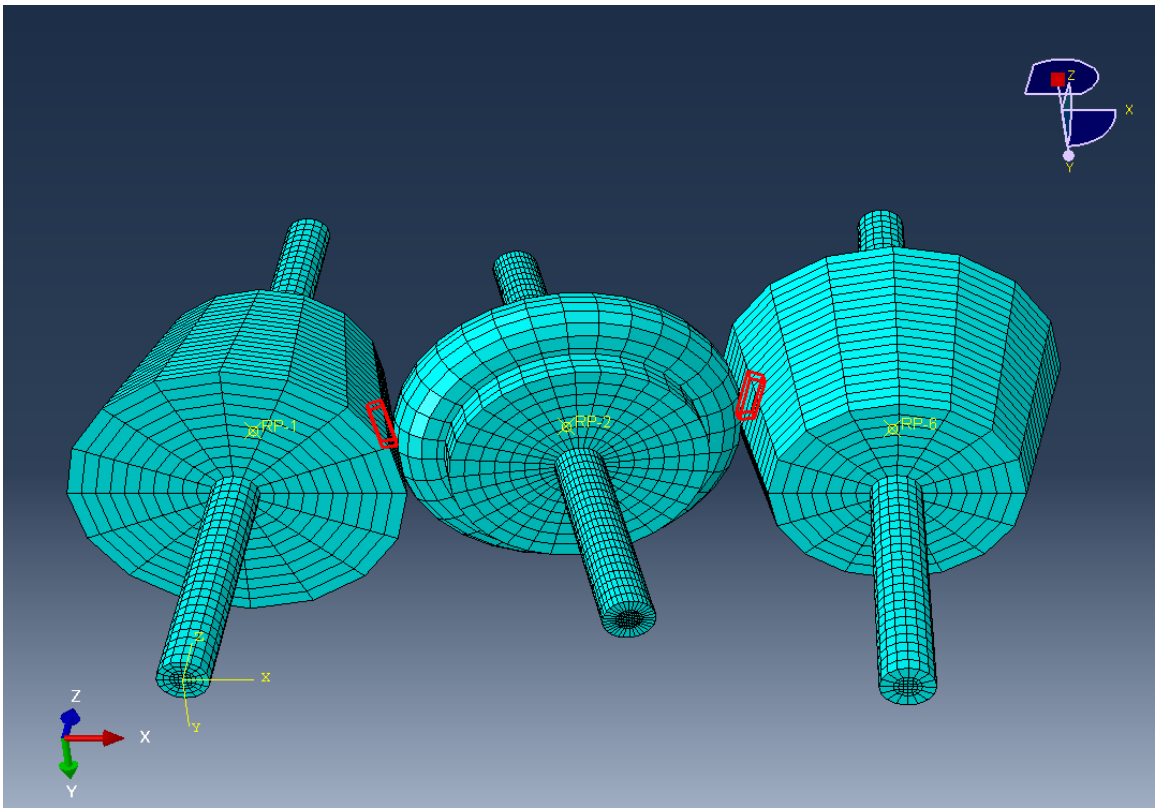


Figure 21: Element set on the counter rotor.

3.5 Design of Experiment

The design of experiment for the CVT simulation would be to test the different materials for the cones and the independent variable, dx the distance of overlap between the cone and the counter rotor's surface. The five different materials would be compared: plastic, rubber, aluminum, steel, and carbon fiber. The overlaping distance between the two contacting surfaces of the cone and counter rotor would be compared: 0.05 , 0.10, 0.15, and 0.20 m. The comparison between cone 1 and cone 2 would be shown for the transfer of stress from the driving cone to the driven cone. The predicted results would show an

increase in stress as the distance of overlap increases. The materials will have a different effect with different material properties in Young's Modulus, Poisson's ratio, density, and the coefficient of friction with rubber. The experimental simulations parameters are shown in Table 3.

Table 3: The design of experiments for material simulated and the overlap distance

	Dx -Overlapping Distance (mm)			
Materials	**0.05**	**0.1**	**0.15**	**0.2**
Plastic	1,2	1,2	1,2	1,2
Rubber	1,2	1,2	1,2	1,2
Aluminum	1,2	1,2	1,2	1,2
Steel	1,2	1,2	1,2	1,2
CarbonFiber	1,2	1,2	1,2	1,2

Cone's 1 and 2: 1,2

CHAPTER 4
Results and Discussion

4.1 Load cell and flapping frequency result

The result from the tachometer measured a flapping frequency of 10 to 11 Hz. The Nano-17 load cell mounted with the testing prototype was positions in the global axis according to Figure 22.

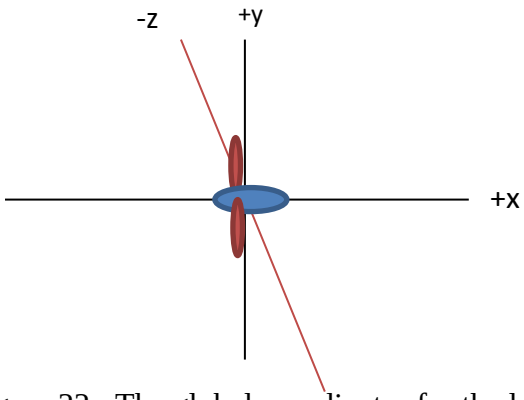


Figure 22: The global coordinates for the load cell with the testing prototype mounted.

In this setting, since the flapping wings of the vehicle cannot be symmetric without a sensor and a feedback loop the test for both wings to be flapping in synchronous would not be accurate. The test for the load cell was to control one wing to flap faster than the other generating a difference in force and would shift the vehicle in the direction according to Figure 2. The load cell was zeroed by subtracting the initial noise value without any motion in the vehicle. The load cell was set to time 5 seconds at 1000 Hz. Unfortunately the data was inconclusive.

4.2 Abaqus Test Simulation:

The results from the test simulation in Abaqus allowed for an understanding of rotating cylindrical parts. The visualization showed in Figure 23, shows the mises between each part.

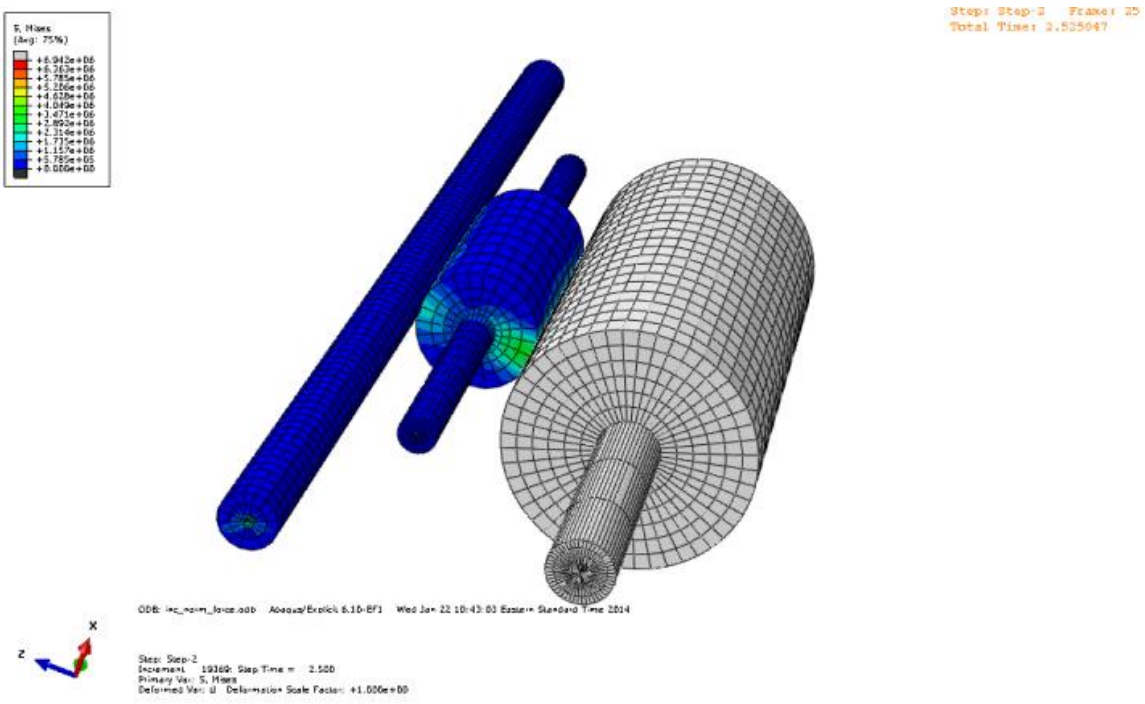


Figure 23: The visualization of the contour plot of mises in the test simulation.

The mises contour plot shows plausible stress on the surface contact areas which makes for a sensible outcome. To further validate the simulation the speed output can be considered.

From Abaqus's history output, tangential velocity could be extracted, by specifically isolating the data in a row of elements on the smaller rotor, tangential velocity could be found for that specific set. In figure 24 the row of elements were selected and the history output for those elements would be averaged to give the tangential velocity result. The tangential velocity given from the boundary condition of 1 rad/s would give 5 m/s given a radius of 5 meters. Abaqus

history output gives tangential velocity in the x and y component, the z component can be neglected since there was no significant change in that direction. In figure 25, the tangential velocity in the Y direction shows the peak tangential velocity of 5 m/s and that the higher coefficient of friction model performed with a faster initial start as opposed to the lower coefficient of friction, this pertaining to the two different material interactions used in prototypes produced (Figure 25). The same occurred in the tangential velocity in the x-direction, with the higher coefficient of friction starting faster initially than the lower coefficient (Figure 26). After the basics of the test simulation, the CVT simulation can be modeled using similar parameters.

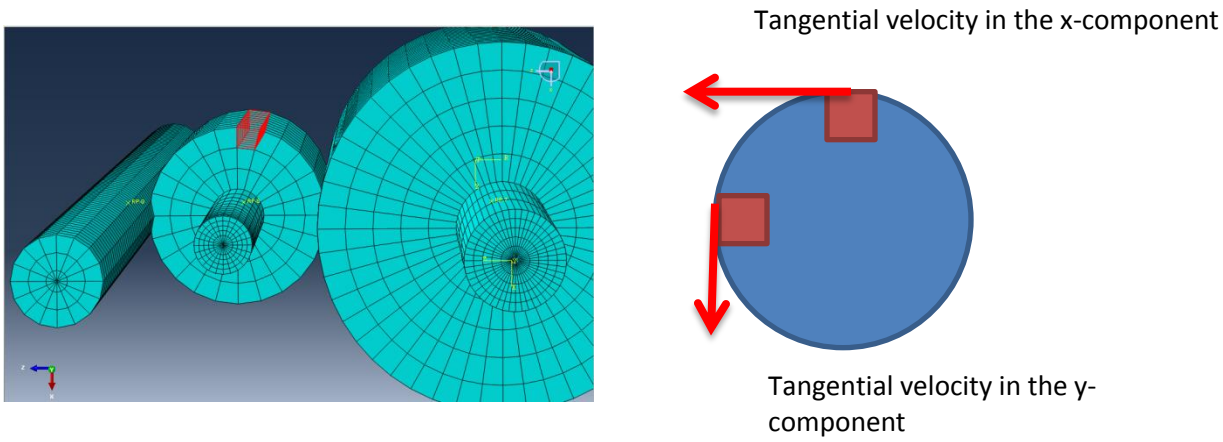


Figure 24: The elements selected for Abaqus's history output.

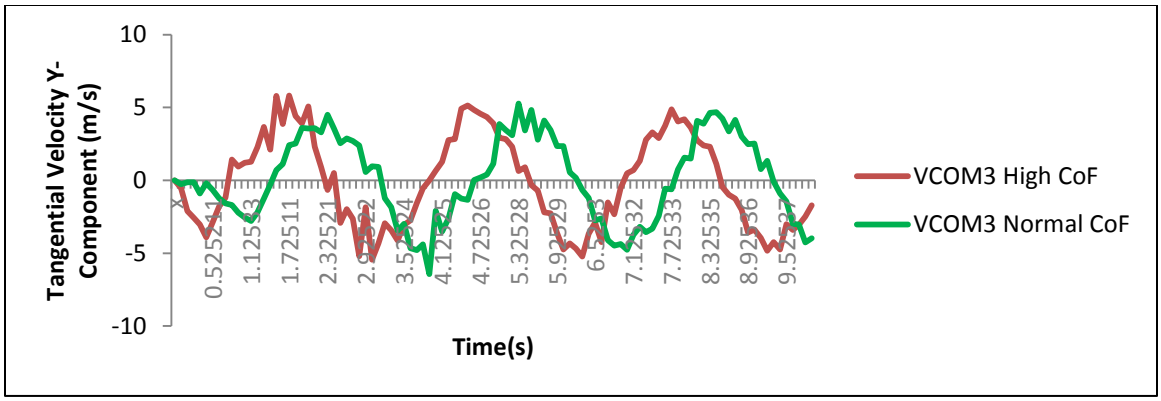


Figure 25: Tangential velocity in the Y component over time for simulating a high coefficient of friction and normal coefficient.

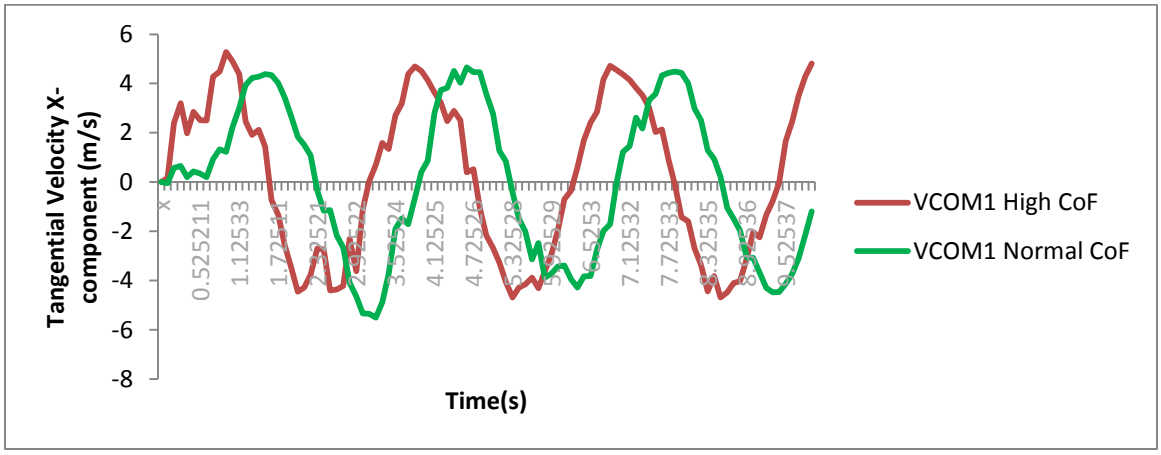


Figure 26: Tangential velocity in the X component over time for simulating a high coefficient of friction and normal coefficient.

4.3 Abaqus CVT Simulation:

The CVT simulation was modeled and designed using a simplified version of the actual model from Solidworks. The model was then scaled 1000X for modeling in Abaqus CAE purposes. The results from Abaqus CAE's contour plots are rendered in isosurface types to visually see the von mises. Von mises are equivalent stress taken from the degrees of freedom of the elements stress tensors. The pinned positions for the boundary conditions show high levels of stress on the cylindrical ends of the cone can be neglected, the primary focus was on the surface to surface contact regions. The von mises contour plots shows the surface stress based on the material properties, surface to surface interactions, and overlapping distance. The von mises range is limited in color spectrum and values that exceed the range will not be shown in color. The range made specifically to serve as visual ranges for the contact surface areas of the CVT simulation which is between the cones and counter rotor. Comparison of the contour plots as the change in overlap distances are taken from the element set on the surface of the cones that were closest to the counter rotor surface contact regions. The history output for the set elements were plotted for comparison for material and overlap distance variables.

4.3.1 Contour plots: Plastic Material

The CVT model results for plastic contour plots are shown in the figures below for the four overlapping distances, 0.05, 0.10, 0.15, and 0.20 m.(Figure 27-30) As the overlap distance increased and the von mises gradually show larger values on the contour plots at the surface contact regions.

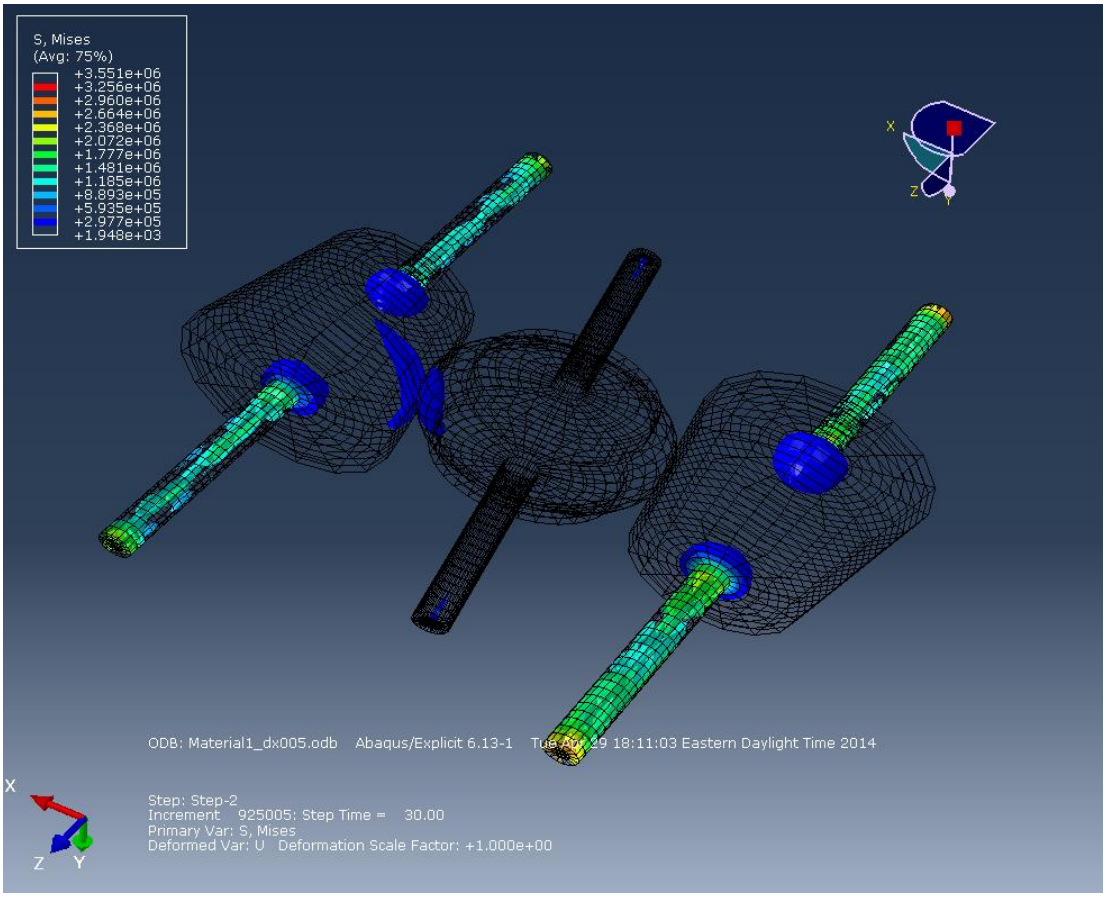


Figure 27: Contour plot of mises for Plastic material with dx= 0.05 m at step time: 30.0 seconds

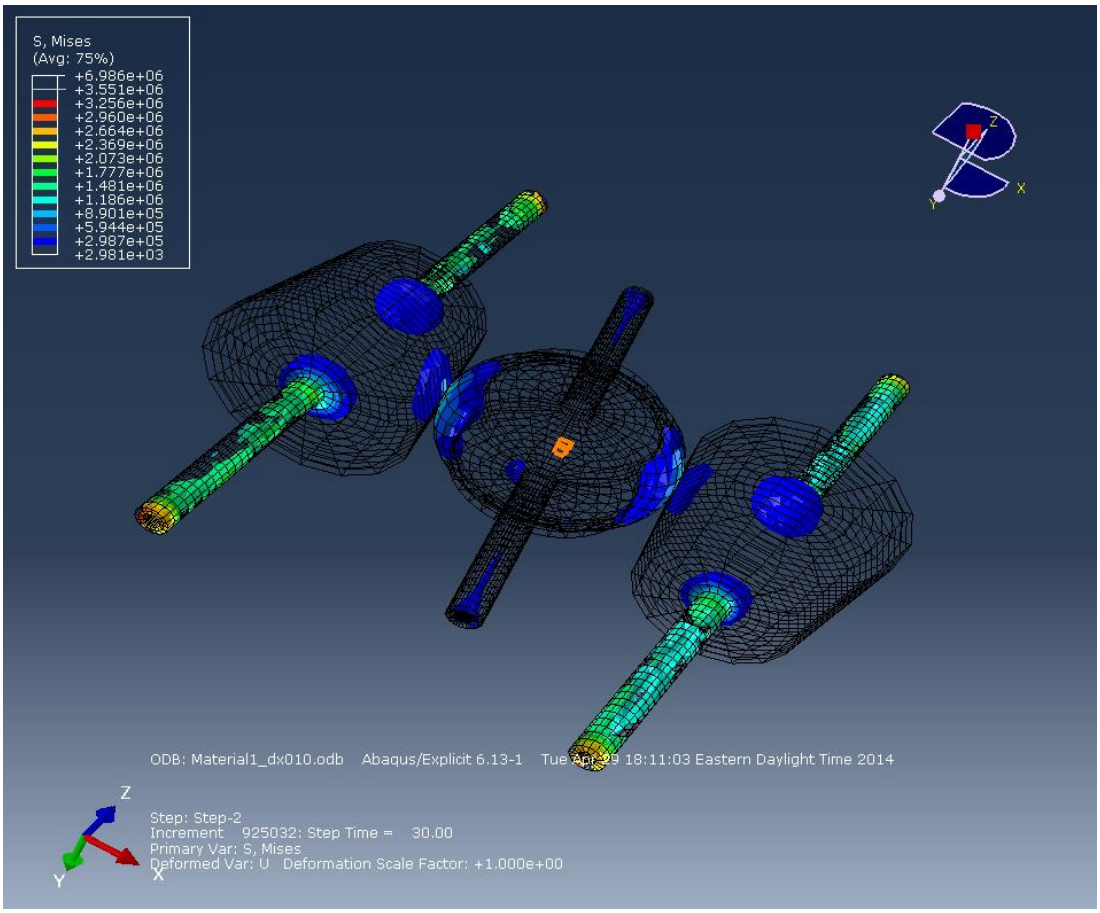


Figure 28: Contour Plot of mises for Plastic material with dx=0.10 m at step time: 30.0 seconds

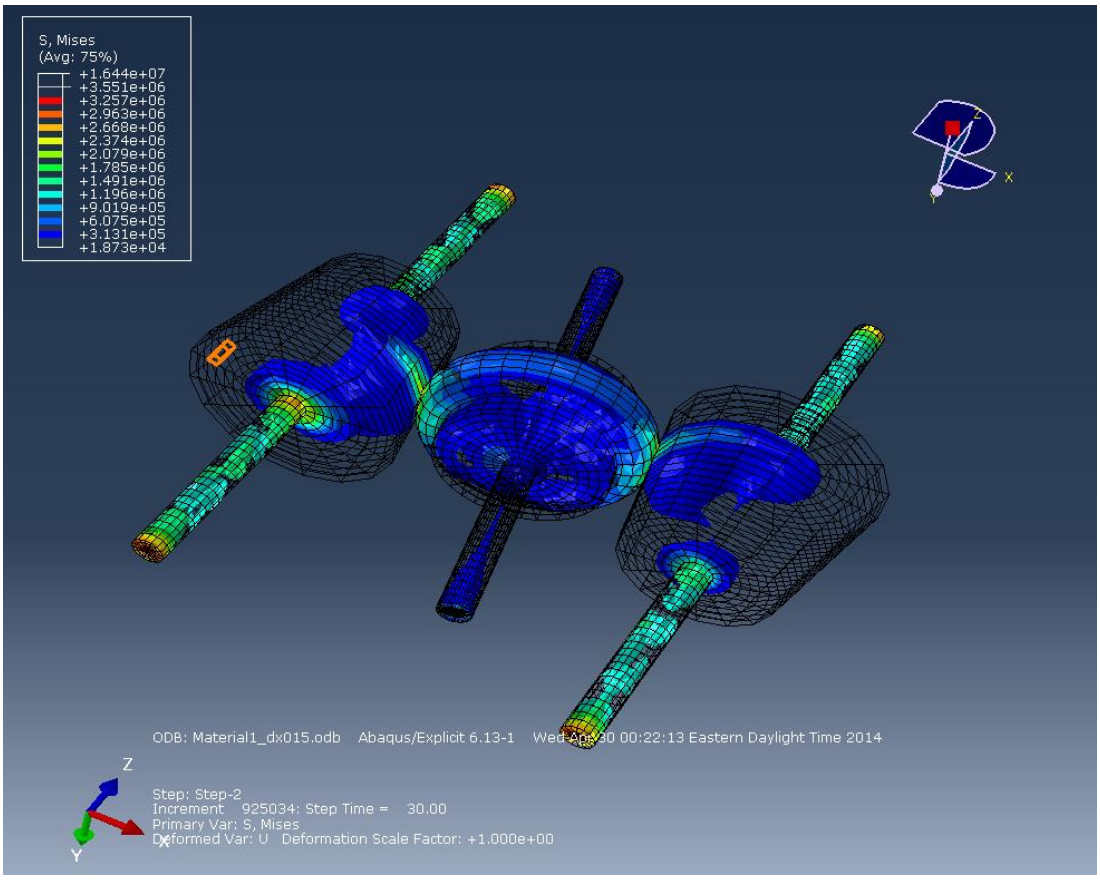


Figure 29: Contour Plot of mises for Plastic material with dx =0.15 m at step time: 30.0 seconds

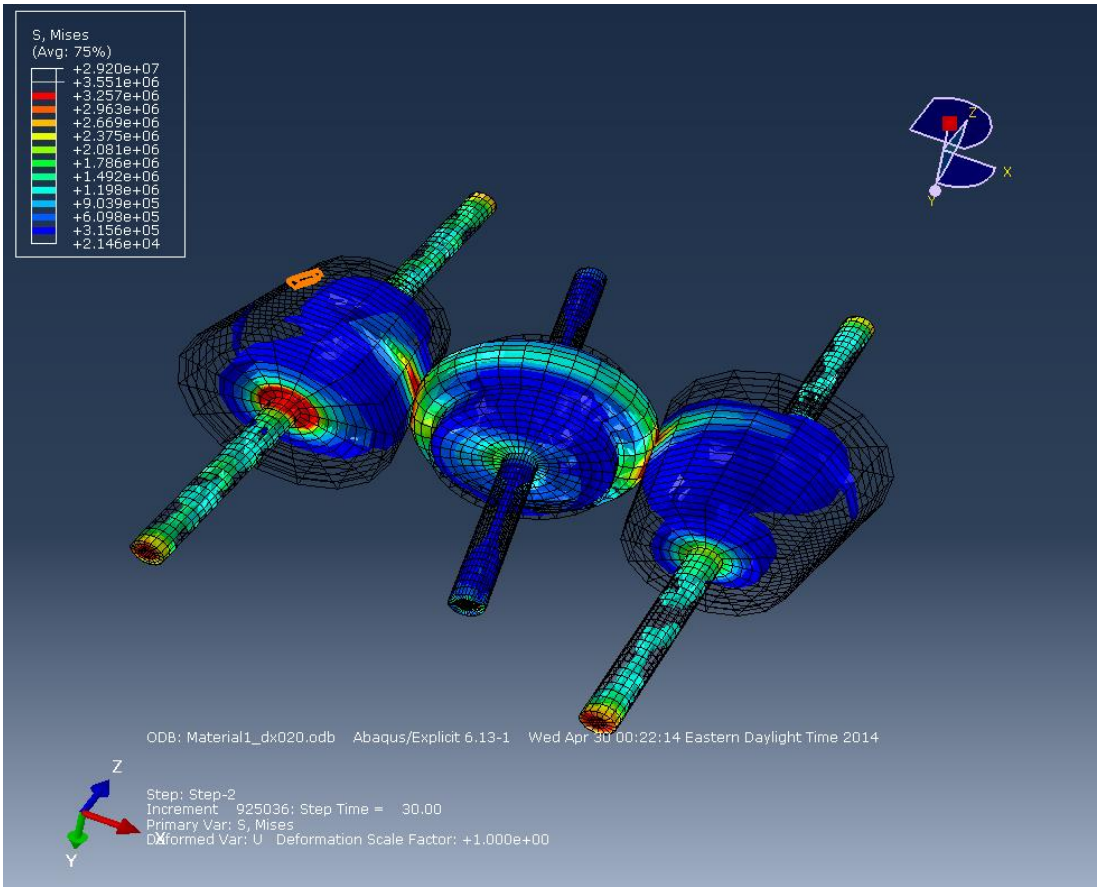
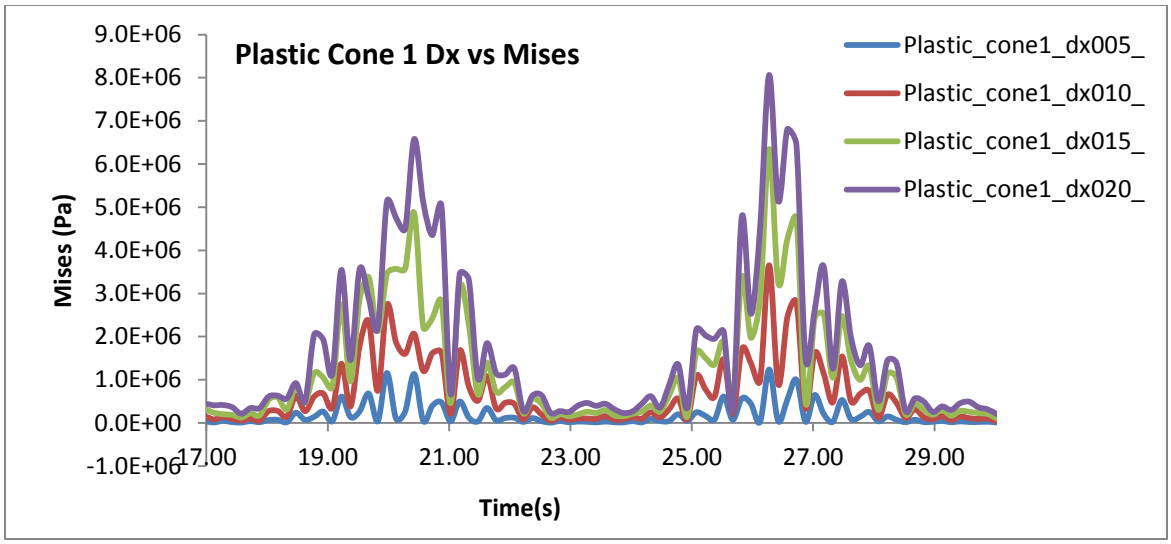


Figure 30: Contour Plot of mises for Plastic material with dx=0.20 m at time step: 30.0 seconds

4.3.2 Comparison Plot for Plastic Material

The results from the history output for a single element on the surface of cone 1 and cone 2 are shown in figure 31 comparing the change in overlap distance for plastic material. A numerical plot of the change in overlap distance shows the increase in maximum mises for the plastic cone surface for the last 2 cycles. The maximum value for von mises for plastic material was about 7.5 MPa at the highest overlap distance. In cone 2 the lowest overlap distance shows a phase shift, since cone 2 was the driven cone this means a delay in rotation due to surface contact interactions. After the overlap distance exceeds 0.10 the difference in cone 1 and cone 2 become minimal.



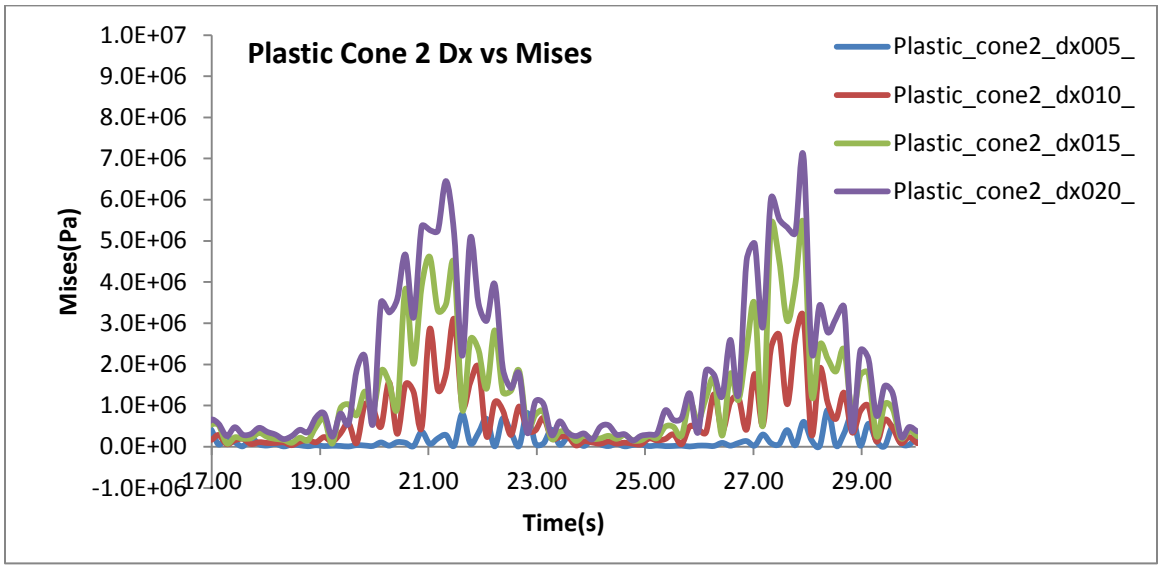


Figure 31: Comparison data for Plastic material with different overlapping distances for cone 1 and cone 2 for the last two cycles.

4.3.4 Contour Plot: Rubber Material

The results for rubber material contour plots are shown in the figures below for the four overlapping distances, 0.05, 0.10, 0.15, and 0.20 m (Figure 32-35) As the overlap distance increased, the mises gradually show larger values on the contour plots. Similarly to Plastic material, the von mises increase near the surface contact region, since the range in contour plots are all the same, rubber material does not have as much stress as plastic material.

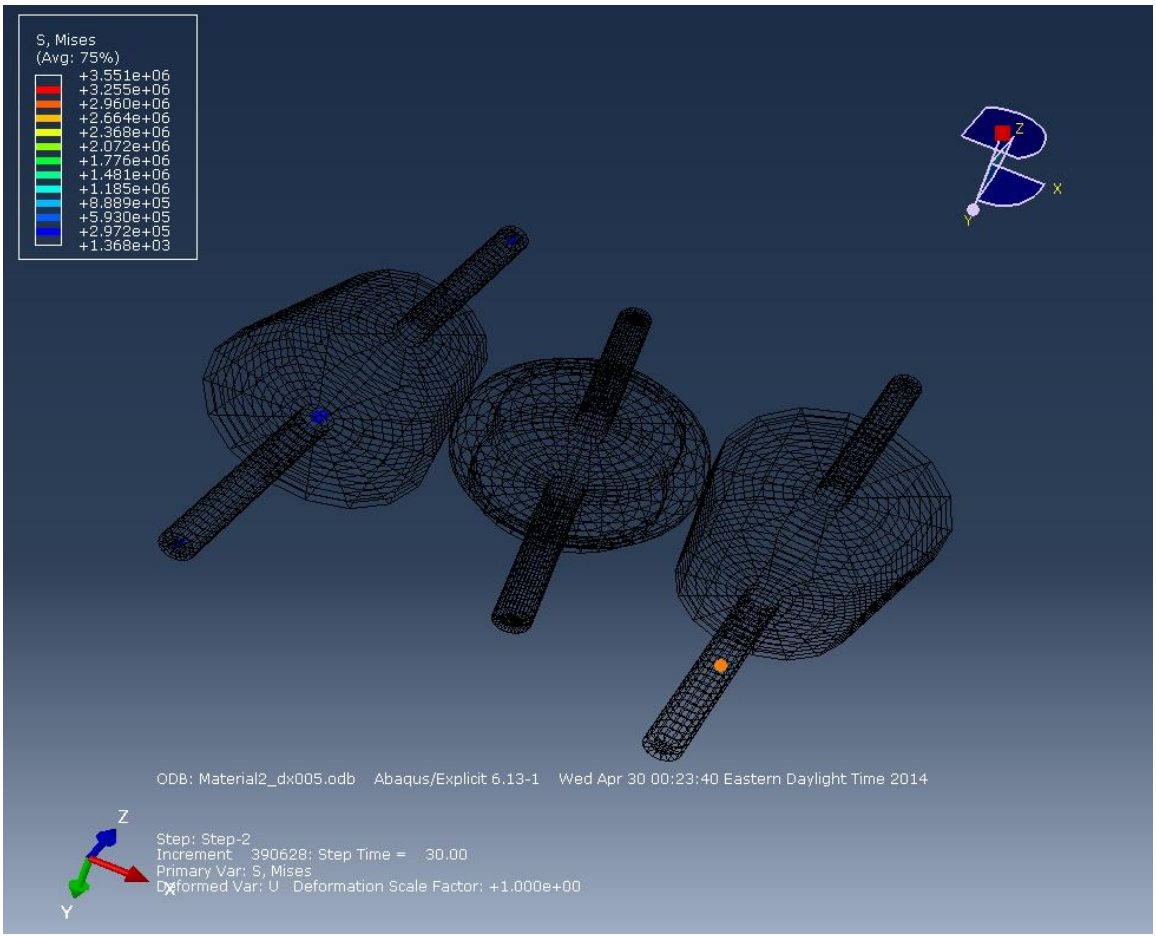


Figure 32: Contour Plot of mises for Rubber material with dx = 0.05 m at time step: 30.0 seconds.

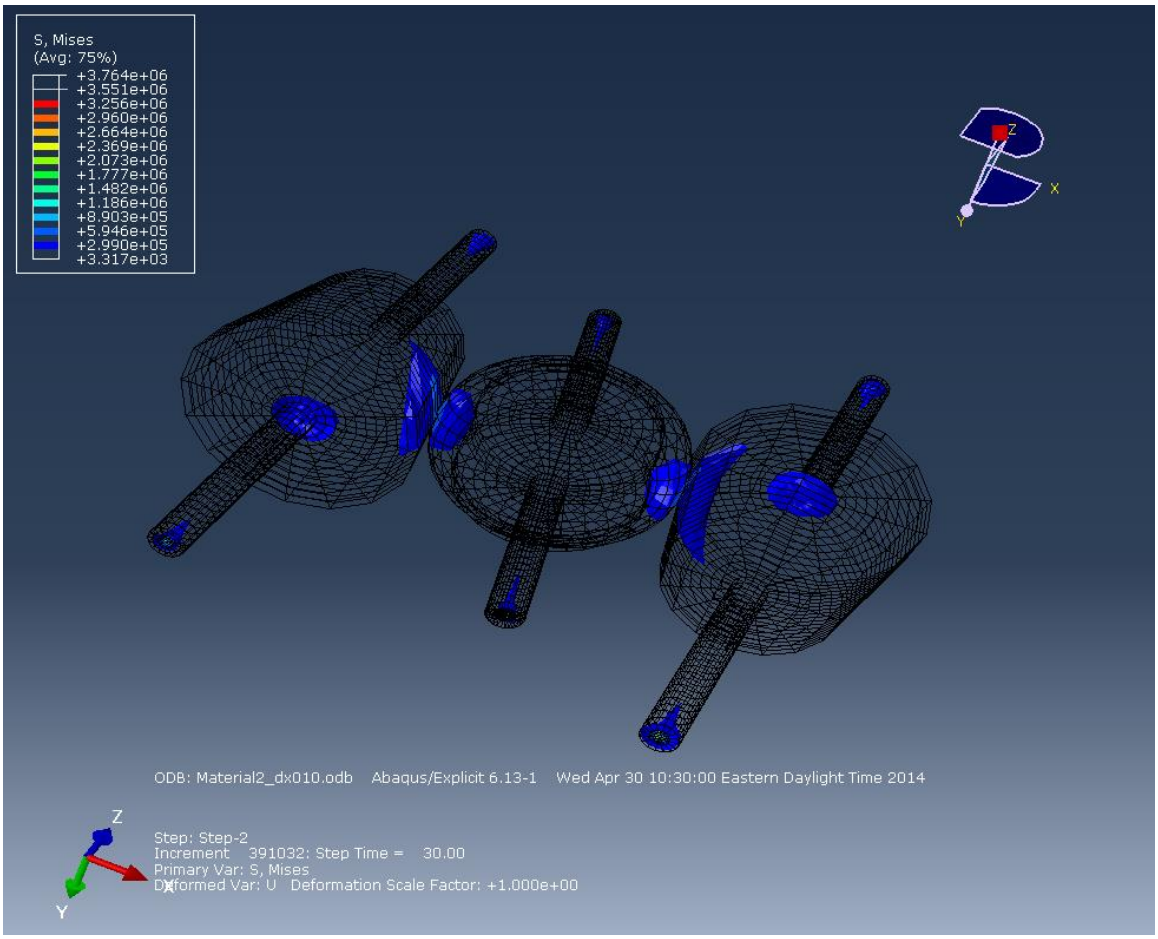


Figure 33: Contour Plot of mises for Rubber Material with dx = 0.10 m at time step: 30.0 seconds

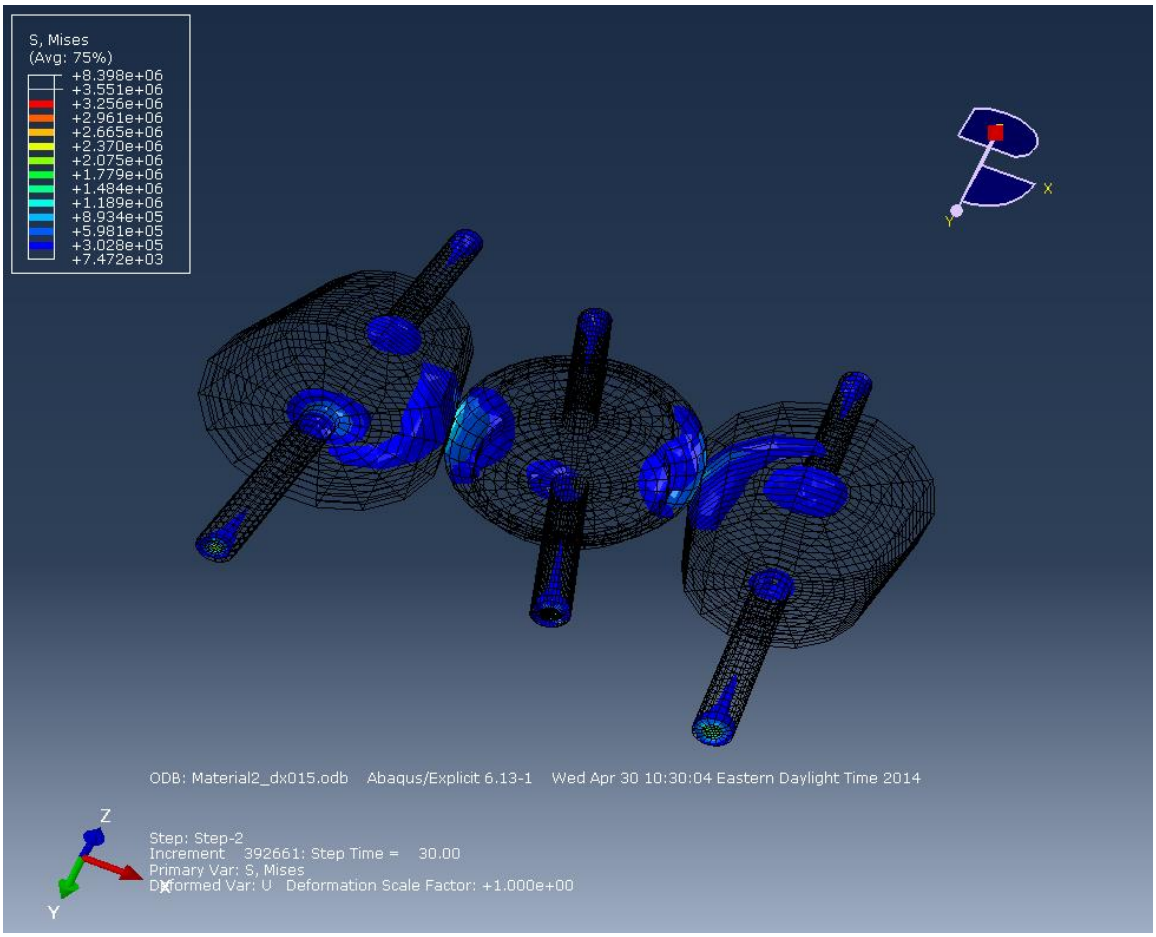


Figure 34: Contour Plot of mises for Rubber Material with dx = 0.15 m at time step: 30.0 seconds

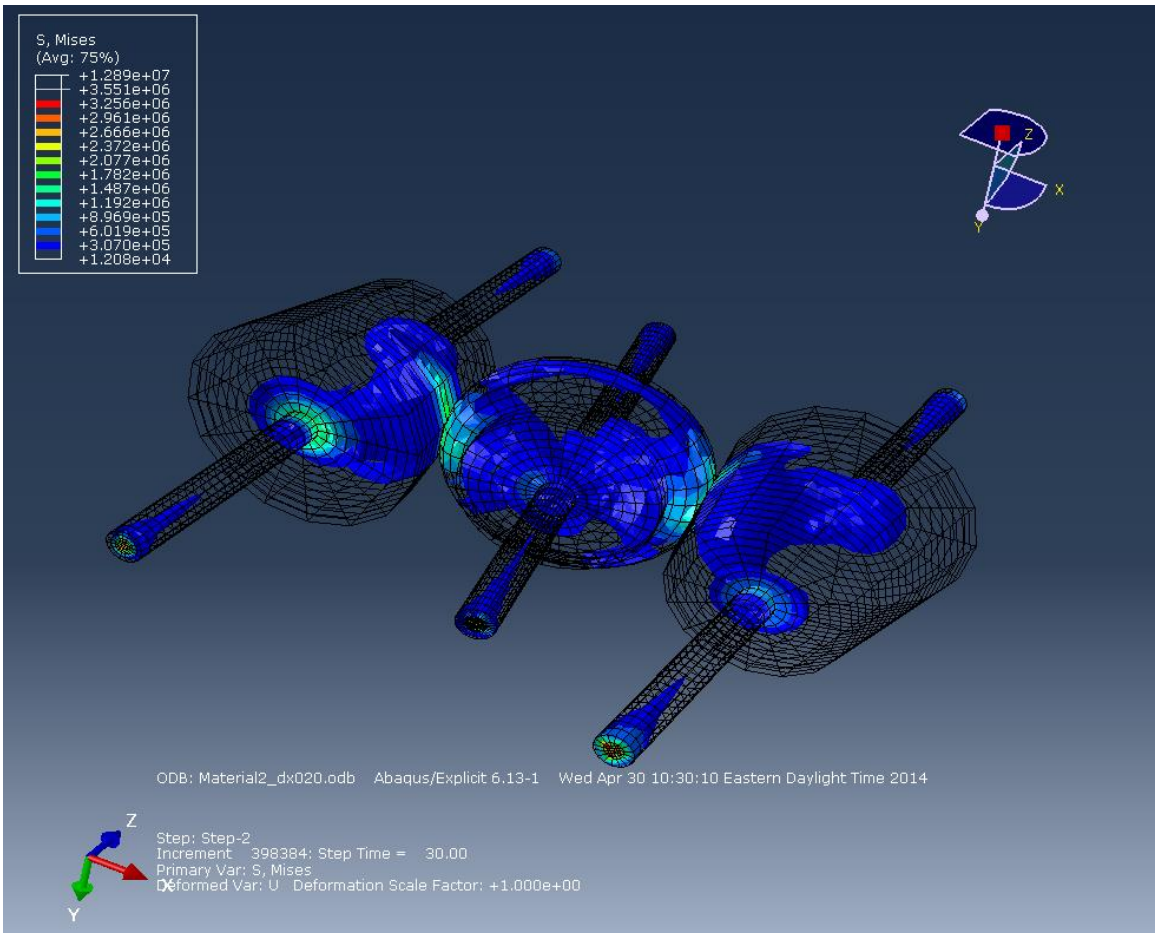


Figure 35: Contour plot of mises for Rubber Material with dx=0.20 m at time step: 30.0 seconds

4.3.5 Comparison Plot for Rubber Material

The results from the history output for a single element on the surface of cone 1 and cone 2 are shown in figure 36 comparing the change in overlap distance for rubber material. A numerical plot of the change in overlap distance shows the increase in maximum mises for the rubber cone surface for the last 2 cycles. Compared to plastic material, rubber material has a maximum von mises of about 2.5 MPa, this can be accounted for lower Young's modulus and a higher Poissons ratio than plastic. In the lowest overlap distance for cone 2 the cycle is shifted to the right, meaning a slower start in rotation even though the coefficient of friction for rubber to rubber is the highest.

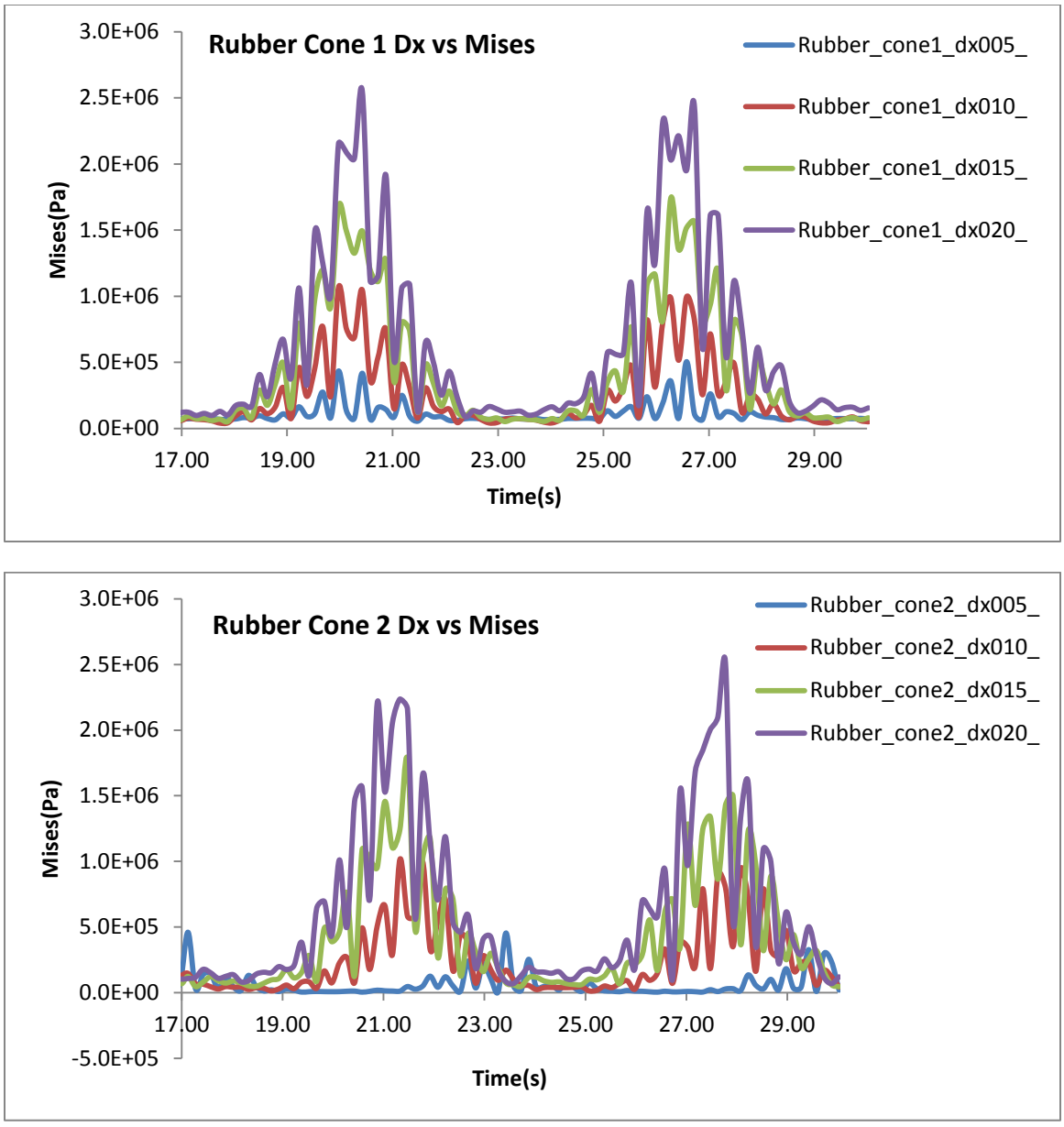


Figure 36: Comparison data for Rubber material with different overlapping distances for cone 1 and cone 2 for the last two cycles.

4.3.6 Contour Plot: Aluminum Material

The results for Aluminum material contour plots are shown in the figures below for the four overlapping distances, 0.05, 0.10, 0.15, and 0.20 m.(Figure 37-40) As the overlap distance increased, the von mises gradually show larger values on the contour plots. Initially for aluminum there was internal stress near the center of mass of cones 1 and cones 2, but this did not affect the surface interaction. The internal stress could be a factor of a high Young's modulus value. The contour plot shows no color to elements that go beyond the range of the contour range, but the surface stresses do not exceed the stress contour range.

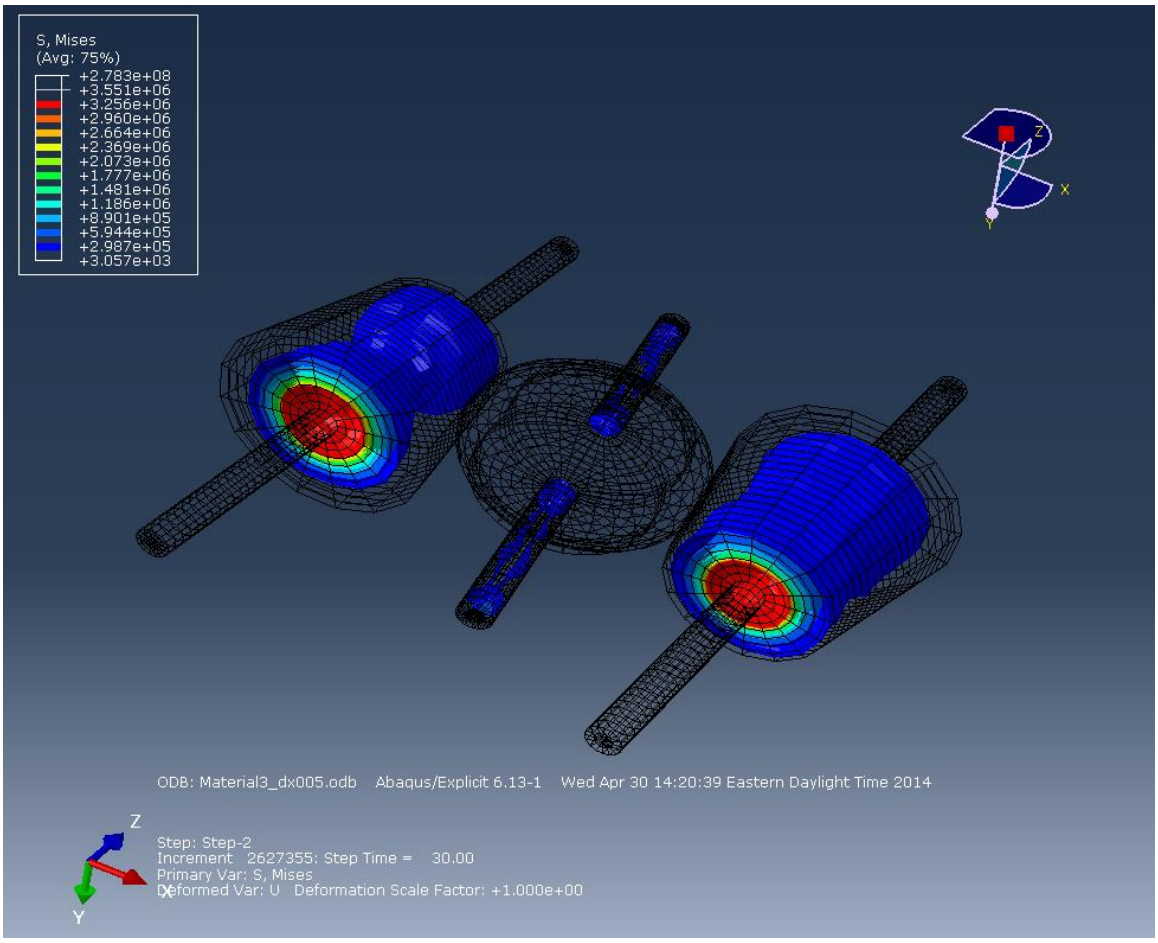


Figure 37: Contour Plot of mises for Aluminum material with dx = 0.05 m at time step: 30.0 seconds

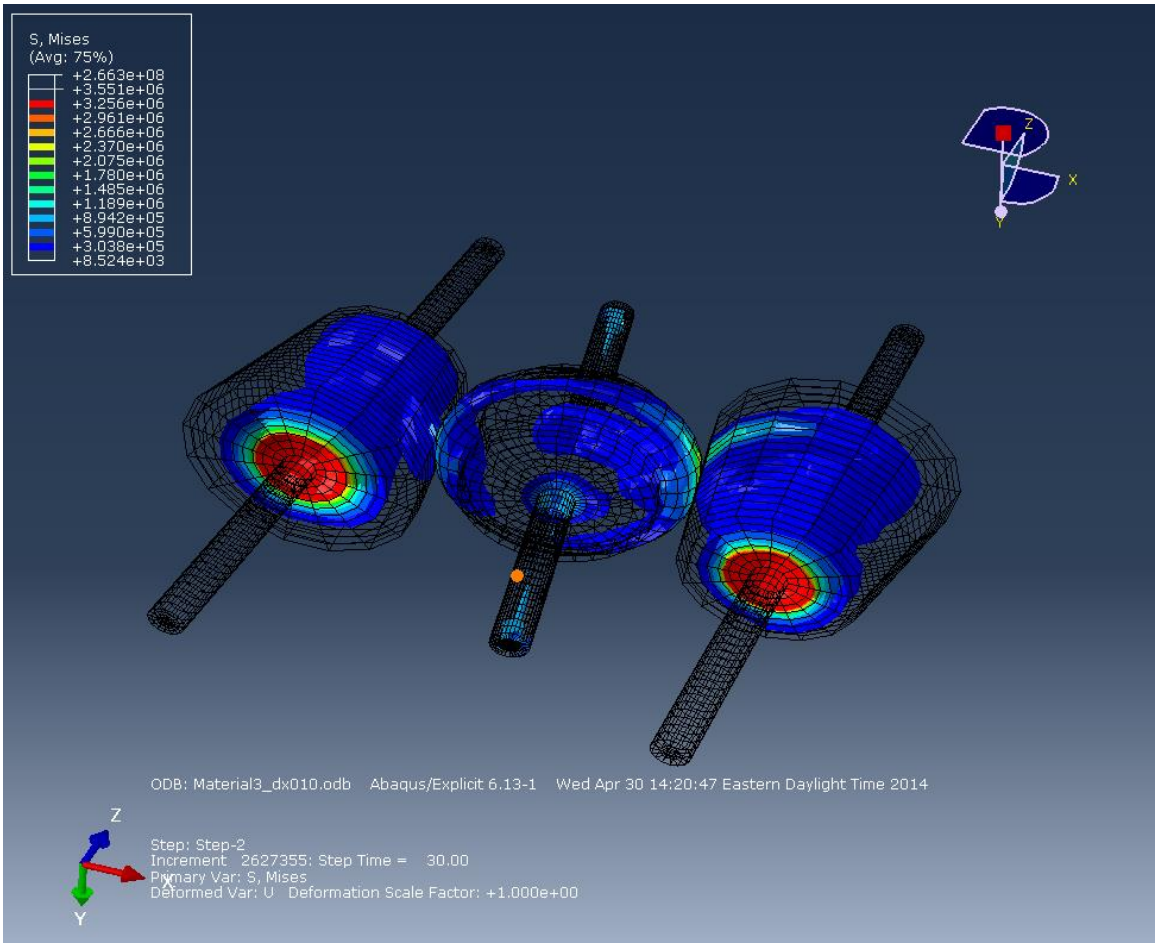


Figure 38: Contour Plot of mises for Aluminum material with dx = 0.10 m at time step: 30.0 seconds

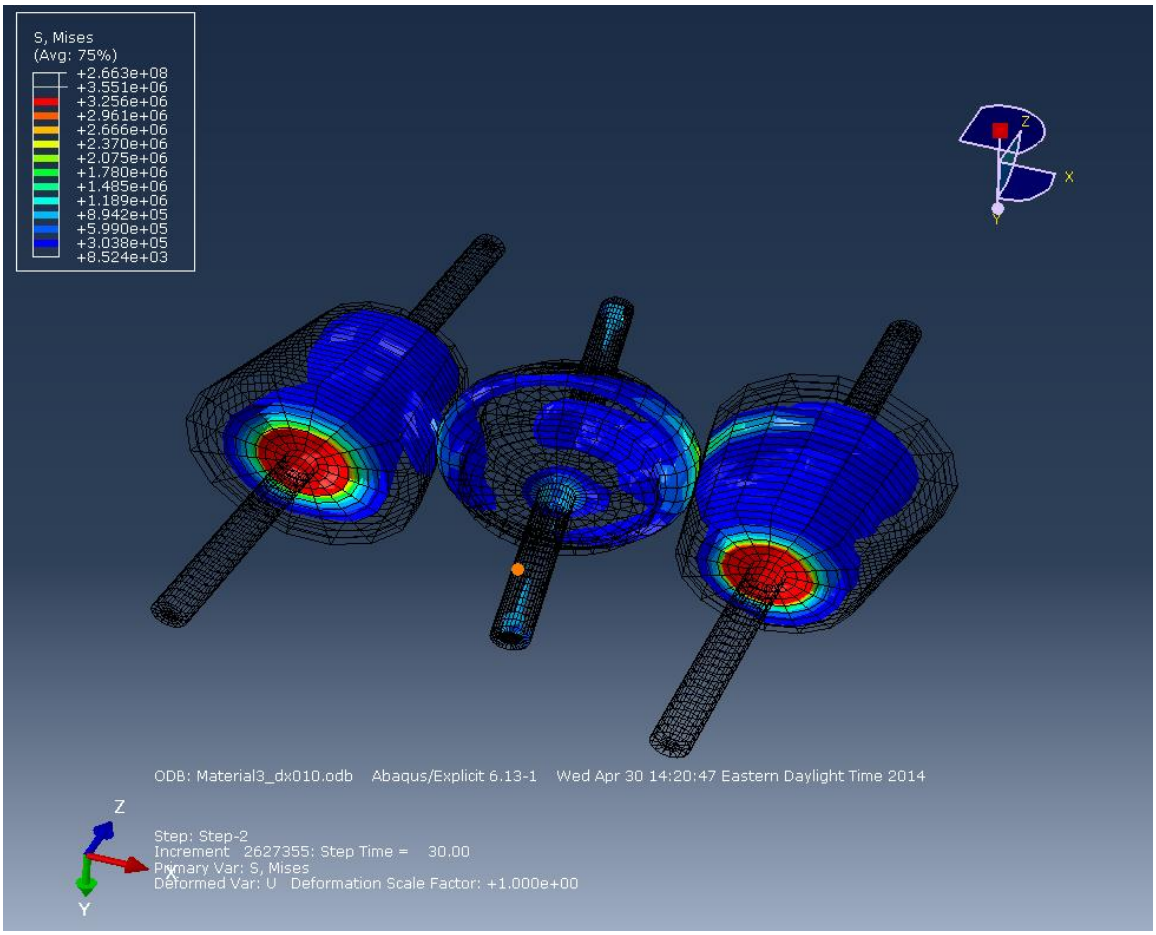


Figure 39: Contour Plot of mises for Aluminum material with dx = 0.15 m at time step: 30.0 seconds

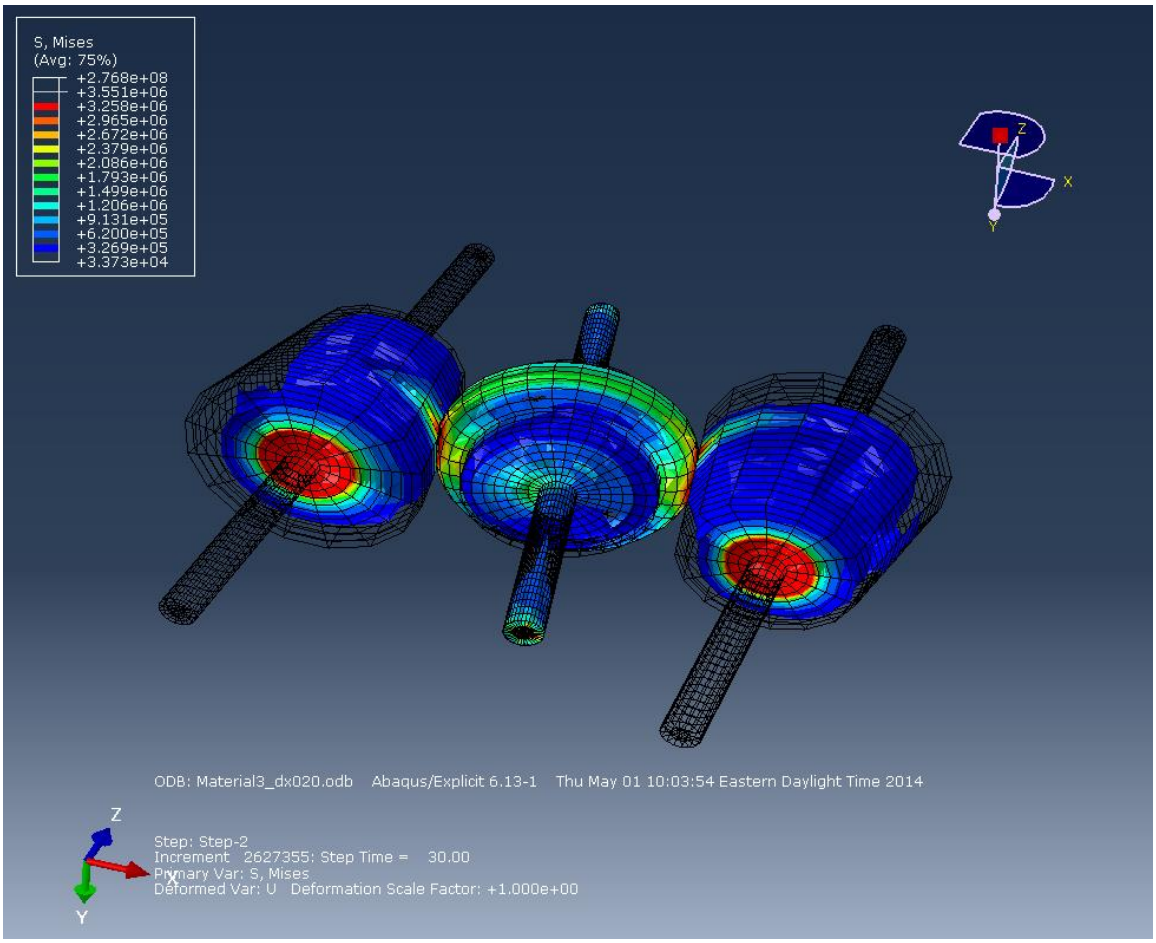


Figure 40: Contour Plot of mises for Aluminum material with dx= 0.20 m at time step: 30.0 seconds

4.3.7 Comparison Plot for Aluminum Material

The results from the history output for a single element on the surface of cone 1 and cone 2 are shown in figure 41 comparing the change in overlap distance for aluminum material. A numerical plot of the change in overlap distance shows the increase in maximum mises for the aluminum cone surface for the last 2 cycles. The maximum stress for aluminum material was about 9.0 MPa. In cone 2 the lowest overlap distances showed very minimal stress values and shows a plateau in maximum stress at about 7.5 MPa. Similarly to the previous materials after overlap distances past 0.10 cone 1 and cone 2 are similar is stress.

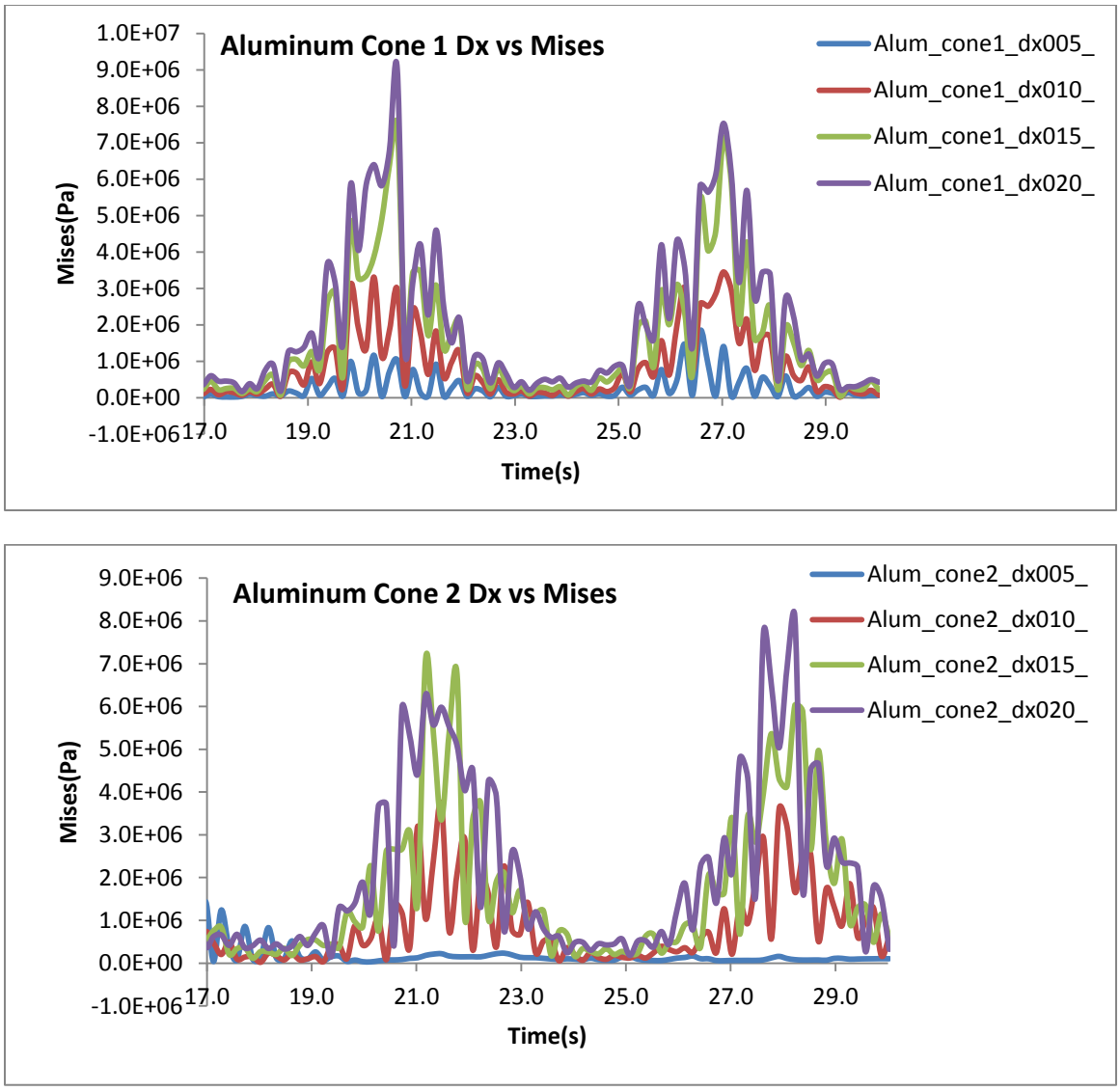


Figure 41: Comparison data for aluminum material with different overlapping distances for cone 1 and cone 2 for the last two cycles.

4.3.8 Contour Plot: Steel Material

The results for steel material contour plots are shown in the figures below for the four overlapping distances, 0.05, 0.10, 0.15, and 0.20 m.(Figure 42-45) As the overlap distance increased, the mises gradually show larger values on the contour plots. Similarly to aluminum material there was internal stress near the center of mass for cone1 and cone 2, since steel has a large Young's Modulus.

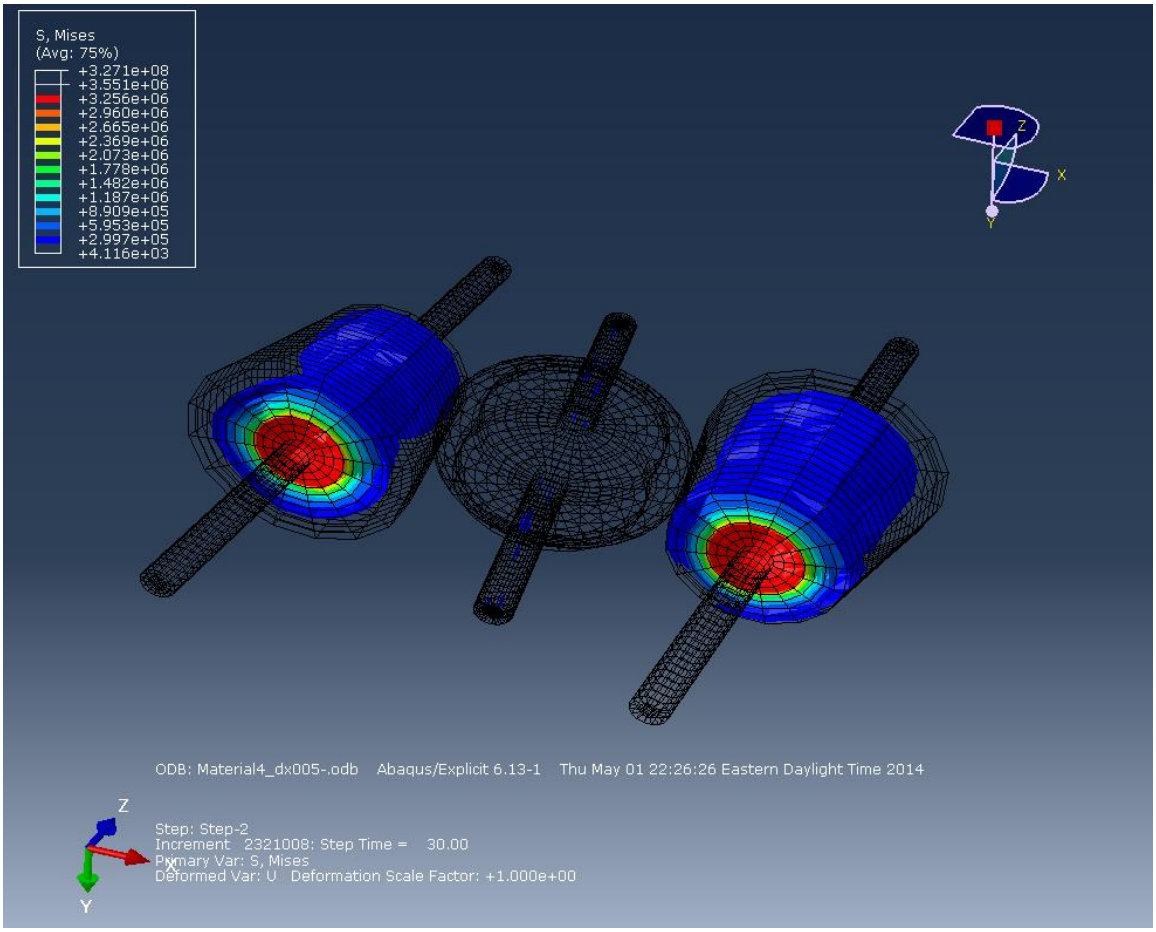


Figure 42: Contour plot of mises for Steel material with dx = 0.05 m at time step: 30.0 seconds

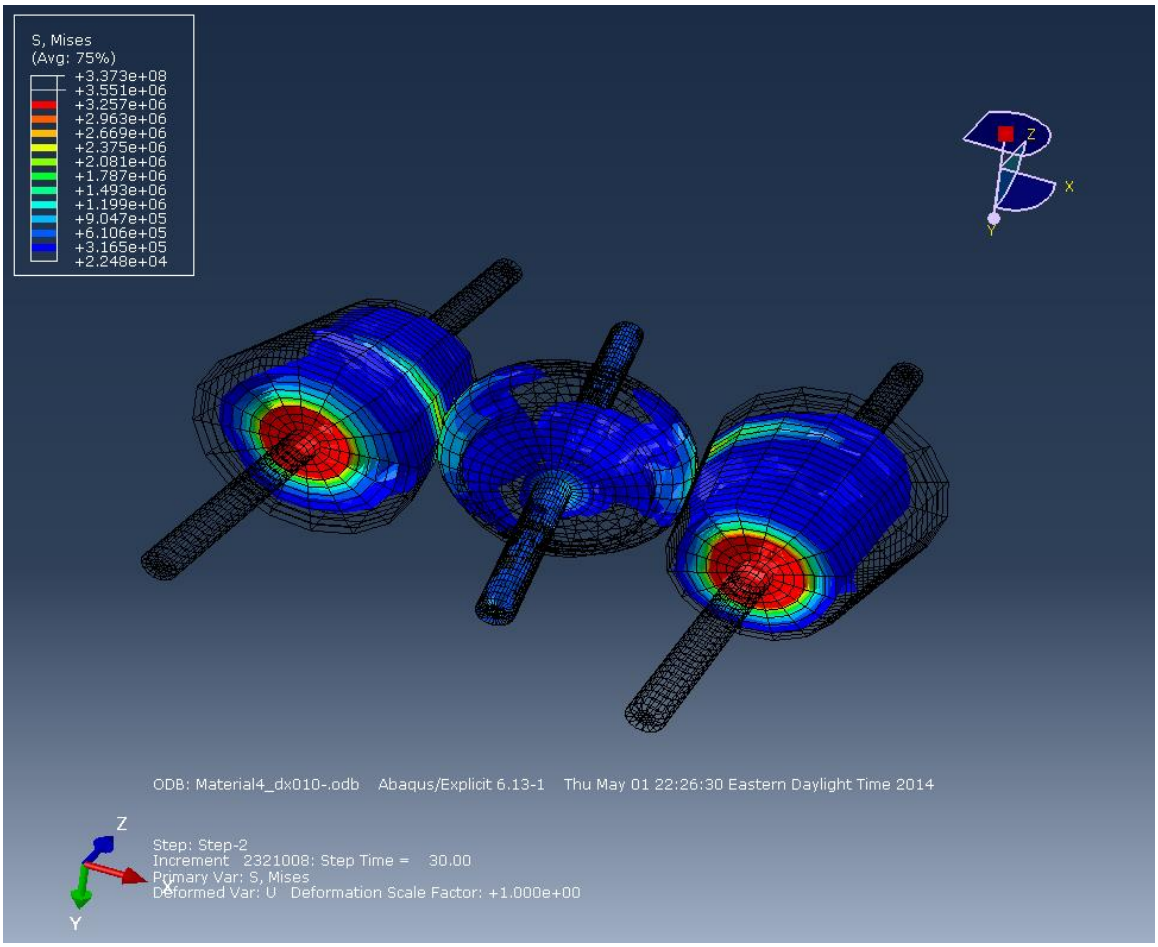


Figure 43: Contour plot of mises for Steel material with dx= 0.10 m at time step: 30.0 seconds

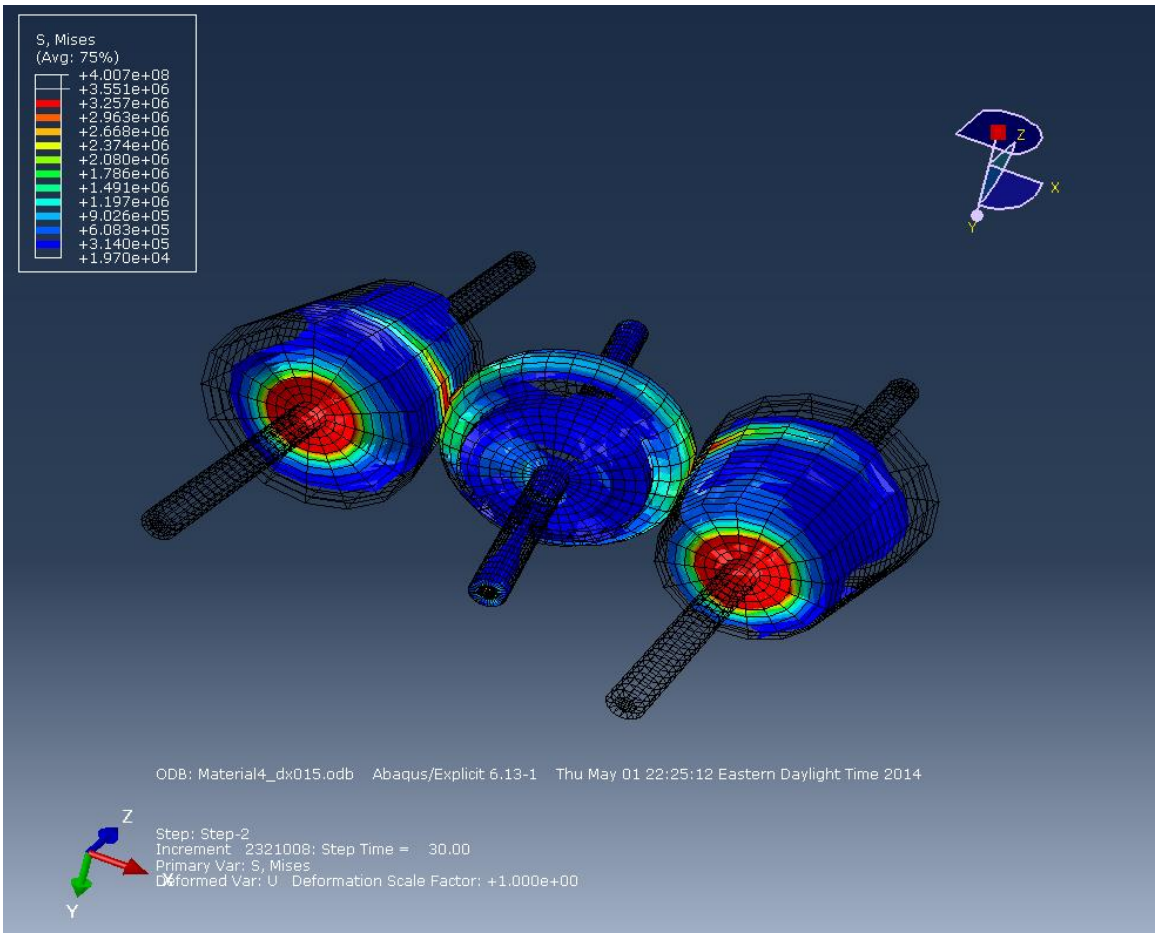


Figure 44: Contour plot of mises for Steel material with dx= 0.15 m at time step: 30.0 seconds

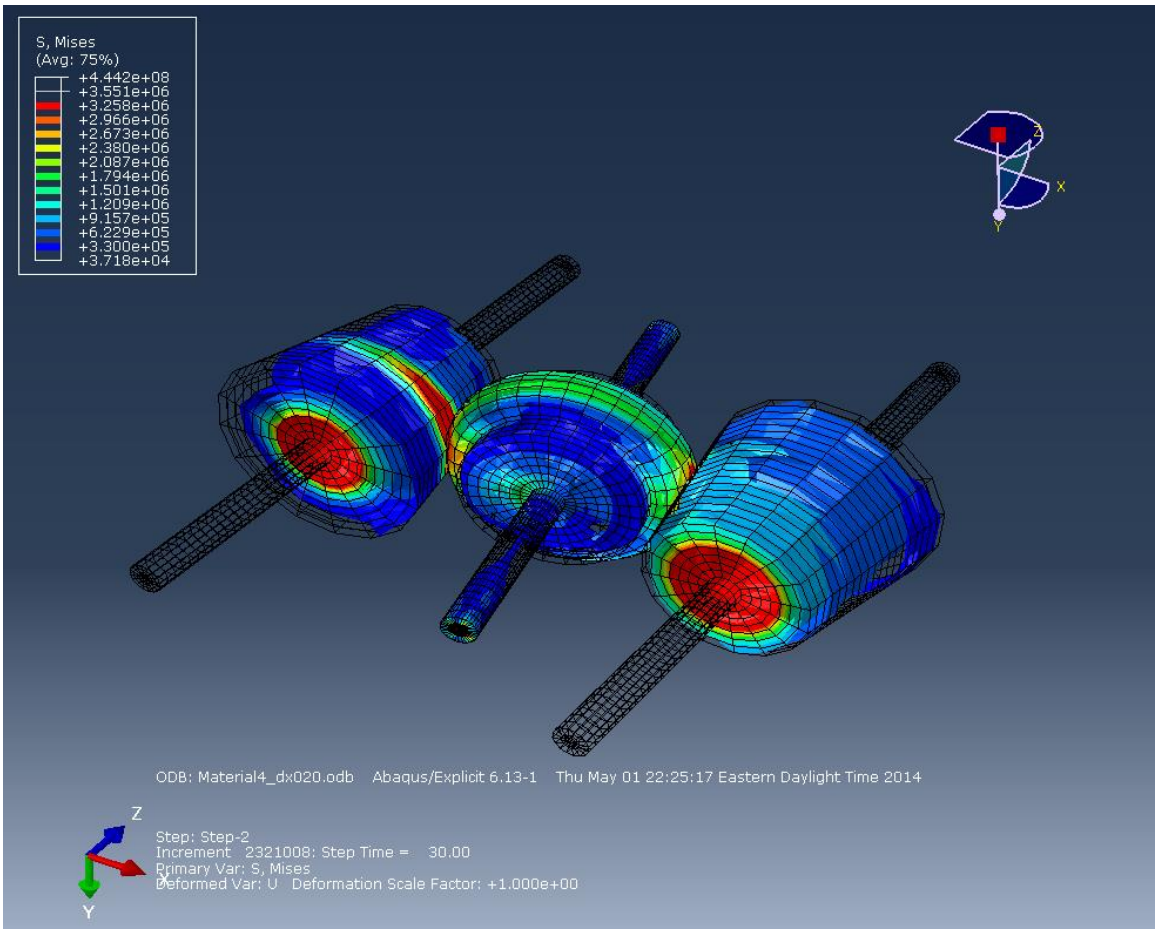


Figure 45: Contour plot of mises for Steel material with dx = 0.20 m at time step: 30.0 seconds

4.3.9 Comparison Plot for Steel Material

The results from the history output for a single element on the surface of cone 1 and cone 2 are shown in figure 46 comparing the change in overlap distance for steel material. A numerical plot of the change in overlap distance shows the increase in maximum von mises for the steel cone surface for the last 2 cycles. The maximum stress for steel material was about 8 MPa. Unlike aluminum material, steel material behaved unstable at the lowest overlap distance. The overlap distance above 0.10 show similar stress values in both cone 1 and cone 2.

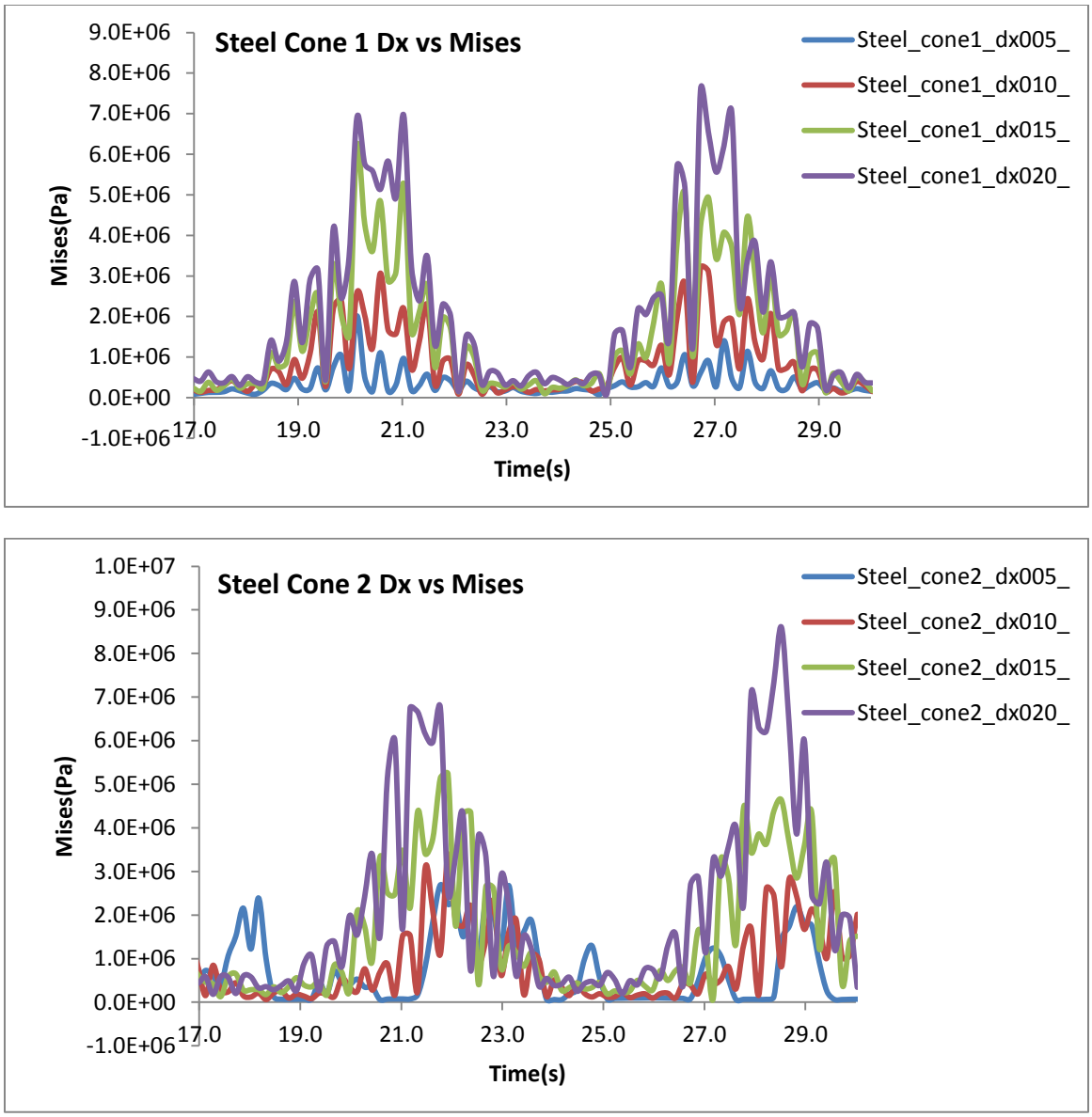


Figure 46: Comparison data for steel material with different overlapping distances for cone 1 and cone 2 for the last two cycles.

4.3.10 Contour Plot: Carbon Fiber Material

The results for carbon fiber material contour plots are shown in the figures below for the four overlapping distances, 0.05, 0.10, 0.15, and 0.20 m.(Figure 47-50) Carbon fiber material show the largest initial internal stress, having lower Young's modulus of steel and lower density than aluminum.

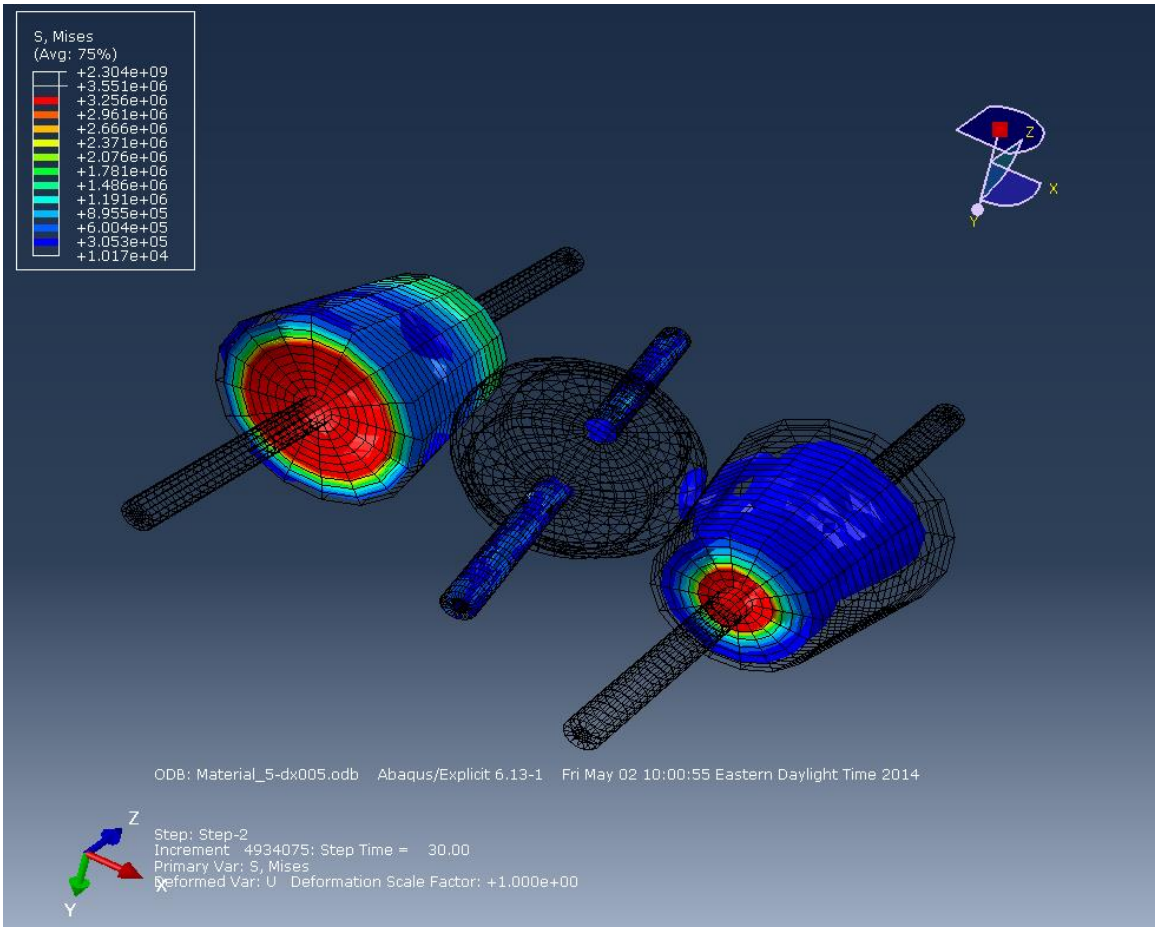


Figure 47: Contour Plot of mises for Carbon Fiber with dx= 0.05 m at time step: 30.0 seconds

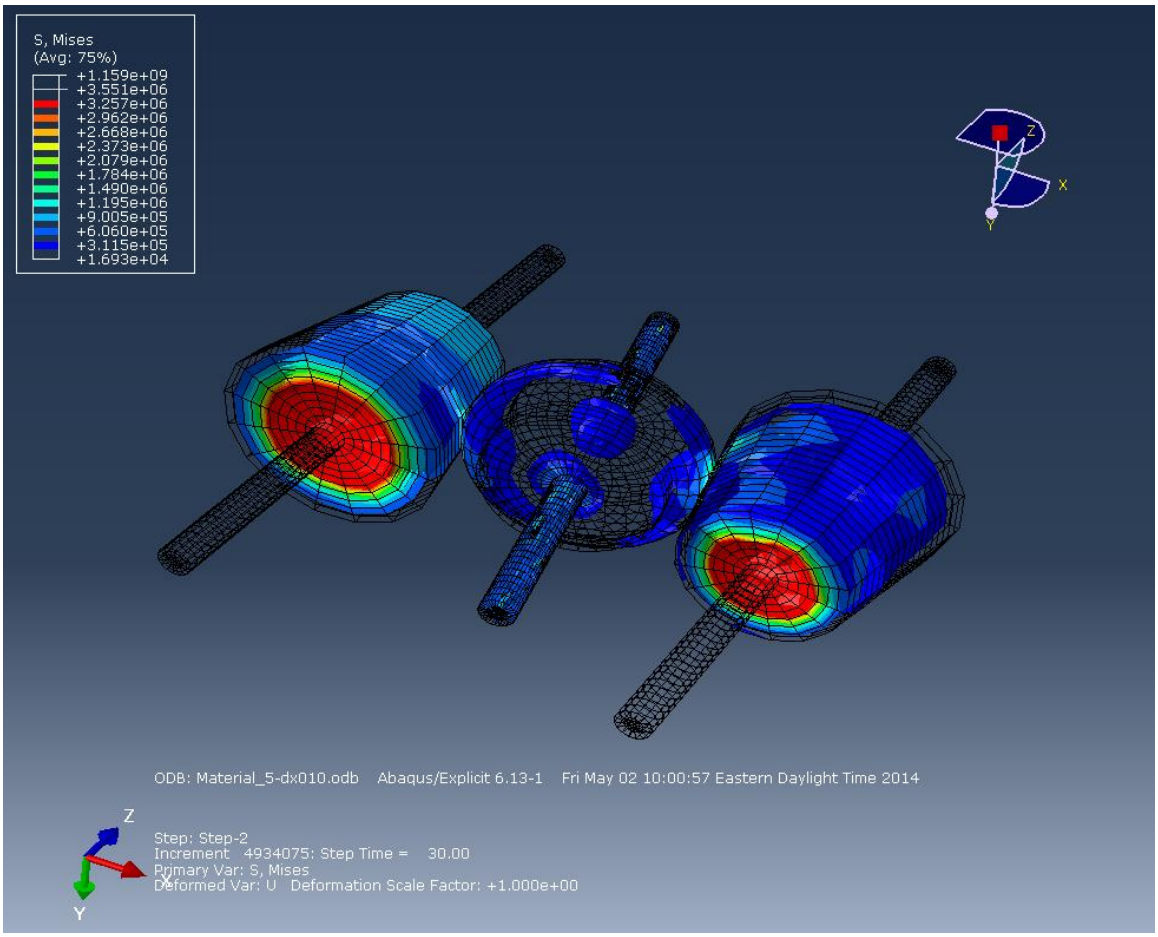


Figure 48: Contour Plot of mises for Carbon fiber with dx= 0.10 m at time step: 30.0 seconds

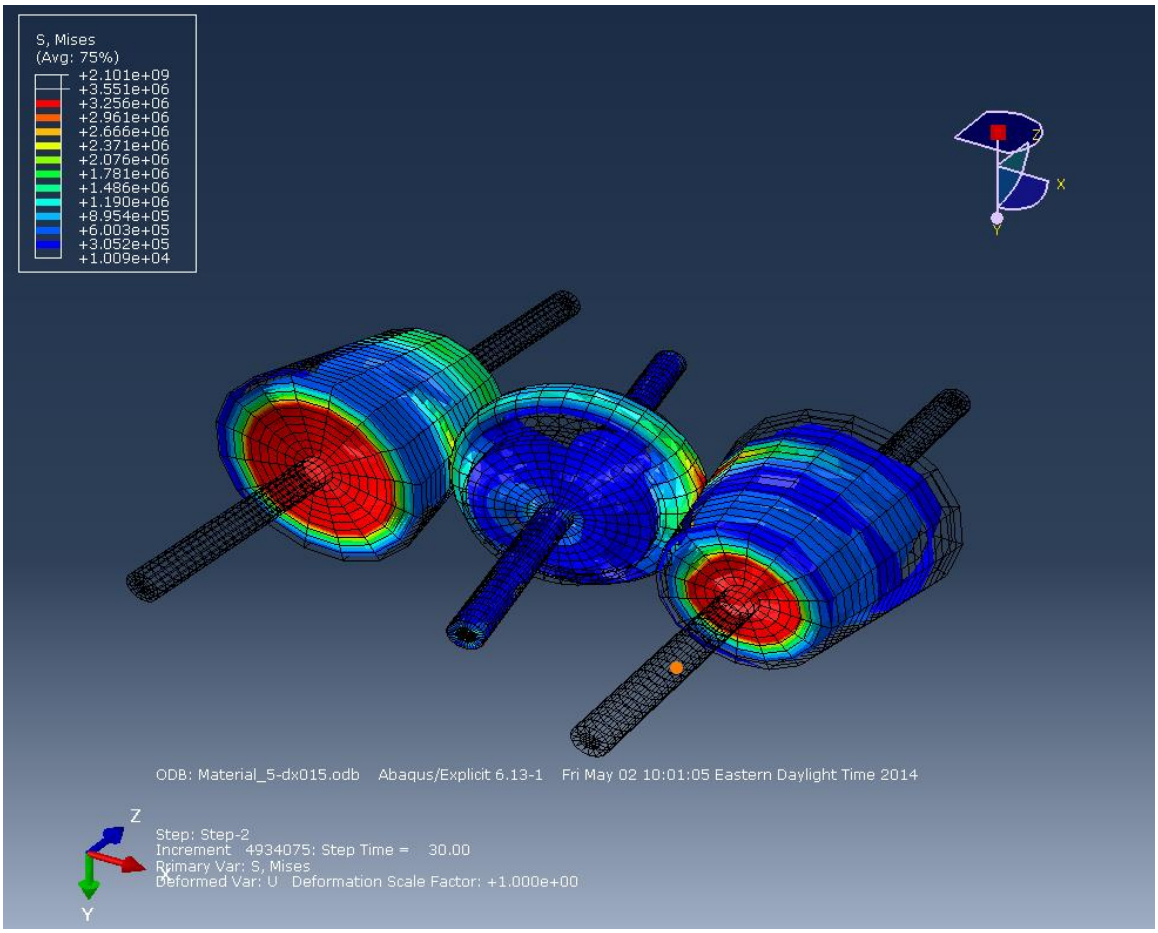


Figure 49: Contour Plot of mises for Carbon Fiber with dx = 0.15 m at time step: 30.0 seconds

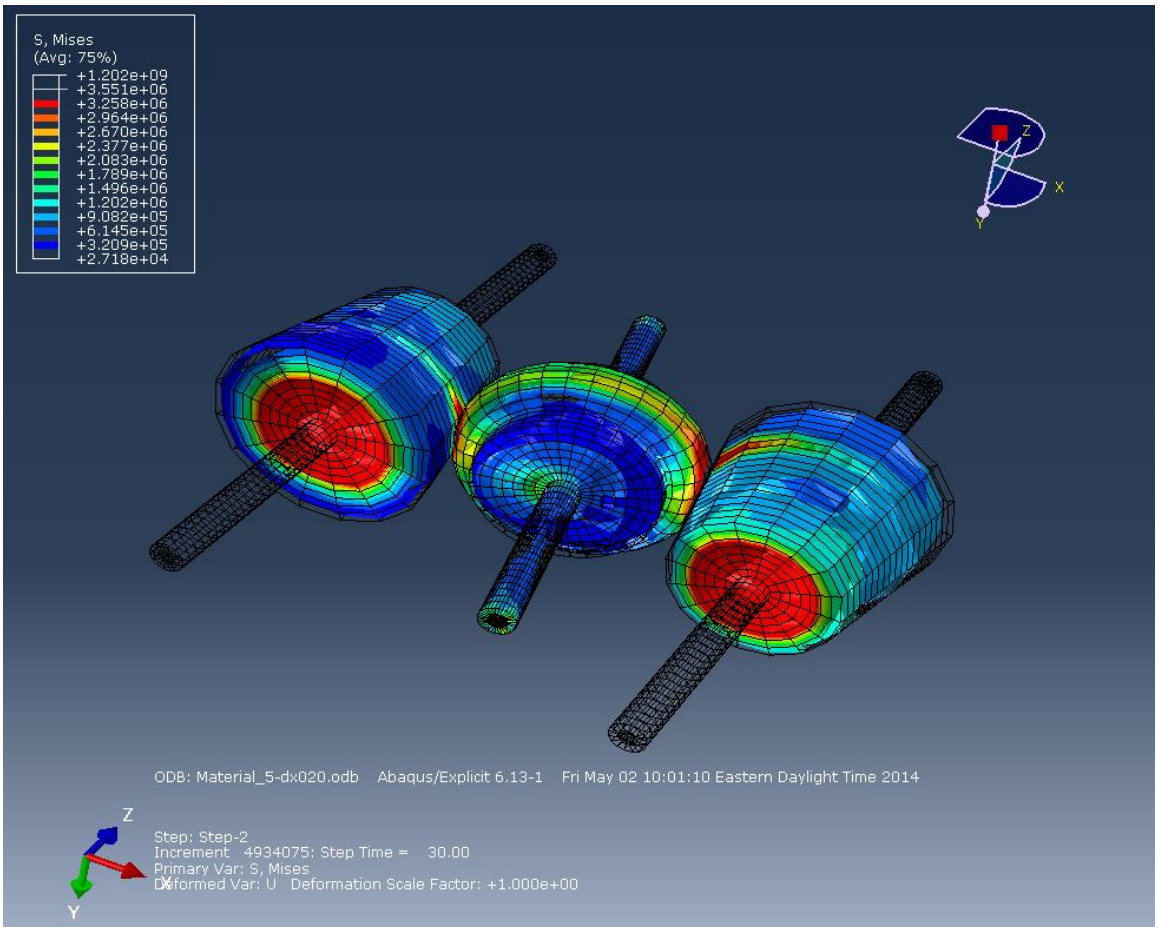
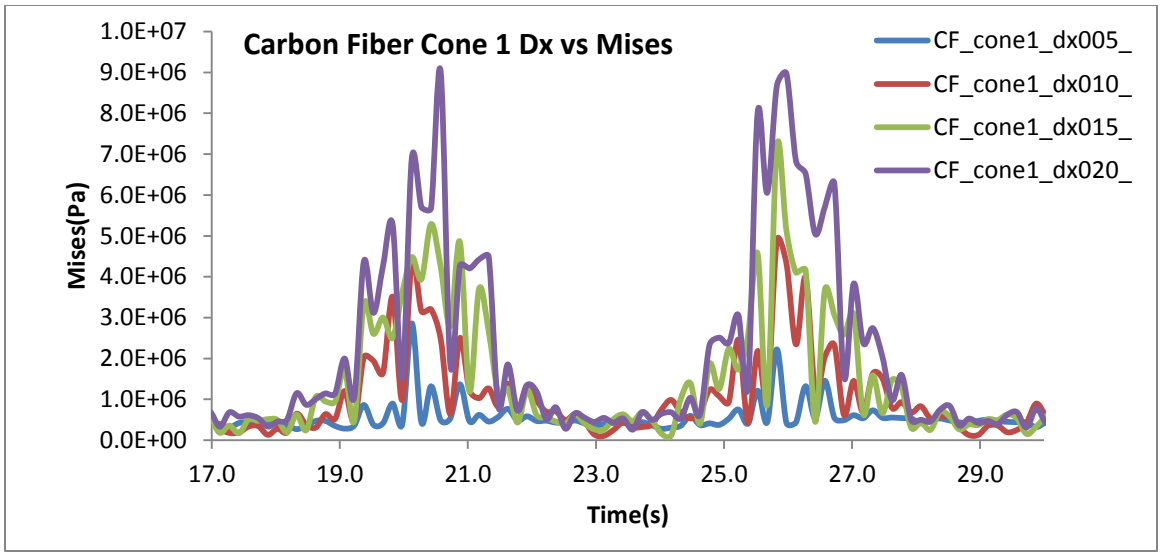


Figure 50: Contour Plot of mises for Carbon Fiber with dx= 0.20 m at time step: 30.0 seconds

4.3.11 Comparison Plot for Carbon Fiber Material

The results from the history output for a single element on the surface of cone 1 and cone 2 are shown in figure 51 comparing the change in overlap distance for steel material. A numerical plot of the change in overlap distance shows the increase in maximum mises for the carbon fiber cone surface for the last 2 cycles. Carbon fiber material showed to have the highest maximum von mises of 10 MPa. In cone 2 the first two overlapping distances have low surface to surface interaction, after overlap distances of 0.15 the stress become very similar to the values in cone 1. Carbon Fiber shows the highest von mises out of all the other materials tested.



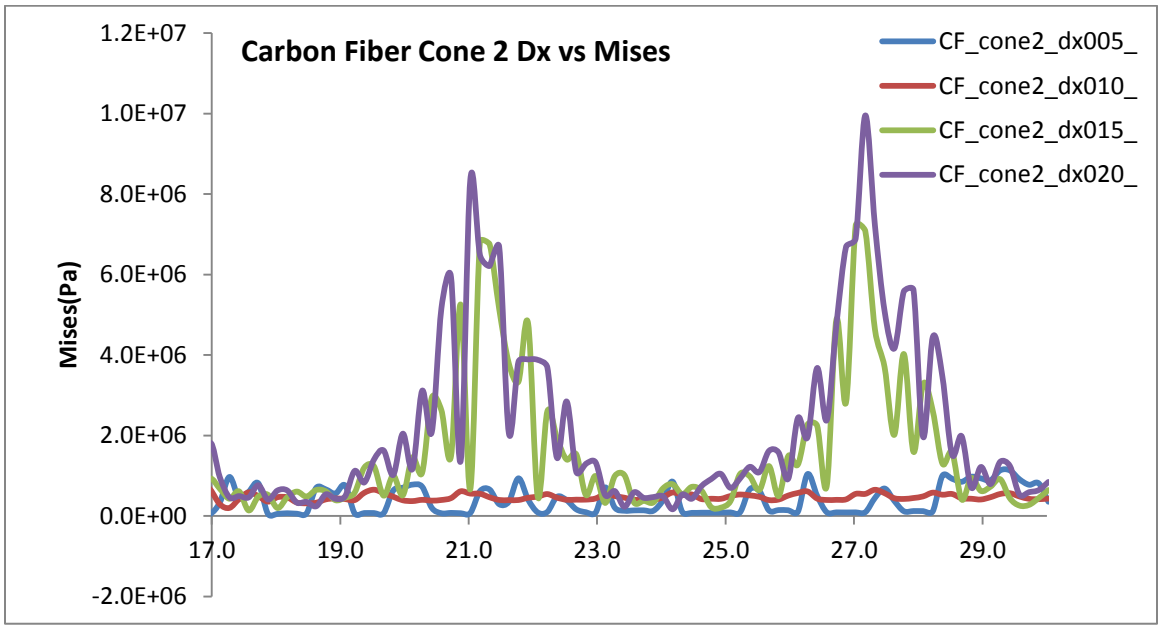
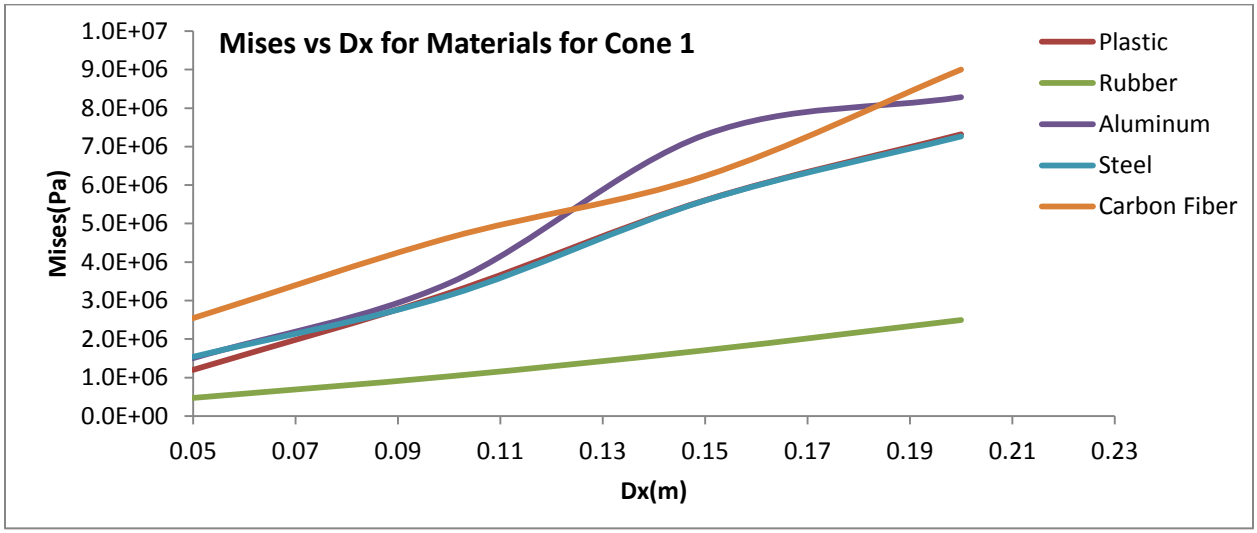


Figure 51: Comparison data for steel material with different overlapping distances for cone 1 and cone 2 for the last two cycles.

4.3.12 Comparison Plot for All Materials and Overlapping Distance

The results from all the materials can be compiled together for comparison, the overlapping distance and the mises for cone 1 and cone 2. The mises were taken at the maximum for the last two cycles at times: 19- 23s and 25-27s. The average of the two maximum mises would be used in the plot shown in figure 52. Rubber material showed the lowest von mises, whereas carbon fiber showed the largest von mises as overlap distance increased to 0.20. The carbon fiber material has the largest mises at the highest overlap distance in cone 1 and cone 2. In cone 1, aluminum has higher mises than carbon fiber but in cone 2, carbon fiber shows the higher mises at 0.15 m overlap distance. The rubber material in cone 1 and 2 show the lowest values of mises. Steel and plastic material show the same linear correlation as the overlap distance increases. Aluminum materials showed signs of plateauing after overlap distances of 0.20 for cone 1 and plateaus at 0.15 in cone 2. Carbon fiber showed to have the best material properties based on the outcome in Figure 52. Cone 2 was the driven cone which shows the materials ability to transfer the stress from the driving cone. Each material follows a difference path as overlap distance increases, thus each material has an optimal overlap distance for the CVT mechanism.



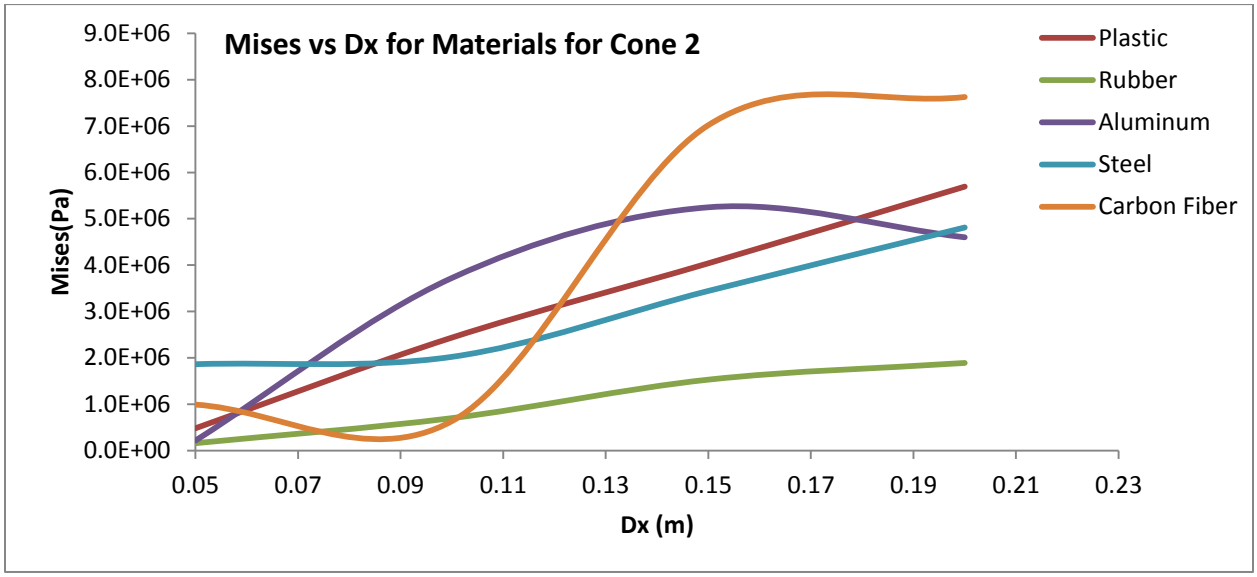


Figure 52: Comparison plots of materials, dx, and mises for cone 1 and cone 2.

4.4 Disscussion

The results from Abaqus using the different materials show the difference in stress on the cones for different overlapping distances. The materials were chosen for their differences in Young's Modulus, Poisson's Ratio, and density. An indirect change with material was the coefficient of friction with rubber. According the results larger Young's modulus increases the amount of stress generated from changing the overlapping distance. Density plays a role in normal forces made by the parts but more importantly in flapping wing MAVs the mass of the vehicle, smaller density materials makes for lighter vehicles.

The results from each contour plot shows increasing stress as the overlap distance was increased. The metal material and carbon fiber show a constant internal stress, shown most clearly on overlap distance of 0.05 m, this is most likely the resistance to deformation from the normal force of the contact surfaces, or could be an effect from the boundary condition that pinned the center of mass of the part. This was not of too much concern as it did not affect the surface interaction von mises. In figure 52 the comparison between materials in cone 2, shows carbon fiber having a higher mises than the other materials for overlapping distance of 0.15 and 0.20 m. Since cone 2 was the driven cone, the transferred stress would equate to the output shaft. The more stress on the cone means more torsion on the surface of the cone and would result in a larger torque and less slip; since torque is proportional to current in a motor, the motor can be selected from their rating. Where power is equal to torque multiplied by rotational speed and power is also equal to current multiplied by voltage, thus torque is proportional to current. Then obtaining a motor with a high enough rating to supply that power would be necessary. The results show that even with a high coefficient of friction, the material properties of Young's

modulus, Poisson's ratio and density play a bigger impact on the stress for the mechanism thus a larger torque generator. The next design would suggest the use of carbon fiber cones at overlapping distances of 0.15 mm – 0.20 mm or even the use of current plastic material but at the higher value of 0.20 mm or greater overlap distance. The results from Abaqus for plastic material shows a linear correlation as the overlap distance increased for both cone 1 and cone 2 in the CVT model. The results from the design of experiment lead to an area of optimization for the CVT design for micro air vehicles.

The results from the load cell were inconclusive. The design when using flapping wings has many factors that can inhibit the expected results in this case the forces generated from the wings moving the air flow behind the vehicle and to the side of the vehicle. The CVT design's mechanism was not generating enough torque to flap the wings at higher frequencies to generate enough force for the load cell to record significant differences. The design needs further development and one area of change was in material properties and the distance of overlap between the surfaces of the cone and counter rotor, by analyzing the use of different materials on a friction based mechanism an optimal material can be selected for the design. The CVT design can be optimized and implementing the system into a developed flapping mechanism would be ideal.

Chapter 5
Conclusion

In conclusion, the CVT design for variable speed in each wing has much more development and further research to investigate. The design using a CVT mechanism was developed proving the concept. Prototypes were fabricated for flapping wing MAV and iterated into a testing prototype. The method of analysis was the load cell, to measure the vehicles body forces in the x, y, z direction and the moments in the x, y z directions. Abaqus was used for the purpose of design optimization for different material and overlap distances between contacting surfaces. The initial design and optimization of the material properties for the parts and the distance of overlap between the surfaces of contacts plays a large role in the effectiveness of the design. The stress and pressure on the surfaces were determined by the normal force generated from the material and position of the parts in the CVT assembly. Unfortunately the results from load cell were inconclusive; the vehicle's flapping frequency was not high enough to generated significant forces to determine the resulting control mechanism. Abaqus's two simulations built up a model for the CVT mechanism. The test simulation resulted in showing the differences in coefficient of friction properties and the tangential velocities in the x and y directions reaction to the change, the larger coefficient of friction begins rotation earlier. The CVT simulation compared the different materials and overlap distances, determining carbon fiber to be the best material to use for the cone properties. Carbon fiber features a high Young's modulus and also a small density compared to the metal counterparts. The smaller density becomes more ideal since flapping wing MAVs have a large weight constraint. Future work on the CVT design for flapping wing MAVs suggests using optimal materials for high Young's modulus and low

density properties and the amount of overlap distance to generate the torque required to run the flapping mechanism and the wing loads for high frequency and high amplitudes. The CVT design features a method of phase shifting the wings that is a common feature in dragonfly flight with 2 pairs of wings. The CVT design can be used for reducing dragonfly model's that use 4 motors for the four wings.

Taking the results from Abaqus allows for better design and modeling of the mechanism that can be used for the CVT. This thesis presents a model for simulation to test the variables of material for the CVT cones and the overlapping distance between the surfaces of the cone and counter rotor for optimal design of a cone CVT mechanism on micro air vehicles to produce a control mechanism that can change the flapping frequency of each wing independently.

APPENDIX

Raw Data From Abaqus

Plastic Cone 1

Time(s)	dx005_mises(Pa)	dx010_mises(Pa)	dx015_mises(Pa)	dx020_mises(Pa)
2.50E-02	0	0	0	0.00E+00
1.75E-01	2.03E+05	4.32E+05	1.06E+06	1.52E+06
3.25E-01	2.64E+05	1.12E+06	1.94E+06	3.12E+06
4.75E-01	7.57E+05	1.37E+06	2.26E+06	3.41E+06
6.25E-01	2.19E+05	2.87E+05	8.95E+05	1.12E+06
7.75E-01	8.58E+05	2.35E+06	2.39E+06	4.64E+06
9.25E-01	2.84E+05	1.56E+06	1.55E+06	3.67E+06
1.07502	3.38E+05	1.53E+06	4.07E+06	4.56E+06
1.22501	1.48E+06	2.77E+06	3.75E+06	5.64E+06
1.37501	1.21E+05	9.85E+05	3.85E+06	5.92E+06
1.525	9.80E+05	1.98E+06	3.86E+06	6.82E+06
1.675	7.17E+05	1.78E+06	5.76E+06	6.87E+06
1.82503	1.62E+04	2.98E+05	6.10E+05	7.56E+05
1.97503	9.56E+05	2.45E+06	2.89E+06	5.16E+06
2.12501	1.48E+05	1.12E+06	2.51E+06	4.16E+06
2.27501	9.31E+04	8.94E+05	1.22E+06	1.33E+06
2.42501	6.10E+05	1.67E+06	2.03E+06	2.95E+06
2.575	9.30E+04	5.19E+05	1.13E+06	1.71E+06
2.725	2.16E+05	7.01E+05	1.51E+06	1.43E+06
2.875	2.08E+05	7.31E+05	1.72E+06	1.78E+06
3.02503	6.00E+04	1.12E+05	2.88E+05	3.56E+05
3.17503	1.96E+05	5.59E+05	9.08E+05	1.28E+06
3.32503	6.83E+04	3.20E+05	7.93E+05	9.83E+05
3.47502	2.09E+04	1.85E+05	2.10E+05	3.41E+05
3.62502	1.09E+05	3.94E+05	4.20E+05	7.57E+05
3.77502	3.32E+04	1.59E+05	2.83E+05	4.86E+05
3.92502	1.70E+04	7.38E+04	1.61E+05	2.25E+05
4.07501	4.32E+04	1.26E+05	2.59E+05	3.21E+05
4.22501	1.17E+04	5.11E+04	1.63E+05	2.67E+05

4.37501	4.78E+04	1.42E+05	3.43E+05	4.29E+05
4.52501	2.08E+04	8.52E+04	2.82E+05	4.25E+05
4.67501	3.04E+04	1.14E+05	2.20E+05	3.90E+05
4.825	4.45E+04	1.45E+05	2.70E+05	4.95E+05
4.975	1.55E+04	5.14E+04	1.31E+05	2.89E+05
5.12503	2.73E+04	1.26E+05	1.58E+05	2.92E+05
5.27503	2.87E+04	1.14E+05	1.36E+05	2.48E+05
5.42503	2.54E+04	1.57E+05	3.68E+05	5.17E+05
5.57502	9.92E+04	2.51E+05	5.59E+05	6.27E+05
5.72502	3.61E+04	5.10E+04	1.67E+05	2.26E+05
5.87502	1.31E+05	4.73E+05	7.12E+05	1.10E+06
6.02502	1.16E+05	5.01E+05	6.27E+05	1.15E+06
6.17501	1.37E+04	3.11E+05	7.38E+05	1.16E+06
6.32501	3.00E+05	9.40E+05	2.11E+06	2.18E+06
6.47501	7.04E+04	1.83E+05	5.46E+05	4.98E+05
6.62501	4.22E+05	1.50E+06	1.86E+06	3.42E+06
6.77501	4.26E+05	1.75E+06	1.56E+06	3.55E+06
6.925	2.85E+04	5.10E+05	1.61E+06	2.74E+06
7.075	9.07E+05	2.08E+06	4.37E+06	3.73E+06
7.22503	9.63E+04	5.44E+05	1.29E+06	1.57E+06
7.37503	4.87E+05	2.48E+06	3.86E+06	6.38E+06
7.52503	8.60E+05	3.05E+06	4.28E+06	5.70E+06
7.67502	1.69E+04	1.15E+06	3.22E+06	4.93E+06
7.82502	9.83E+05	2.95E+06	3.68E+06	5.95E+06
7.97502	4.24E+05	2.31E+06	3.58E+06	7.44E+06
8.12502	5.66E+04	6.98E+05	1.93E+06	1.49E+06
8.27501	8.58E+05	1.73E+06	3.81E+06	3.76E+06
8.42501	8.04E+04	6.20E+05	1.67E+06	2.73E+06
8.57501	3.11E+05	1.13E+06	2.12E+06	2.17E+06
8.72501	3.86E+05	1.40E+06	2.76E+06	2.72E+06
8.87501	4.17E+04	1.94E+05	4.32E+05	6.69E+05
9.025	3.23E+05	1.11E+06	1.18E+06	2.29E+06
9.175	1.43E+05	8.14E+05	1.12E+06	2.03E+06
9.32503	1.89E+04	1.38E+05	3.88E+05	2.93E+05
9.47503	2.05E+05	5.44E+05	9.60E+05	1.16E+06
9.62503	4.22E+04	2.45E+05	4.95E+05	7.39E+05
9.77502	6.20E+04	1.96E+05	4.67E+05	3.74E+05
9.92502	7.70E+04	2.67E+05	6.45E+05	6.23E+05
10.075	2.17E+04	6.97E+04	2.24E+05	3.10E+05
10.225	3.54E+04	1.27E+05	1.87E+05	2.94E+05
10.375	2.38E+04	1.26E+05	2.23E+05	3.46E+05
10.525	1.44E+04	8.22E+04	1.71E+05	2.89E+05
10.675	4.20E+04	1.58E+05	2.55E+05	5.08E+05

10.825	1.33E+04	9.43E+04	2.24E+05	4.53E+05
10.975	4.12E+04	1.06E+05	2.85E+05	3.63E+05
11.125	2.70E+04	1.04E+05	2.50E+05	3.90E+05
11.275	8.45E+03	4.40E+04	1.28E+05	2.34E+05
11.425	3.98E+04	1.24E+05	2.50E+05	2.55E+05
11.575	1.88E+04	8.77E+04	2.11E+05	2.59E+05
11.725	5.41E+04	2.29E+05	4.03E+05	6.69E+05
11.875	9.49E+04	3.66E+05	4.45E+05	7.21E+05
12.025	2.49E+04	6.60E+04	1.66E+05	4.75E+05
12.175	2.13E+05	4.64E+05	8.45E+05	1.33E+06
12.325	8.90E+04	3.25E+05	4.76E+05	1.01E+06
12.475	1.08E+05	4.81E+05	1.16E+06	1.38E+06
12.625	3.46E+05	9.12E+05	1.97E+06	1.50E+06
12.775	5.34E+04	5.76E+04	3.76E+05	1.94E+05
12.925	4.82E+05	1.51E+06	2.47E+06	3.37E+06
13.075	2.30E+05	1.07E+06	1.87E+06	2.73E+06
13.225	1.40E+04	9.48E+05	2.33E+06	3.30E+06
13.375	1.00E+06	2.29E+06	4.35E+06	3.74E+06
13.525	5.85E+04	2.54E+05	4.26E+05	6.98E+05
13.675	1.19E+06	2.91E+06	4.07E+06	6.58E+06
13.825	7.96E+05	2.92E+06	3.53E+06	7.56E+06
13.975	4.24E+04	1.30E+06	3.10E+06	4.84E+06
14.125	1.32E+06	2.65E+06	5.46E+06	6.69E+06
14.275	7.56E+04	1.15E+06	3.13E+06	5.52E+06
14.425	3.27E+05	1.40E+06	2.34E+06	3.23E+06
14.575	8.72E+05	2.53E+06	3.50E+06	4.52E+06
14.725	6.62E+04	5.04E+05	1.06E+06	1.46E+06
14.875	4.43E+05	1.05E+06	2.21E+06	3.41E+06
15.025	2.32E+05	9.90E+05	1.98E+06	3.74E+06
15.175	2.33E+04	1.74E+05	3.83E+05	5.95E+05
15.325	3.91E+05	9.68E+05	1.97E+06	1.68E+06
15.475	9.40E+04	4.90E+05	1.18E+06	1.67E+06
15.625	4.55E+04	3.43E+05	4.62E+05	6.00E+05
15.775	1.70E+05	6.27E+05	9.62E+05	9.85E+05
15.925	3.24E+04	1.89E+05	4.13E+05	4.34E+05
16.075	9.30E+04	2.23E+05	3.48E+05	6.95E+05
16.225	5.80E+04	2.27E+05	4.02E+05	7.62E+05
16.375	1.18E+04	4.22E+04	9.59E+04	2.44E+05
16.525	4.12E+04	1.14E+05	2.66E+05	3.09E+05
16.675	2.05E+04	7.77E+04	2.03E+05	3.16E+05
16.825	1.83E+04	1.07E+05	1.93E+05	3.18E+05
16.975	3.45E+04	1.53E+05	3.07E+05	4.36E+05
17.125	1.21E+04	8.28E+04	2.35E+05	4.08E+05

17.275	4.70E+04	1.43E+05	2.01E+05	4.15E+05
17.425	2.02E+04	9.03E+04	1.85E+05	3.65E+05
17.575	9.17E+03	5.64E+04	1.24E+05	2.13E+05
17.725	4.17E+04	9.68E+04	2.22E+05	3.46E+05
17.875	1.73E+04	5.71E+04	1.74E+05	3.43E+05
18.025	6.78E+04	2.73E+05	5.34E+05	6.11E+05
18.175	7.26E+04	2.77E+05	5.92E+05	6.30E+05
18.325	1.53E+04	1.46E+05	3.07E+05	5.65E+05
18.475	2.36E+05	6.27E+05	8.40E+05	9.24E+05
18.625	6.99E+04	2.71E+05	4.69E+05	5.00E+05
18.775	1.41E+05	6.09E+05	1.15E+06	2.05E+06
18.925	2.63E+05	6.82E+05	1.05E+06	1.93E+06
19.075	3.74E+04	3.45E+05	8.30E+05	1.14E+06
19.225	6.12E+05	1.37E+06	2.75E+06	3.55E+06
19.375	1.35E+05	3.81E+05	9.65E+05	1.45E+06
19.525	2.66E+05	1.79E+06	2.87E+06	3.56E+06
19.675	6.81E+05	2.36E+06	3.38E+06	2.89E+06
19.825	3.78E+04	7.44E+05	2.12E+06	2.21E+06
19.975	1.16E+06	2.74E+06	3.45E+06	5.13E+06
20.125	1.01E+05	1.87E+06	3.57E+06	4.75E+06
20.275	2.60E+05	1.60E+06	3.57E+06	4.50E+06
20.425	1.13E+06	2.06E+06	4.87E+06	6.58E+06
20.575	4.39E+04	1.20E+06	2.21E+06	5.11E+06
20.725	4.00E+05	1.62E+06	2.43E+06	4.35E+06
20.875	4.75E+05	1.63E+06	2.82E+06	5.02E+06
21.025	3.86E+04	2.08E+05	4.55E+05	6.72E+05
21.175	4.97E+05	1.68E+06	3.15E+06	3.45E+06
21.325	1.23E+05	8.45E+05	2.28E+06	3.32E+06
21.475	3.59E+04	5.13E+05	6.64E+05	1.03E+06
21.625	3.48E+05	1.08E+06	1.40E+06	1.85E+06
21.775	6.00E+04	3.36E+05	7.21E+05	1.15E+06
21.925	1.13E+05	4.67E+05	8.32E+05	1.12E+06
22.075	1.20E+05	4.42E+05	9.34E+05	1.27E+06
22.225	2.30E+04	8.29E+04	2.18E+05	2.74E+05
22.375	1.12E+05	3.62E+05	5.60E+05	6.35E+05
22.525	3.93E+04	1.94E+05	4.40E+05	6.39E+05
22.675	8.36E+03	5.07E+04	1.18E+05	2.30E+05
22.825	4.42E+04	1.30E+05	2.02E+05	2.74E+05
22.975	1.61E+04	7.68E+04	1.54E+05	2.54E+05
23.125	3.10E+04	1.02E+05	1.98E+05	4.02E+05
23.275	2.52E+04	1.04E+05	2.59E+05	4.63E+05
23.425	1.35E+04	9.36E+04	2.31E+05	3.96E+05
23.575	3.25E+04	1.58E+05	2.97E+05	4.45E+05

23.725	1.47E+04	7.68E+04	1.73E+05	3.16E+05
23.875	1.45E+04	8.19E+04	1.54E+05	2.29E+05
24.025	4.01E+04	1.37E+05	2.12E+05	2.68E+05
24.175	1.45E+04	9.79E+04	2.62E+05	4.42E+05
24.325	9.33E+04	2.47E+05	4.04E+05	6.20E+05
24.475	4.38E+04	1.28E+05	2.65E+05	3.57E+05
24.625	4.24E+04	3.14E+05	6.30E+05	8.70E+05
24.775	2.01E+05	5.67E+05	1.04E+06	1.36E+06
24.925	4.90E+04	8.03E+04	1.39E+05	3.47E+05
25.075	2.46E+05	1.09E+06	1.65E+06	2.16E+06
25.225	1.64E+05	7.82E+05	1.50E+06	2.03E+06
25.375	7.48E+04	6.07E+05	1.35E+06	1.95E+06
25.525	6.14E+05	1.48E+06	1.87E+06	2.12E+06
25.675	7.24E+04	2.07E+05	4.81E+05	3.00E+05
25.825	5.70E+05	1.71E+06	3.39E+06	4.79E+06
25.975	4.42E+05	1.39E+06	1.97E+06	2.53E+06
26.125	2.40E+04	9.75E+05	2.85E+06	4.51E+06
26.275	1.24E+06	3.65E+06	6.35E+06	8.06E+06
26.425	4.06E+04	8.93E+05	3.25E+06	5.14E+06
26.575	5.41E+05	2.45E+06	4.26E+06	6.81E+06
26.725	1.00E+06	2.79E+06	4.73E+06	6.45E+06
26.875	2.59E+04	3.44E+05	4.65E+05	1.49E+06
27.025	6.49E+05	1.63E+06	2.43E+06	2.61E+06
27.175	2.07E+05	1.14E+06	2.53E+06	3.62E+06
27.325	2.47E+04	4.76E+05	1.04E+06	1.26E+06
27.475	5.33E+05	1.54E+06	2.47E+06	3.28E+06
27.625	8.70E+04	4.97E+05	1.44E+06	1.97E+06
27.775	1.41E+05	6.74E+05	9.97E+05	1.34E+06
27.925	2.55E+05	7.40E+05	1.32E+06	1.79E+06
28.075	3.76E+04	1.15E+05	3.00E+05	5.02E+05
28.225	1.50E+05	6.55E+05	1.13E+06	1.45E+06
28.375	7.26E+04	4.61E+05	1.05E+06	1.39E+06
28.525	1.59E+04	1.16E+05	2.00E+05	2.73E+05
28.675	7.45E+04	3.19E+05	4.43E+05	5.67E+05
28.825	1.96E+04	1.32E+05	3.01E+05	4.91E+05
28.975	2.53E+04	8.58E+04	1.88E+05	2.54E+05
29.125	4.63E+04	1.58E+05	3.11E+05	3.83E+05
29.275	1.56E+04	6.77E+04	1.68E+05	3.01E+05
29.425	3.46E+04	1.50E+05	2.78E+05	4.57E+05
29.575	2.13E+04	1.11E+05	2.58E+05	4.91E+05
29.725	2.10E+04	9.28E+04	2.28E+05	3.61E+05
29.875	2.69E+04	1.04E+05	2.07E+05	3.15E+05
30.025	8.66E+03	3.83E+04	1.04E+05	2.06E+05

Plastic Cone 2

Time(s)	dx005_mises(Pa)	dx010_mises(Pa)	dx015_mises(Pa)	dx020_mises(Pa)
2.50E-02	0	0	0	0
1.75E-01	4.26E+05	7.92E+05	1.15E+06	1.44E+06
3.25E-01	3.58E+05	9.26E+05	1.48E+06	1.23E+06
4.75E-01	3.40E+05	1.34E+05	1.22E+06	1.96E+06
6.25E-01	1.83E+05	7.78E+05	1.41E+06	1.42E+06
7.75E-01	7.13E+04	7.83E+05	5.01E+05	1.74E+06
9.25E-01	7.09E+04	3.74E+05	2.77E+06	3.69E+06
1.07502	8.89E+04	1.64E+06	1.73E+06	1.16E+06
1.22501	9.78E+04	7.14E+05	2.61E+06	4.56E+06
1.37501	3.17E+05	1.69E+06	3.71E+06	4.25E+06
1.525	3.78E+05	2.37E+06	4.94E+05	5.89E+06
1.675	1.03E+05	2.18E+05	3.75E+06	4.82E+06
1.82503	5.09E+04	2.42E+06	3.51E+06	4.94E+06
1.97503	2.71E+05	2.13E+06	2.73E+06	5.86E+06
2.12501	5.16E+05	1.12E+06	5.08E+06	7.32E+06
2.27501	9.02E+04	2.98E+06	4.19E+06	1.97E+06
2.42501	1.15E+05	1.34E+06	1.58E+06	2.48E+06
2.575	7.02E+05	1.25E+06	2.73E+06	4.09E+06
2.725	3.16E+04	1.92E+06	2.00E+06	1.33E+06
2.875	5.02E+05	3.71E+05	2.49E+06	3.70E+06
3.02503	4.89E+05	1.51E+06	3.00E+06	3.47E+06
3.17503	8.49E+03	1.59E+06	6.82E+05	1.09E+06
3.32503	8.80E+05	1.48E+05	1.57E+06	2.50E+06
3.47502	6.28E+04	1.15E+06	1.60E+06	1.88E+06
3.62502	3.32E+04	6.65E+05	2.91E+05	7.07E+05
3.77502	8.50E+05	2.25E+05	8.04E+05	1.11E+06
3.92502	8.66E+04	5.33E+05	6.38E+05	7.00E+05
4.07501	9.92E+04	2.18E+05	3.15E+05	5.39E+05
4.22501	3.33E+05	2.61E+05	5.63E+05	6.12E+05
4.37501	3.56E+04	3.42E+05	2.50E+05	1.70E+05
4.52501	2.55E+05	5.50E+04	2.23E+05	4.03E+05
4.67501	1.27E+05	1.65E+05	3.15E+05	3.84E+05

4.825	1.92E+04	1.63E+05	1.52E+05	3.14E+05
4.975	1.88E+05	5.80E+04	2.27E+05	5.18E+05
5.12503	5.99E+04	1.21E+05	2.42E+05	4.41E+05
5.27503	1.85E+04	8.45E+04	1.76E+05	2.63E+05
5.42503	7.98E+04	8.72E+04	1.85E+05	2.01E+05
5.57502	1.54E+04	7.30E+04	8.95E+04	1.40E+05
5.72502	3.11E+04	3.91E+04	2.36E+05	3.41E+05
5.87502	3.12E+04	1.57E+05	2.87E+05	2.98E+05
6.02502	1.40E+04	1.54E+05	2.81E+05	7.20E+05
6.17501	3.57E+04	1.79E+05	6.52E+05	9.80E+05
6.32501	1.91E+04	3.97E+05	5.28E+05	1.09E+05
6.47501	2.01E+04	1.43E+05	4.87E+05	1.14E+06
6.62501	2.87E+04	3.68E+05	7.86E+05	1.32E+06
6.77501	8.61E+03	4.51E+05	1.78E+05	1.08E+06
6.925	2.74E+04	2.31E+05	1.20E+06	1.69E+06
7.075	3.26E+04	9.56E+05	9.01E+05	1.36E+06
7.22503	1.23E+04	3.78E+05	1.39E+06	2.35E+06
7.37503	1.05E+05	1.12E+06	2.61E+06	1.78E+06
7.52503	4.08E+04	1.80E+06	3.66E+05	1.81E+06
7.67502	6.41E+04	1.93E+05	3.66E+06	5.24E+06
7.82502	1.76E+05	2.46E+06	3.67E+06	2.55E+06
7.97502	3.40E+04	1.45E+06	2.24E+06	6.27E+06
8.12502	2.44E+05	1.74E+06	4.26E+06	6.09E+06
8.27501	1.82E+05	2.09E+06	3.88E+06	5.46E+06
8.42501	2.79E+04	9.83E+05	3.99E+06	5.16E+06
8.57501	5.87E+05	2.05E+06	2.84E+06	6.22E+06
8.72501	7.74E+04	2.68E+06	3.44E+06	3.02E+06
8.87501	3.06E+05	1.64E+05	2.61E+06	2.64E+06
9.025	5.40E+05	2.40E+06	3.23E+06	3.43E+06
9.175	2.74E+04	1.89E+06	5.49E+05	1.03E+06
9.32503	9.47E+05	5.90E+05	1.95E+06	3.42E+06
9.47503	5.82E+04	1.65E+06	1.73E+06	2.40E+06
9.62503	4.05E+03	6.72E+05	7.29E+05	1.19E+06
9.77502	1.04E+06	6.96E+05	1.96E+06	1.75E+06
9.92502	5.87E+04	1.21E+06	1.18E+06	6.60E+05
10.075	1.84E+05	2.88E+05	7.91E+05	1.60E+06
10.225	4.52E+05	5.05E+05	1.23E+06	1.67E+06
10.375	2.92E+04	4.72E+05	5.61E+05	2.83E+05
10.525	4.24E+05	8.83E+04	3.51E+05	6.32E+05
10.675	2.65E+05	3.62E+05	3.97E+05	6.92E+05
10.825	3.52E+04	1.72E+05	1.02E+05	2.37E+05
10.975	3.61E+05	7.42E+04	2.92E+05	3.42E+05
11.125	6.80E+04	1.90E+05	2.75E+05	3.17E+05

11.275	7.06E+04	1.05E+05	1.42E+05	3.63E+05
11.425	1.95E+05	9.44E+04	3.18E+05	5.25E+05
11.575	4.07E+04	1.02E+05	2.72E+05	3.69E+05
11.725	5.70E+04	8.32E+04	1.69E+05	3.36E+05
11.875	5.11E+04	1.24E+05	1.58E+05	2.66E+05
12.025	6.62E+03	5.63E+04	8.22E+04	2.48E+05
12.175	4.78E+04	9.56E+04	2.28E+05	3.42E+05
12.325	2.44E+04	1.95E+05	1.88E+05	2.95E+05
12.475	2.08E+04	1.08E+05	4.38E+05	5.91E+05
12.625	3.65E+04	2.49E+05	7.33E+05	5.06E+05
12.775	1.49E+04	2.66E+05	2.56E+05	4.36E+04
12.925	3.43E+04	1.27E+05	7.77E+05	1.25E+06
13.075	2.07E+04	4.70E+05	1.03E+06	7.03E+05
13.225	6.88E+03	2.02E+05	4.62E+05	1.85E+06
13.375	4.38E+04	7.37E+05	1.28E+06	2.73E+06
13.525	2.54E+04	1.08E+06	9.22E+05	4.67E+05
13.675	4.17E+04	6.41E+04	1.71E+06	2.84E+06
13.825	1.09E+05	1.70E+06	2.07E+06	2.72E+06
13.975	2.71E+04	1.10E+06	1.08E+05	2.46E+06
14.125	1.57E+05	1.02E+06	4.09E+06	3.44E+06
14.275	1.04E+05	1.91E+06	3.36E+06	2.08E+06
14.425	1.88E+04	1.91E+05	3.79E+06	5.88E+06
14.575	3.93E+05	2.33E+06	4.51E+06	5.08E+06
14.725	6.62E+04	1.78E+06	3.85E+06	4.59E+06
14.875	3.18E+05	8.33E+05	3.53E+06	6.30E+06
15.025	2.43E+05	3.31E+06	3.94E+06	8.58E+06
15.175	2.29E+04	1.84E+06	2.75E+06	1.43E+06
15.325	7.61E+05	9.56E+05	2.39E+06	4.33E+06
15.475	7.38E+04	2.45E+06	2.61E+06	4.95E+06
15.625	3.52E+05	7.52E+05	6.28E+05	1.44E+06
15.775	7.31E+05	1.02E+06	2.88E+06	2.73E+06
15.925	1.18E+04	1.16E+06	2.35E+06	2.55E+06
16.075	8.47E+05	2.37E+05	8.68E+05	1.16E+06
16.225	1.19E+05	8.13E+05	1.79E+06	1.65E+06
16.375	2.33E+04	6.25E+05	1.04E+06	3.15E+05
16.525	8.76E+05	1.30E+05	6.83E+05	9.73E+05
16.675	6.99E+04	6.29E+05	9.83E+05	1.05E+06
16.825	2.18E+05	3.64E+05	4.00E+05	2.96E+05
16.975	4.31E+05	1.67E+05	5.30E+05	6.50E+05
17.125	5.37E+04	2.85E+05	5.27E+05	5.58E+05
17.275	2.30E+05	6.27E+04	8.03E+04	2.60E+05
17.425	1.10E+05	1.56E+05	2.29E+05	4.75E+05
17.575	1.15E+04	1.91E+05	1.95E+05	2.91E+05

17.725	2.14E+05	6.65E+04	2.09E+05	3.10E+05
17.875	5.87E+04	1.11E+05	3.36E+05	4.59E+05
18.025	2.93E+04	9.18E+04	2.38E+05	3.61E+05
18.175	6.86E+04	9.20E+04	1.91E+05	2.96E+05
18.325	9.01E+03	1.06E+05	1.66E+05	1.86E+05
18.475	4.82E+04	3.75E+04	9.64E+04	2.57E+05
18.625	3.68E+04	1.22E+05	2.18E+05	4.11E+05
18.775	1.29E+04	1.64E+05	1.55E+05	3.57E+05
18.925	3.65E+04	1.09E+05	4.86E+05	7.12E+05
19.075	1.53E+04	2.36E+05	6.83E+05	8.09E+05
19.225	2.45E+04	1.26E+05	7.59E+04	2.42E+05
19.375	2.01E+04	3.21E+05	9.31E+05	8.05E+05
19.525	7.64E+03	5.73E+05	1.03E+06	5.58E+05
19.675	3.86E+04	8.83E+04	7.65E+05	1.85E+06
19.825	2.98E+04	1.03E+06	1.34E+06	2.20E+06
19.975	1.91E+04	9.32E+05	8.77E+05	5.43E+05
20.125	1.04E+05	4.90E+05	1.84E+06	3.50E+06
20.275	2.63E+04	1.57E+06	1.56E+06	3.26E+06
20.425	1.12E+05	3.13E+05	9.41E+05	3.59E+06
20.575	9.55E+04	1.51E+06	3.83E+06	4.67E+06
20.725	1.44E+04	1.33E+06	2.01E+06	3.14E+06
20.875	3.63E+05	4.59E+05	3.90E+06	5.35E+06
21.025	7.08E+04	2.86E+06	4.61E+06	5.26E+06
21.175	2.03E+05	1.38E+06	3.31E+06	5.25E+06
21.325	2.85E+05	1.78E+06	3.47E+06	6.46E+06
21.475	2.60E+04	3.10E+06	4.43E+06	5.18E+06
21.625	8.01E+05	1.01E+06	9.05E+05	2.21E+06
21.775	8.22E+04	1.57E+06	2.60E+06	5.08E+06
21.925	3.40E+05	1.92E+06	2.35E+06	3.49E+06
22.075	6.76E+05	2.49E+05	1.41E+06	3.06E+06
22.225	8.73E+03	1.08E+06	2.83E+06	3.95E+06
22.375	6.92E+05	8.79E+05	1.33E+06	1.90E+06
22.525	3.51E+05	2.86E+05	1.36E+06	1.43E+06
22.675	1.72E+04	9.78E+05	1.85E+06	1.77E+06
22.825	8.22E+05	4.05E+05	4.54E+05	3.36E+05
22.975	7.94E+04	3.96E+05	7.75E+05	1.10E+06
23.125	8.20E+04	7.00E+05	8.53E+05	1.04E+06
23.275	4.13E+05	2.05E+05	1.90E+05	2.82E+05
23.425	4.76E+04	2.39E+05	3.66E+05	6.17E+05
23.575	2.28E+05	2.45E+05	3.54E+05	3.41E+05
23.725	1.38E+05	3.07E+04	1.40E+05	2.60E+05
23.875	1.94E+04	1.34E+05	2.75E+05	3.22E+05
24.025	1.76E+05	1.04E+05	1.88E+05	1.78E+05

24.175	5.87E+04	7.39E+04	2.03E+05	4.84E+05
24.325	1.63E+04	1.30E+05	2.64E+05	5.22E+05
24.475	6.91E+04	7.55E+04	1.93E+05	2.95E+05
24.625	1.03E+04	9.96E+04	2.84E+05	3.03E+05
24.775	4.26E+04	7.37E+04	1.54E+05	1.51E+05
24.925	4.95E+04	5.76E+04	1.57E+05	2.65E+05
25.075	1.60E+04	2.01E+05	2.61E+05	2.96E+05
25.225	3.06E+04	1.54E+05	2.10E+05	3.32E+05
25.375	1.53E+04	1.89E+05	4.89E+05	8.85E+05
25.525	1.92E+04	3.01E+05	4.83E+05	6.51E+05
25.675	2.67E+04	5.96E+04	2.68E+05	6.95E+05
25.825	7.07E+03	4.95E+05	1.11E+06	1.30E+06
25.975	2.70E+04	4.37E+05	6.21E+05	3.40E+05
26.125	2.78E+04	3.47E+05	1.18E+06	1.84E+06
26.275	1.88E+04	1.28E+06	1.65E+06	1.75E+06
26.425	9.37E+04	3.86E+05	2.70E+05	1.22E+06
26.575	2.65E+04	1.08E+06	1.77E+06	2.60E+06
26.725	9.07E+04	1.20E+06	1.13E+06	1.27E+06
26.875	1.38E+05	4.17E+05	2.38E+06	4.52E+06
27.025	2.76E+04	1.77E+06	3.47E+06	4.93E+06
27.175	2.97E+05	5.18E+05	5.18E+05	2.90E+06
27.325	8.81E+04	2.39E+06	5.37E+06	6.02E+06
27.475	6.08E+04	2.72E+06	4.54E+06	5.53E+06
27.625	4.05E+05	1.03E+06	3.06E+06	5.33E+06
27.775	3.61E+04	2.63E+06	3.95E+06	5.19E+06
27.925	6.05E+05	3.16E+06	5.41E+06	7.07E+06
28.075	1.59E+05	2.88E+05	1.27E+06	2.33E+06
28.225	2.01E+04	1.91E+06	2.48E+06	3.44E+06
28.375	8.98E+05	1.06E+06	2.13E+06	2.78E+06
28.525	2.80E+04	6.77E+05	1.83E+06	3.11E+06
28.675	3.25E+05	1.31E+06	2.36E+06	3.39E+06
28.825	7.59E+05	3.46E+05	8.23E+05	3.81E+05
28.975	2.45E+04	8.65E+05	1.74E+06	2.33E+06
29.125	5.59E+05	9.87E+05	1.79E+06	2.13E+06
29.275	1.38E+05	1.26E+05	2.52E+05	7.55E+05
29.425	1.43E+04	6.55E+05	1.04E+06	1.48E+06
29.575	4.88E+05	4.51E+05	9.15E+05	1.29E+06
29.725	8.51E+04	8.68E+04	2.08E+05	2.49E+05
29.875	4.98E+04	2.36E+05	3.98E+05	4.78E+05
30.025	2.53E+05	8.39E+04	2.57E+05	3.72E+05

Rubber Cone 1

Time(s)	dx005_mises(Pa)	dx010_mises(Pa)	dx015_mises(Pa)	dx020_mises(Pa)
2.50E-02	0	0	0	0
1.75E-01	1.95E+05	3.70E+05	5.45E+05	6.88E+05
3.25E-01	6.18E+04	1.40E+05	1.88E+05	3.72E+05
4.75E-01	9.89E+04	4.59E+05	7.32E+05	8.66E+05
6.25E-01	8.32E+04	2.05E+05	3.08E+05	4.09E+05
7.75E-01	3.91E+05	7.36E+05	1.02E+06	1.49E+06
9.25E-01	4.40E+05	6.71E+05	4.76E+05	9.73E+05
1.07501	9.92E+04	8.67E+05	1.21E+06	1.68E+06
1.22503	9.10E+05	1.59E+06	1.53E+06	2.13E+06
1.37504	2.98E+04	7.43E+05	1.55E+06	2.16E+06
1.52506	5.75E+05	1.01E+06	1.51E+06	1.90E+06
1.67507	4.09E+05	9.98E+05	1.36E+06	2.01E+06
1.82501	8.74E+04	1.97E+05	5.68E+05	1.08E+06
1.97503	3.21E+05	8.47E+05	1.10E+06	1.35E+06
2.12504	4.93E+04	4.59E+05	9.56E+05	1.35E+06
2.27506	1.13E+05	2.67E+05	4.94E+05	7.74E+05
2.42507	3.09E+05	5.39E+05	8.91E+05	1.11E+06
2.57501	1.19E+05	2.68E+05	3.07E+05	3.09E+05
2.72502	3.43E+04	1.92E+05	4.18E+05	5.86E+05
2.87504	7.24E+04	3.41E+05	5.91E+05	8.13E+05
3.02505	9.29E+04	1.23E+05	2.72E+05	5.43E+05
3.17507	9.87E+04	1.45E+05	1.76E+05	1.59E+05
3.32501	8.18E+04	1.12E+05	2.51E+05	3.56E+05
3.47502	6.45E+04	8.33E+04	9.77E+04	1.19E+05
3.62503	8.84E+04	1.45E+05	2.64E+05	2.49E+05
3.77505	7.91E+04	1.33E+05	1.32E+05	1.35E+05
3.92506	6.43E+04	7.61E+04	1.29E+05	1.14E+05
4.075	6.13E+04	5.23E+04	7.20E+04	9.86E+04
4.22502	5.69E+04	3.10E+04	9.39E+04	1.04E+05
4.37503	6.94E+04	1.15E+05	2.36E+04	5.33E+04
4.52505	7.30E+04	6.54E+04	1.04E+05	8.09E+04
4.67506	7.24E+04	8.49E+04	8.96E+04	1.02E+05
4.82508	7.07E+04	7.82E+04	1.13E+05	1.13E+05
4.97501	8.13E+04	9.12E+04	1.01E+05	1.07E+05
5.12503	7.53E+04	9.55E+04	8.77E+04	8.46E+04

5.27504	7.68E+04	4.84E+04	6.63E+04	7.63E+04
5.42506	6.60E+04	5.47E+04	1.46E+05	1.99E+05
5.57507	7.84E+04	1.07E+05	1.45E+05	2.04E+05
5.72501	8.20E+04	8.29E+04	1.09E+05	1.59E+05
5.87503	8.36E+04	1.15E+05	2.22E+05	3.10E+05
6.02504	7.27E+04	1.50E+05	2.63E+05	4.21E+05
6.17506	7.24E+04	6.30E+04	1.33E+05	1.76E+05
6.32507	1.45E+05	3.01E+05	5.41E+05	6.69E+05
6.47501	9.88E+04	2.02E+05	2.09E+05	2.24E+05
6.62502	1.26E+05	3.52E+05	6.51E+05	9.90E+05
6.77504	1.93E+05	4.97E+05	8.10E+05	1.12E+06
6.92505	8.96E+04	9.42E+04	4.35E+05	4.32E+05
7.07507	2.64E+05	8.51E+05	1.30E+06	1.72E+06
7.22501	8.45E+04	4.67E+05	4.54E+05	1.02E+06
7.37502	1.00E+05	8.72E+05	1.72E+06	2.43E+06
7.52504	4.55E+05	1.04E+06	1.64E+06	1.94E+06
7.67505	7.83E+04	5.08E+05	1.51E+06	2.03E+06
7.82507	3.69E+05	1.07E+06	1.60E+06	2.32E+06
7.975	2.03E+05	8.91E+05	1.59E+06	2.28E+06
8.12502	7.07E+04	8.66E+04	3.20E+05	2.30E+05
8.27503	3.97E+05	8.08E+05	1.21E+06	1.72E+06
8.42505	1.26E+05	4.03E+05	8.57E+05	1.34E+06
8.57506	1.03E+05	3.11E+05	4.74E+05	6.18E+05
8.72508	1.69E+05	5.21E+05	8.52E+05	1.18E+06
8.87501	7.50E+04	1.88E+05	3.37E+05	3.46E+05
9.02503	1.20E+05	2.65E+05	4.28E+05	5.27E+05
9.17504	1.20E+05	2.75E+05	4.94E+05	6.80E+05
9.32506	9.39E+04	1.11E+05	1.38E+05	2.12E+05
9.47507	9.66E+04	1.56E+05	2.46E+05	3.39E+05
9.62501	6.49E+04	1.14E+05	1.99E+05	3.01E+05
9.77503	5.80E+04	6.08E+04	4.67E+04	8.57E+04
9.92504	8.43E+04	1.20E+05	2.14E+05	1.89E+05
10.0751	8.02E+04	1.08E+05	1.03E+05	1.52E+05
10.2251	7.26E+04	6.14E+04	8.97E+04	9.45E+04
10.375	6.44E+04	3.13E+04	7.10E+04	1.02E+05
10.525	6.95E+04	5.48E+04	3.95E+04	9.26E+04
10.675	7.61E+04	6.99E+04	3.93E+04	1.02E+05
10.8251	7.64E+04	7.72E+04	7.67E+04	1.11E+05
10.9751	7.04E+04	6.67E+04	6.11E+04	1.69E+05
11.125	7.31E+04	6.08E+04	9.38E+04	9.90E+04
11.275	7.44E+04	5.89E+04	5.70E+04	1.23E+05
11.425	6.57E+04	4.72E+04	5.36E+04	1.13E+05
11.5751	6.47E+04	4.62E+04	4.26E+04	9.30E+04

11.7251	7.43E+04	8.24E+04	9.38E+04	1.37E+05
11.875	9.53E+04	1.29E+05	1.47E+05	1.75E+05
12.025	8.51E+04	8.29E+04	9.62E+04	9.61E+04
12.175	7.92E+04	1.37E+05	2.49E+05	3.38E+05
12.325	7.78E+04	1.48E+05	2.33E+05	3.38E+05
12.4751	7.02E+04	8.74E+04	1.79E+05	3.02E+05
12.625	1.17E+05	3.13E+05	4.96E+05	6.62E+05
12.775	8.50E+04	1.44E+05	1.16E+05	1.41E+05
12.925	1.62E+05	4.26E+05	7.00E+05	9.42E+05
13.075	1.66E+05	4.93E+05	5.86E+05	1.13E+06
13.2251	8.23E+04	1.00E+05	5.50E+05	8.43E+05
13.3751	3.03E+05	7.67E+05	1.27E+06	1.76E+06
13.525	9.57E+04	2.14E+05	1.88E+05	5.79E+05
13.675	1.47E+05	1.06E+06	1.75E+06	2.47E+06
13.825	3.76E+05	1.08E+06	1.62E+06	1.89E+06
13.9751	8.24E+04	5.71E+05	1.33E+06	2.06E+06
14.1251	4.08E+05	1.10E+06	1.65E+06	2.31E+06
14.275	1.06E+05	8.31E+05	1.32E+06	2.04E+06
14.425	6.49E+04	3.19E+05	5.81E+05	7.11E+05
14.575	3.55E+05	8.16E+05	1.35E+06	1.83E+06
14.7251	1.20E+05	2.87E+05	5.48E+05	1.14E+06
14.8751	1.15E+05	3.25E+05	6.99E+05	8.43E+05
15.025	1.63E+05	5.26E+05	8.13E+05	1.20E+06
15.175	6.96E+04	1.44E+05	1.54E+05	2.99E+05
15.325	1.01E+05	2.36E+05	4.67E+05	5.83E+05
15.4751	1.08E+05	2.64E+05	4.18E+05	6.52E+05
15.6251	8.40E+04	1.08E+05	1.30E+05	2.24E+05
15.775	7.80E+04	1.62E+05	2.61E+05	3.55E+05
15.925	6.33E+04	1.06E+05	1.54E+05	3.30E+05
16.075	6.77E+04	5.46E+04	8.38E+04	6.86E+04
16.225	8.68E+04	1.10E+05	1.46E+05	1.73E+05
16.375	8.70E+04	9.09E+04	1.01E+05	1.12E+05
16.525	7.40E+04	5.55E+04	5.56E+04	1.20E+05
16.675	6.87E+04	3.69E+04	7.53E+04	1.32E+05
16.8251	6.76E+04	6.53E+04	4.75E+04	9.72E+04
16.9751	7.32E+04	5.90E+04	6.35E+04	1.20E+05
17.1251	7.28E+04	7.89E+04	9.39E+04	1.23E+05
17.2751	7.62E+04	6.97E+04	7.38E+04	9.85E+04
17.425	7.20E+04	6.65E+04	7.61E+04	1.14E+05
17.575	7.65E+04	5.73E+04	6.06E+04	9.85E+04
17.725	6.90E+04	4.07E+04	6.99E+04	1.30E+05
17.875	6.87E+04	4.26E+04	5.23E+04	1.03E+05
18.025	7.19E+04	9.51E+04	1.38E+05	1.74E+05

18.175	8.22E+04	1.25E+05	1.52E+05	1.83E+05
18.325	7.86E+04	6.48E+04	8.04E+04	1.67E+05
18.475	9.63E+04	1.50E+05	2.90E+05	4.08E+05
18.6251	7.50E+04	1.12E+05	1.75E+05	2.40E+05
18.7751	6.52E+04	1.63E+05	3.35E+05	4.95E+05
18.9251	1.11E+05	3.11E+05	4.98E+05	6.74E+05
19.0751	8.07E+04	7.48E+04	1.56E+05	3.81E+05
19.225	1.64E+05	4.60E+05	7.94E+05	1.06E+06
19.375	9.12E+04	2.42E+05	3.95E+05	3.29E+05
19.525	1.13E+05	4.57E+05	9.81E+05	1.49E+06
19.675	2.75E+05	7.71E+05	1.20E+06	1.25E+06
19.825	7.95E+04	2.40E+05	9.15E+05	1.01E+06
19.975	4.35E+05	1.07E+06	1.68E+06	2.15E+06
20.125	1.33E+05	7.53E+05	1.49E+06	2.09E+06
20.275	7.67E+04	6.87E+05	1.32E+06	2.04E+06
20.425	4.18E+05	1.05E+06	1.49E+06	2.55E+06
20.5751	7.16E+04	3.65E+05	1.20E+06	1.12E+06
20.7251	1.60E+05	5.41E+05	1.11E+06	1.15E+06
20.8751	1.43E+05	7.51E+05	1.27E+06	1.91E+06
21.0251	8.47E+04	1.50E+05	3.55E+05	5.20E+05
21.175	2.51E+05	4.83E+05	8.02E+05	1.06E+06
21.325	9.23E+04	3.09E+05	7.36E+05	1.09E+06
21.475	5.47E+04	7.85E+04	1.24E+05	1.28E+05
21.625	1.08E+05	3.07E+05	4.83E+05	6.53E+05
21.775	8.75E+04	1.67E+05	3.41E+05	4.99E+05
21.925	8.99E+04	1.28E+05	1.71E+05	2.51E+05
22.075	6.10E+04	1.47E+05	2.82E+05	4.33E+05
22.225	6.13E+04	4.46E+04	1.26E+05	2.36E+05
22.3751	7.39E+04	9.79E+04	9.37E+04	8.92E+04
22.5251	7.68E+04	1.01E+05	1.38E+05	1.32E+05
22.6751	7.29E+04	6.76E+04	8.51E+04	1.24E+05
22.8251	6.88E+04	4.21E+04	6.82E+04	1.66E+05
22.975	7.19E+04	4.40E+04	7.98E+04	1.47E+05
23.125	7.25E+04	7.03E+04	5.22E+04	1.23E+05
23.275	7.94E+04	7.48E+04	6.98E+04	1.26E+05
23.425	7.22E+04	7.35E+04	7.47E+04	1.31E+05
23.575	7.17E+04	6.94E+04	6.90E+04	1.01E+05
23.725	7.50E+04	6.32E+04	6.41E+04	1.10E+05
23.875	6.69E+04	4.72E+04	5.35E+04	1.42E+05
24.025	6.85E+04	4.20E+04	7.49E+04	1.64E+05
24.175	6.87E+04	6.45E+04	6.28E+04	1.34E+05
24.3251	7.57E+04	1.16E+05	1.33E+05	1.92E+05
24.4751	7.54E+04	7.99E+04	1.33E+05	1.88E+05

24.6251	7.74E+04	1.05E+05	1.01E+05	2.38E+05
24.7751	7.66E+04	1.75E+05	2.95E+05	4.18E+05
24.925	7.28E+04	5.46E+04	1.22E+05	1.52E+05
25.075	1.34E+05	2.88E+05	3.49E+05	5.73E+05
25.225	9.12E+04	2.08E+05	4.36E+05	5.62E+05
25.375	1.31E+05	3.11E+05	2.81E+05	5.65E+05
25.525	1.65E+05	4.76E+05	7.69E+05	1.10E+06
25.675	7.75E+04	8.80E+04	2.54E+05	1.77E+05
25.825	2.40E+05	8.20E+05	1.08E+06	1.64E+06
25.975	7.53E+04	3.12E+05	1.17E+06	1.24E+06
26.1251	1.92E+05	8.02E+05	8.19E+05	2.32E+06
26.2751	3.60E+05	9.89E+05	1.74E+06	2.03E+06
26.4251	7.55E+04	5.16E+05	1.35E+06	2.21E+06
26.5751	5.05E+05	9.95E+05	1.52E+06	1.95E+06
26.725	1.10E+05	8.19E+05	1.56E+06	2.43E+06
26.875	6.52E+04	2.55E+05	8.11E+05	6.08E+05
27.025	2.62E+05	7.16E+05	9.35E+05	1.61E+06
27.175	8.77E+04	2.57E+05	1.19E+06	1.61E+06
27.325	1.26E+05	3.58E+05	2.89E+05	5.40E+05
27.475	1.14E+05	4.94E+05	8.16E+05	1.12E+06
27.625	6.71E+04	1.21E+05	7.01E+05	7.61E+05
27.775	1.25E+05	2.50E+05	1.44E+05	2.67E+05
27.925	1.00E+05	2.22E+05	5.25E+05	6.14E+05
28.0751	8.59E+04	1.10E+05	3.45E+05	2.89E+05
28.2251	8.20E+04	1.86E+05	1.85E+05	4.28E+05
28.3751	6.78E+04	9.47E+04	2.92E+05	4.72E+05
28.5251	6.91E+04	6.55E+04	1.29E+05	2.05E+05
28.675	7.92E+04	9.26E+04	9.48E+04	1.20E+05
28.825	7.46E+04	8.65E+04	1.19E+05	1.31E+05
28.975	6.62E+04	5.61E+04	8.15E+04	1.69E+05
29.125	6.83E+04	4.30E+04	8.17E+04	2.16E+05
29.275	7.16E+04	4.37E+04	8.58E+04	1.93E+05
29.425	7.52E+04	6.30E+04	5.26E+04	1.42E+05
29.575	7.47E+04	7.13E+04	6.99E+04	1.58E+05
29.725	7.38E+04	8.77E+04	8.19E+04	1.61E+05
29.8751	7.67E+04	5.86E+04	6.60E+04	1.37E+05
30.025	7.06E+04	5.03E+04	8.08E+04	1.56E+05

Rubber Cone 2

Time(s)	dx005_mises(Pa)	dx010_mises(Pa)	dx015_mises(Pa)	dx020_mises(Pa)
2.50E-02	0	0	0	0

1.75E-01	1.57E+05	2.85E+05	4.30E+05	5.28E+05
3.25E-01	1.69E+05	3.54E+05	5.28E+05	6.84E+05
4.75E-01	1.58E+05	3.35E+05	3.61E+05	3.78E+05
6.25E-01	1.37E+05	1.00E+05	3.91E+05	5.87E+05
7.75E-01	1.24E+05	1.37E+05	2.26E+05	6.28E+05
9.25E-01	8.70E+04	2.97E+05	6.50E+05	5.15E+05
1.07501	2.68E+04	3.65E+05	4.45E+05	1.35E+06
1.22503	2.70E+04	5.54E+04	8.96E+05	1.67E+06
1.37504	2.62E+04	4.86E+05	1.23E+06	1.18E+06
1.52506	2.44E+04	1.84E+05	8.68E+05	5.34E+05
1.67507	3.27E+04	7.00E+05	6.54E+05	1.89E+06
1.82501	9.26E+04	5.26E+05	1.27E+06	1.62E+06
1.97503	1.60E+05	6.16E+05	1.24E+06	1.62E+06
2.12504	1.90E+05	1.01E+06	1.41E+06	2.19E+06
2.27506	9.07E+04	5.50E+05	1.64E+06	4.24E+05
2.42507	5.32E+04	6.02E+05	3.90E+05	1.66E+06
2.57501	1.95E+04	1.19E+06	1.26E+06	1.46E+06
2.72502	9.31E+04	5.27E+05	1.14E+06	2.78E+05
2.87504	1.97E+05	6.54E+05	1.36E+05	9.61E+05
3.02505	6.90E+04	7.05E+05	8.37E+05	1.28E+06
3.17507	1.82E+04	1.85E+05	8.12E+05	5.53E+05
3.32501	1.98E+05	4.99E+05	1.97E+05	5.76E+05
3.47502	1.31E+05	4.16E+05	4.76E+05	5.44E+05
3.62503	2.86E+04	7.88E+04	2.65E+05	1.79E+05
3.77505	4.74E+05	3.05E+05	1.74E+05	3.73E+05
3.92506	4.60E+05	1.89E+05	2.97E+05	2.53E+05
4.075	3.63E+04	7.82E+04	1.22E+05	1.94E+05
4.22502	3.06E+05	1.73E+05	7.66E+04	1.94E+05
4.37503	2.85E+05	1.02E+05	2.11E+05	1.25E+05
4.52505	3.06E+04	6.22E+04	5.84E+04	1.25E+05
4.67506	2.64E+05	6.55E+04	1.29E+05	1.52E+05
4.82508	6.63E+04	4.36E+04	1.07E+05	1.49E+05
4.97501	1.87E+04	4.38E+04	7.24E+04	1.80E+05
5.12503	2.32E+05	3.97E+04	8.09E+04	1.15E+05
5.27504	7.58E+04	4.34E+04	1.01E+05	1.22E+05
5.42506	1.79E+04	3.52E+04	9.07E+04	8.97E+04
5.57507	6.83E+04	4.11E+04	7.75E+04	9.67E+04
5.72501	2.19E+04	4.28E+04	6.14E+04	1.22E+05
5.87503	4.28E+04	2.96E+04	9.02E+04	1.55E+05

6.02504	3.91E+04	2.52E+04	6.80E+04	1.24E+05
6.17506	2.76E+04	4.89E+04	1.43E+05	2.36E+05
6.32507	3.77E+04	5.18E+04	1.70E+05	1.29E+05
6.47501	3.23E+04	6.39E+04	8.88E+04	2.71E+05
6.62502	2.06E+04	9.75E+04	2.60E+05	3.78E+05
6.77504	5.41E+03	4.93E+04	1.70E+05	1.61E+05
6.92505	1.76E+04	1.31E+05	3.26E+05	6.64E+05
7.07507	1.63E+04	1.75E+05	5.67E+05	5.17E+05
7.22501	1.99E+04	5.47E+04	8.36E+04	5.48E+05
7.37502	1.80E+04	3.07E+05	7.20E+05	1.05E+06
7.52504	3.37E+04	1.77E+05	6.04E+05	2.25E+05
7.67505	1.07E+04	3.16E+05	7.99E+05	1.48E+06
7.82507	1.23E+04	4.86E+05	1.18E+06	1.08E+06
7.975	3.73E+04	7.06E+04	2.77E+05	1.74E+06
8.12502	2.08E+04	7.55E+05	1.51E+06	1.70E+06
8.27503	2.09E+04	3.94E+05	1.36E+06	2.28E+06
8.42505	3.26E+04	5.69E+05	1.12E+06	1.81E+06
8.57506	2.67E+04	1.08E+06	1.74E+06	2.55E+06
8.72508	4.24E+04	5.23E+05	1.35E+06	7.65E+05
8.87501	2.50E+04	8.14E+05	4.79E+05	1.45E+06
9.02503	3.10E+04	9.92E+05	1.30E+06	1.77E+06
9.17504	9.56E+04	1.24E+05	6.92E+05	2.48E+05
9.32506	3.08E+04	7.10E+05	5.15E+05	1.17E+06
9.47507	1.64E+05	6.04E+05	8.85E+05	1.07E+06
9.62501	9.74E+04	1.42E+05	3.73E+05	2.39E+05
9.77503	3.05E+04	5.49E+05	3.51E+05	6.53E+05
9.92504	2.97E+05	3.72E+05	4.49E+05	3.93E+05
10.0751	4.25E+04	1.00E+05	9.60E+04	2.38E+05
10.2251	1.28E+05	3.00E+05	2.95E+05	4.24E+05
10.375	1.99E+05	1.48E+05	2.59E+05	2.36E+05
10.525	2.25E+04	1.44E+05	7.95E+04	8.85E+04
10.675	2.82E+05	1.92E+05	1.11E+05	1.22E+05
10.8251	5.22E+04	9.46E+04	6.39E+04	4.66E+04
10.9751	1.29E+04	7.79E+04	5.24E+04	1.52E+05
11.125	2.59E+05	4.92E+04	9.59E+04	1.54E+05
11.275	3.33E+04	2.01E+04	8.42E+04	1.24E+05
11.425	6.07E+04	5.15E+04	7.46E+04	1.02E+05
11.5751	1.49E+05	4.15E+04	6.85E+04	1.37E+05
11.7251	3.60E+04	3.70E+04	7.88E+04	6.35E+04
11.875	6.11E+04	3.28E+04	6.45E+04	8.59E+04
12.025	6.21E+04	2.86E+04	4.17E+04	9.30E+04
12.175	2.25E+04	5.97E+04	6.96E+04	1.56E+05
12.325	4.26E+04	1.59E+04	8.75E+04	1.29E+05

12.4751	1.79E+04	3.00E+04	7.62E+04	1.84E+05
12.625	1.26E+04	4.26E+04	1.38E+05	2.14E+05
12.775	3.23E+04	4.20E+04	1.24E+05	6.10E+04
12.925	1.14E+04	7.00E+04	1.05E+05	3.56E+05
13.075	1.13E+04	1.05E+05	2.72E+05	2.32E+05
13.2251	1.07E+04	4.11E+04	9.01E+04	4.39E+05
13.3751	1.22E+04	1.34E+05	4.35E+05	7.21E+05
13.525	1.03E+04	1.42E+05	4.82E+05	1.58E+05
13.675	1.22E+04	1.04E+05	2.54E+05	9.40E+05
13.825	9.56E+03	3.30E+05	7.82E+05	7.43E+05
13.9751	6.92E+03	1.58E+05	3.64E+05	1.09E+06
14.1251	9.28E+03	3.75E+05	9.73E+05	1.65E+06
14.275	8.37E+03	4.45E+05	1.22E+06	4.33E+05
14.425	1.61E+04	5.06E+04	2.62E+05	1.98E+06
14.575	9.23E+03	7.86E+05	1.81E+06	1.94E+06
14.7251	2.92E+04	4.06E+05	1.21E+06	1.82E+06
14.8751	1.56E+04	5.68E+05	1.13E+06	2.31E+06
15.025	9.59E+03	1.01E+06	1.59E+06	1.82E+06
15.175	4.54E+04	3.96E+05	1.35E+06	6.02E+05
15.325	1.75E+04	9.22E+05	7.46E+05	1.66E+06
15.4751	8.94E+04	9.50E+05	1.19E+06	1.17E+06
15.6251	6.96E+04	1.61E+05	5.33E+05	6.47E+05
15.775	2.47E+04	7.18E+05	6.74E+05	1.14E+06
15.925	1.78E+05	5.16E+05	8.12E+05	6.74E+05
16.075	4.68E+04	1.27E+05	2.23E+05	4.62E+05
16.225	8.19E+04	5.22E+05	4.28E+05	5.97E+05
16.375	1.39E+05	2.51E+05	4.21E+05	1.48E+05
16.525	2.22E+04	1.52E+05	1.21E+05	4.01E+05
16.675	3.60E+05	2.82E+05	2.84E+05	4.13E+05
16.8251	2.54E+04	9.69E+04	2.48E+05	1.35E+05
16.9751	8.02E+04	1.28E+05	7.15E+04	1.06E+05
17.1251	4.61E+05	1.48E+05	1.25E+05	1.09E+05
17.2751	2.98E+04	6.79E+04	4.72E+04	1.18E+05
17.425	1.39E+05	6.59E+04	8.20E+04	1.79E+05
17.575	1.45E+05	4.60E+04	1.23E+05	1.52E+05
17.725	3.16E+04	2.92E+04	9.09E+04	1.10E+05
17.875	1.25E+05	4.76E+04	7.44E+04	1.25E+05
18.025	4.47E+04	4.22E+04	9.00E+04	1.38E+05
18.175	1.67E+04	4.51E+04	7.46E+04	8.35E+04
18.325	1.33E+05	2.60E+04	5.27E+04	9.24E+04
18.475	4.80E+04	3.84E+04	4.89E+04	1.42E+05
18.6251	1.45E+04	3.44E+04	7.25E+04	1.57E+05
18.7751	2.26E+04	1.47E+04	9.83E+04	1.53E+05

18.9251	1.02E+04	3.01E+04	1.08E+05	2.00E+05
19.0751	2.84E+04	5.88E+04	1.76E+05	1.78E+05
19.225	1.97E+04	3.13E+04	1.14E+05	2.07E+05
19.375	5.65E+03	8.10E+04	1.54E+05	3.85E+05
19.525	8.38E+03	8.37E+04	2.84E+05	1.30E+05
19.675	1.02E+04	3.44E+04	8.82E+04	6.44E+05
19.825	8.97E+03	1.67E+05	4.91E+05	6.96E+05
19.975	8.43E+03	7.56E+04	3.89E+05	4.36E+05
20.125	9.03E+03	2.27E+05	4.63E+05	1.01E+06
20.275	1.22E+04	2.69E+05	7.60E+05	5.02E+05
20.425	1.32E+04	7.58E+04	1.26E+05	1.45E+06
20.5751	5.25E+03	4.94E+05	1.09E+06	1.57E+06
20.7251	1.15E+04	1.77E+05	1.02E+06	7.11E+05
20.8751	2.00E+04	5.10E+05	9.55E+05	2.21E+06
21.0251	1.53E+04	6.65E+05	1.46E+06	1.53E+06
21.175	1.34E+04	2.89E+05	1.10E+06	2.05E+06
21.325	1.32E+04	1.02E+06	1.25E+06	2.24E+06
21.475	4.77E+04	5.83E+05	1.78E+06	2.16E+06
21.625	2.76E+04	5.89E+05	4.78E+05	5.63E+05
21.775	5.08E+04	9.99E+05	1.02E+06	1.66E+06
21.925	1.26E+05	3.27E+05	1.17E+06	1.14E+06
22.075	4.19E+04	5.46E+05	2.69E+05	7.07E+05
22.225	1.22E+05	7.11E+05	7.89E+05	1.19E+06
22.3751	5.26E+04	1.67E+05	7.13E+05	5.37E+05
22.5251	1.28E+04	4.43E+05	1.29E+05	4.61E+05
22.6751	2.42E+05	3.79E+05	4.52E+05	5.92E+05
22.8251	3.66E+04	7.28E+04	3.12E+05	1.86E+05
22.975	2.20E+05	2.82E+05	1.61E+05	4.09E+05
23.125	1.07E+05	1.75E+05	3.02E+05	4.25E+05
23.275	1.16E+04	9.50E+04	1.86E+05	1.73E+05
23.425	4.55E+05	1.73E+05	7.57E+04	8.52E+04
23.575	5.36E+04	1.02E+05	6.08E+04	7.04E+04
23.725	1.68E+04	5.89E+04	4.86E+04	1.31E+05
23.875	2.55E+05	5.62E+04	1.16E+05	1.93E+05
24.025	4.40E+04	2.46E+04	1.18E+05	1.61E+05
24.175	4.90E+04	3.90E+04	9.15E+04	1.58E+05
24.3251	6.47E+04	4.09E+04	7.98E+04	1.49E+05
24.4751	2.13E+04	3.98E+04	8.32E+04	1.60E+05
24.6251	8.42E+04	3.91E+04	6.99E+04	1.07E+05
24.7751	3.89E+04	4.16E+04	6.29E+04	1.08E+05
24.925	1.12E+04	4.58E+04	6.24E+04	1.66E+05
25.075	7.35E+04	1.46E+04	1.04E+05	1.80E+05
25.225	3.18E+04	1.88E+04	9.85E+04	1.65E+05

25.375	1.47E+04	5.17E+04	1.28E+05	2.59E+05
25.525	1.26E+04	3.95E+04	1.88E+05	1.92E+05
25.675	8.23E+03	7.04E+04	6.83E+04	2.42E+05
25.825	1.73E+04	9.26E+04	2.26E+05	4.01E+05
25.975	1.28E+04	2.56E+04	2.17E+05	1.77E+05
26.1251	1.19E+04	1.39E+05	2.89E+05	6.99E+05
26.2751	7.78E+03	9.50E+04	5.55E+05	6.37E+05
26.4251	5.06E+03	1.48E+05	1.69E+05	5.79E+05
26.5751	1.22E+04	3.34E+05	6.19E+05	9.39E+05
26.725	7.18E+03	7.17E+04	7.11E+05	1.02E+05
26.875	7.84E+03	3.79E+05	3.44E+05	1.54E+06
27.025	1.07E+04	3.49E+05	1.28E+06	9.69E+05
27.175	8.54E+03	2.00E+05	6.65E+05	1.68E+06
27.325	5.84E+03	7.93E+05	1.24E+06	1.85E+06
27.475	2.35E+04	1.84E+05	1.34E+06	2.00E+06
27.625	9.56E+03	9.02E+05	8.65E+05	2.10E+06
27.775	2.93E+04	8.00E+05	1.43E+06	2.51E+06
27.925	3.11E+04	3.51E+05	1.50E+06	5.33E+05
28.0751	1.68E+04	9.43E+05	3.67E+05	1.33E+06
28.2251	1.36E+05	7.15E+05	1.23E+06	1.60E+06
28.3751	5.73E+04	1.63E+05	9.72E+05	3.51E+05
28.5251	2.97E+04	7.91E+05	3.20E+05	1.10E+06
28.675	1.02E+05	3.25E+05	8.89E+05	9.96E+05
28.825	2.04E+04	2.78E+05	5.30E+05	2.26E+05
28.975	1.84E+05	4.76E+05	2.52E+05	6.14E+05
29.125	3.37E+04	1.68E+05	4.43E+05	3.81E+05
29.275	4.30E+04	2.31E+05	1.90E+05	2.94E+05
29.425	3.29E+05	2.24E+05	2.59E+05	5.04E+05
29.575	1.01E+04	5.72E+04	3.23E+05	2.92E+05
29.725	2.97E+05	1.71E+05	1.65E+05	1.20E+05
29.8751	2.38E+05	1.24E+05	6.22E+04	6.98E+04
30.025	2.06E+04	4.42E+04	4.70E+04	1.22E+05

Aluminum Cone 1

Time(s)	dx005_mises(Pa)	dx010_mises(Pa)	dx015_mises(Pa)	dx020_mises(Pa)
2.50E-02	0	0	0	0
1.75E-01	2.49E+05	6.92E+05	1.27E+06	1.81E+06
3.25E-01	4.25E+05	1.50E+06	2.45E+06	3.82E+06
4.75E-01	7.91E+05	1.73E+06	2.48E+06	3.99E+06

6.25E-01	2.01E+05	3.59E+05	1.32E+06	1.80E+06
7.75E-01	1.19E+06	3.13E+06	2.60E+06	5.11E+06
9.25E-01	2.55E+05	2.14E+06	1.85E+06	4.79E+06
1.07501	3.91E+05	1.55E+06	5.52E+06	7.06E+06
1.225	1.97E+06	2.25E+06	5.10E+06	5.34E+06
1.375	5.51E+04	1.24E+06	4.28E+06	7.04E+06
1.525	1.29E+06	2.13E+06	4.71E+06	6.34E+06
1.67501	7.62E+05	2.20E+06	5.88E+06	4.96E+06
1.82501	8.58E+04	1.73E+05	5.86E+05	6.09E+05
1.97501	8.37E+05	3.07E+06	3.00E+06	6.14E+06
2.125	1.24E+05	1.34E+06	2.78E+06	4.63E+06
2.275	2.37E+05	1.01E+06	1.72E+06	1.80E+06
2.425	6.90E+05	1.80E+06	2.19E+06	3.36E+06
2.575	7.80E+04	2.78E+05	1.07E+06	1.52E+06
2.725	4.69E+05	8.71E+05	2.06E+06	1.65E+06
2.875	2.23E+05	7.23E+05	1.86E+06	1.84E+06
3.02501	8.64E+04	1.89E+05	2.72E+05	4.64E+05
3.17501	3.19E+05	7.65E+05	1.10E+06	1.51E+06
3.32501	7.93E+04	2.30E+05	7.29E+05	8.67E+05
3.47501	1.14E+05	3.81E+05	4.52E+05	7.36E+05
3.62501	2.00E+05	5.02E+05	5.18E+05	9.41E+05
3.77501	6.18E+04	1.22E+05	2.15E+05	3.51E+05
3.92501	6.39E+04	1.15E+05	2.76E+05	2.90E+05
4.075	1.84E+04	1.16E+05	1.92E+05	3.10E+05
4.225	2.12E+04	7.05E+04	1.93E+05	3.34E+05
4.37501	8.64E+04	2.03E+05	4.47E+05	4.63E+05
4.52501	2.18E+04	8.30E+04	2.78E+05	4.74E+05
4.67501	2.80E+04	1.66E+05	3.14E+05	6.03E+05
4.825	3.13E+04	1.98E+05	2.82E+05	5.68E+05
4.975	1.87E+04	2.62E+04	7.99E+04	1.58E+05
5.12501	6.69E+04	1.88E+05	2.29E+05	4.14E+05
5.27501	4.42E+04	1.45E+05	1.41E+05	3.18E+05
5.42501	3.56E+04	1.61E+05	4.49E+05	6.18E+05
5.575	1.46E+05	2.43E+05	6.22E+05	7.64E+05
5.725	3.45E+04	3.44E+04	1.66E+05	2.39E+05
5.87501	1.48E+05	5.22E+05	8.40E+05	1.39E+06
6.02501	1.64E+05	5.38E+05	6.97E+05	1.47E+06
6.17501	3.28E+04	2.37E+05	6.99E+05	1.39E+06
6.325	4.05E+05	1.18E+06	2.53E+06	2.09E+06
6.475	7.47E+04	4.80E+05	1.44E+06	9.23E+05
6.62501	1.72E+05	1.18E+06	2.15E+06	3.89E+06

6.77501	5.28E+05	2.16E+06	1.79E+06	4.51E+06
6.92501	2.46E+04	5.97E+04	1.54E+05	1.35E+06
7.075	9.68E+05	2.12E+06	4.82E+06	4.08E+06
7.225	4.47E+05	1.56E+06	3.41E+06	2.41E+06
7.37501	2.28E+04	1.05E+06	2.98E+06	6.34E+06
7.52501	1.91E+06	3.60E+06	4.44E+06	6.69E+06
7.67501	1.03E+05	1.12E+06	3.56E+06	6.14E+06
7.825	7.40E+05	2.09E+06	4.52E+06	6.52E+06
7.975	9.25E+05	3.21E+06	3.73E+06	8.14E+06
8.12501	2.16E+04	4.90E+05	2.29E+06	2.08E+06
8.27501	8.17E+05	1.75E+06	3.86E+06	3.79E+06
8.42501	2.23E+05	1.55E+06	3.26E+06	4.82E+06
8.575	4.10E+04	5.05E+05	9.58E+05	1.53E+06
8.725	8.50E+05	1.97E+06	3.42E+06	2.55E+06
8.87501	5.25E+04	6.42E+05	1.89E+06	2.47E+06
9.02501	2.22E+05	8.27E+05	1.07E+06	2.25E+06
9.17501	3.75E+05	1.20E+06	1.59E+06	2.45E+06
9.325	5.92E+04	1.72E+05	4.30E+05	6.89E+05
9.475	2.02E+05	4.72E+05	9.62E+05	1.46E+06
9.62501	6.60E+04	4.21E+05	7.78E+05	1.33E+06
9.77501	4.68E+04	1.08E+05	2.55E+05	3.35E+05
9.92501	2.13E+05	4.02E+05	7.95E+05	6.97E+05
10.075	5.17E+04	1.91E+05	4.28E+05	6.58E+05
10.225	1.79E+04	9.70E+04	1.69E+05	2.58E+05
10.375	5.85E+04	1.99E+05	3.13E+05	3.24E+05
10.525	1.82E+04	3.46E+04	9.39E+04	2.06E+05
10.675	5.46E+04	1.50E+05	2.52E+05	5.82E+05
10.825	4.42E+04	1.52E+05	2.89E+05	5.63E+05
10.975	1.75E+04	8.56E+04	2.19E+05	4.04E+05
11.125	5.25E+04	1.47E+05	3.54E+05	5.67E+05
11.275	2.17E+04	4.92E+04	1.26E+05	3.31E+05
11.425	4.65E+04	1.37E+05	2.59E+05	2.96E+05
11.575	9.01E+04	2.08E+05	3.69E+05	3.11E+05
11.725	3.77E+04	7.70E+04	1.96E+05	3.70E+05
11.875	1.03E+05	3.37E+05	5.13E+05	7.96E+05
12.025	4.86E+04	2.83E+05	4.66E+05	4.79E+05
12.175	3.81E+04	2.61E+05	5.58E+05	9.59E+05
12.325	3.21E+05	4.76E+05	7.90E+05	1.66E+06
12.475	4.70E+04	1.44E+05	2.92E+05	4.84E+05
12.625	1.96E+05	9.00E+05	1.83E+06	2.05E+06
12.775	3.81E+05	9.78E+05	2.09E+06	2.14E+06
12.925	4.06E+04	2.28E+05	1.03E+06	1.22E+06
13.075	6.26E+05	1.95E+06	2.83E+06	4.30E+06

13.225	1.57E+05	9.03E+05	1.34E+06	2.12E+06
13.375	9.99E+04	1.75E+06	3.43E+06	3.95E+06
13.525	1.29E+06	2.49E+06	5.21E+06	3.98E+06
13.675	4.75E+04	3.34E+05	1.14E+06	8.60E+05
13.825	1.02E+06	3.50E+06	3.98E+06	7.41E+06
13.975	7.20E+05	2.60E+06	4.46E+06	6.09E+06
14.125	2.22E+04	1.75E+06	3.73E+06	5.76E+06
14.275	8.49E+05	2.67E+06	5.80E+06	7.52E+06
14.425	3.05E+05	1.65E+06	4.34E+06	7.44E+06
14.575	3.06E+05	1.74E+06	2.41E+06	2.20E+06
14.725	1.00E+06	2.73E+06	4.57E+06	3.88E+06
14.875	3.36E+04	5.10E+05	1.44E+06	2.67E+06
15.025	5.03E+05	1.26E+06	1.78E+06	3.74E+06
15.175	3.24E+05	1.08E+06	2.05E+06	3.54E+06
15.325	3.38E+04	1.63E+05	2.43E+05	3.84E+05
15.475	5.08E+05	1.21E+06	2.19E+06	2.69E+06
15.625	1.01E+05	5.78E+05	1.39E+06	2.11E+06
15.775	6.44E+04	4.44E+05	6.11E+05	6.38E+05
15.925	3.22E+05	8.05E+05	1.30E+06	1.11E+06
16.075	3.17E+04	1.38E+05	5.42E+05	6.49E+05
16.225	1.08E+05	3.15E+05	3.93E+05	6.74E+05
16.375	9.26E+04	2.85E+05	4.80E+05	6.94E+05
16.525	2.68E+04	3.55E+04	5.40E+04	2.47E+05
16.675	6.38E+04	1.52E+05	2.92E+05	4.58E+05
16.825	2.22E+04	8.70E+04	2.15E+05	3.47E+05
16.975	2.24E+04	1.07E+05	2.25E+05	3.51E+05
17.125	9.46E+04	2.28E+05	4.57E+05	6.02E+05
17.275	2.72E+04	8.22E+04	2.17E+05	4.53E+05
17.425	1.91E+04	1.65E+05	2.53E+05	4.55E+05
17.575	1.75E+04	1.37E+05	2.56E+05	4.06E+05
17.725	3.46E+04	6.52E+04	1.14E+05	1.67E+05
17.875	9.73E+04	1.65E+05	2.38E+05	3.85E+05
18.025	5.75E+04	1.02E+05	1.68E+05	2.51E+05
18.175	4.12E+04	2.36E+05	4.73E+05	7.50E+05
18.325	1.06E+05	3.73E+05	6.29E+05	9.20E+05
18.475	4.69E+04	4.03E+04	6.84E+04	1.75E+05
18.625	1.83E+05	6.71E+05	9.85E+05	1.27E+06
18.775	1.27E+05	6.79E+05	1.05E+06	1.26E+06
18.925	5.73E+04	3.52E+05	8.71E+05	1.39E+06
19.075	5.29E+05	9.84E+05	1.27E+06	1.77E+06
19.225	7.01E+04	3.86E+05	7.75E+05	1.13E+06
19.375	2.83E+05	1.25E+06	2.61E+06	3.67E+06
19.525	5.32E+05	1.34E+06	2.89E+06	3.16E+06

19.675	4.33E+04	2.61E+05	5.67E+05	1.45E+06
19.825	9.98E+05	3.10E+06	4.79E+06	5.84E+06
19.975	1.32E+05	1.91E+06	3.29E+06	4.04E+06
20.125	2.03E+05	1.34E+06	3.34E+06	5.84E+06
20.275	1.17E+06	3.31E+06	3.87E+06	6.40E+06
20.425	3.47E+04	1.13E+06	4.87E+06	5.82E+06
20.575	7.18E+05	1.84E+06	6.38E+06	6.78E+06
20.725	1.04E+06	2.99E+06	7.48E+06	9.04E+06
20.875	3.23E+04	3.19E+05	1.47E+06	1.27E+06
21.025	7.75E+05	2.41E+06	3.43E+06	3.15E+06
21.175	1.31E+05	1.76E+06	3.46E+06	4.21E+06
21.325	5.33E+04	6.37E+05	1.70E+06	2.27E+06
21.475	9.22E+05	1.83E+06	3.09E+06	4.60E+06
21.625	3.84E+04	5.45E+05	1.33E+06	2.47E+06
21.775	2.60E+05	9.69E+05	1.79E+06	1.50E+06
21.925	4.68E+05	1.29E+06	2.13E+06	2.19E+06
22.075	3.30E+04	1.32E+05	2.53E+05	4.66E+05
22.225	2.43E+05	6.03E+05	9.14E+05	1.15E+06
22.375	1.86E+05	4.15E+05	7.93E+05	1.08E+06
22.525	2.57E+04	1.02E+05	2.42E+05	4.05E+05
22.675	2.79E+05	4.90E+05	8.18E+05	9.57E+05
22.825	4.07E+04	1.53E+05	4.14E+05	6.62E+05
22.975	5.51E+04	1.03E+05	1.94E+05	2.82E+05
23.125	1.02E+05	1.85E+05	3.16E+05	4.37E+05
23.275	3.71E+04	4.29E+04	1.03E+05	2.04E+05
23.425	3.36E+04	1.47E+05	2.68E+05	4.01E+05
23.575	4.82E+04	1.29E+05	2.76E+05	5.05E+05
23.725	4.57E+04	6.18E+04	2.16E+05	4.37E+05
23.875	8.27E+04	1.94E+05	3.04E+05	5.34E+05
24.025	5.17E+04	4.25E+04	6.98E+04	2.88E+05
24.175	9.09E+04	1.67E+05	3.05E+05	4.02E+05
24.325	1.39E+05	2.53E+05	3.86E+05	4.56E+05
24.475	6.50E+04	9.98E+04	2.03E+05	4.32E+05
24.625	1.06E+05	2.39E+05	5.37E+05	7.45E+05
24.775	4.10E+04	1.67E+05	4.32E+05	6.78E+05
24.925	6.62E+04	2.79E+05	6.15E+05	8.65E+05
25.075	2.87E+05	6.83E+05	7.78E+05	8.83E+05
25.225	7.17E+04	1.59E+05	2.82E+05	3.63E+05
25.375	2.14E+05	7.88E+05	1.95E+06	2.52E+06
25.525	2.82E+05	9.60E+05	2.09E+06	1.99E+06
25.675	6.02E+04	5.79E+05	8.36E+05	1.61E+06
25.825	7.74E+05	1.57E+06	2.94E+06	4.20E+06
25.975	1.16E+05	6.19E+05	2.00E+06	2.17E+06

26.125	4.77E+05	1.97E+06	3.11E+06	4.32E+06
26.275	1.47E+06	3.00E+06	2.34E+06	3.58E+06
26.425	6.41E+04	7.16E+05	6.39E+05	1.38E+06
26.575	1.84E+06	2.57E+06	5.42E+06	5.82E+06
26.725	9.30E+05	2.51E+06	4.04E+06	5.64E+06
26.875	4.60E+04	2.85E+06	4.57E+06	6.12E+06
27.025	1.41E+06	3.45E+06	7.13E+06	7.53E+06
27.175	4.68E+04	2.96E+06	5.91E+06	6.16E+06
27.325	4.25E+05	1.50E+06	2.03E+06	3.16E+06
27.475	8.05E+05	2.15E+06	4.27E+06	5.69E+06
27.625	4.15E+04	7.51E+05	1.61E+06	2.73E+06
27.775	5.61E+05	1.68E+06	1.79E+06	3.45E+06
27.925	3.30E+05	1.67E+06	2.50E+06	3.39E+06
28.075	2.98E+04	2.58E+05	2.13E+05	4.58E+05
28.225	5.97E+05	1.14E+06	1.95E+06	2.74E+06
28.375	4.63E+04	6.14E+05	1.53E+06	2.25E+06
28.525	1.15E+05	4.74E+05	8.81E+05	1.06E+06
28.675	2.78E+05	8.41E+05	1.29E+06	1.19E+06
28.825	3.65E+04	1.77E+05	4.98E+05	5.97E+05
28.975	1.51E+05	3.03E+05	6.61E+05	9.39E+05
29.125	1.22E+05	2.47E+05	7.02E+05	9.21E+05
29.275	3.89E+04	1.29E+04	4.41E+04	2.28E+05
29.425	1.32E+05	2.43E+05	2.95E+05	3.00E+05
29.575	6.79E+04	1.32E+05	2.30E+05	3.05E+05
29.725	4.49E+04	1.04E+05	2.37E+05	3.93E+05
29.875	6.86E+04	2.02E+05	4.61E+05	4.97E+05
30.025	5.56E+04	6.80E+04	2.19E+05	4.27E+05

Aluminum Cone 2

Time(s)	dx005_mises(Pa)	dx010_mises(Pa)	dx015_mises(Pa)	dx020_mises(Pa)
2.50E-02	0	0	0	0
1.75E-01	4.64E+05	1.19E+06	1.90E+06	2.60E+06
3.25E-01	2.91E+05	9.24E+05	1.37E+06	1.42E+06
4.75E-01	3.60E+05	6.73E+05	1.49E+06	2.22E+06
6.25E-01	3.44E+05	5.43E+05	1.36E+06	1.05E+06
7.75E-01	1.52E+05	1.30E+06	5.33E+05	3.82E+06
9.25E-	1.18E+05	8.53E+05	3.10E+06	4.15E+06

01				
1.07501	7.76E+04	1.05E+06	2.48E+06	1.41E+06
1.225	9.36E+04	1.18E+06	2.35E+06	6.18E+06
1.375	5.69E+04	1.16E+05	4.66E+06	4.46E+06
1.525	9.59E+03	2.31E+06	1.34E+06	4.74E+06
1.67501	1.31E+05	1.70E+06	3.97E+06	3.79E+06
1.82501	3.93E+05	9.62E+05	4.05E+06	6.29E+06
1.97501	6.03E+05	4.02E+06	3.17E+06	6.02E+06
2.125	2.49E+05	1.17E+06	5.24E+06	7.59E+06
2.275	2.98E+04	2.11E+06	5.43E+06	4.29E+06
2.425	2.06E+04	3.33E+06	9.36E+05	2.95E+06
2.575	4.20E+05	3.73E+05	3.44E+06	4.71E+06
2.725	5.07E+05	2.61E+06	3.05E+06	1.45E+06
2.875	1.20E+04	2.37E+06	2.48E+06	3.94E+06
3.02501	7.53E+03	5.30E+05	2.90E+06	3.17E+06
3.17501	8.57E+05	1.47E+06	7.36E+05	1.68E+06
3.32501	6.20E+04	5.95E+05	2.16E+06	2.93E+06
3.47501	2.04E+04	9.70E+05	2.01E+06	1.17E+06
3.62501	1.30E+06	1.46E+06	3.52E+05	9.35E+05
3.77501	1.11E+05	1.49E+05	7.40E+05	1.16E+06
3.92501	1.58E+04	6.52E+05	6.69E+05	2.59E+05
4.075	1.15E+06	5.15E+05	5.55E+05	7.78E+05
4.225	2.46E+04	9.09E+04	5.69E+05	5.78E+05
4.37501	5.40E+04	3.03E+05	2.21E+05	3.20E+05
4.52501	7.77E+05	1.77E+05	3.88E+05	6.28E+05
4.67501	3.11E+04	1.14E+05	4.19E+05	4.10E+05
4.825	3.55E+05	2.33E+05	1.46E+05	3.87E+05
4.975	5.16E+05	5.89E+04	2.97E+05	5.66E+05
5.12501	2.93E+04	1.64E+05	3.03E+05	3.69E+05
5.27501	2.39E+05	1.94E+05	2.50E+05	4.23E+05
5.42501	2.39E+05	3.61E+04	2.61E+05	3.59E+05
5.575	2.08E+04	1.53E+05	1.50E+05	3.07E+05
5.725	1.56E+05	1.02E+05	3.87E+05	4.47E+05
5.87501	7.23E+04	1.19E+05	4.12E+05	3.12E+05
6.02501	1.13E+04	2.07E+05	2.22E+05	7.92E+05
6.17501	1.15E+05	1.58E+05	6.11E+05	9.24E+05
6.325	2.49E+04	2.21E+05	7.16E+05	2.15E+05
6.475	2.29E+04	4.08E+05	4.07E+05	1.57E+06
6.62501	9.30E+04	1.24E+05	1.27E+06	1.65E+06
6.77501	4.75E+04	7.44E+05	1.03E+06	1.08E+06
6.92501	4.12E+04	8.52E+05	1.16E+06	2.06E+06
7.075	5.47E+04	1.71E+05	1.34E+06	1.75E+06
7.225	6.36E+04	1.12E+06	2.54E+05	2.89E+06

7.37501	5.65E+04	5.92E+05	2.46E+06	2.34E+06
7.52501	6.68E+04	1.03E+06	1.58E+06	8.88E+05
7.67501	7.79E+04	1.22E+06	2.28E+06	5.49E+06
7.825	1.17E+05	8.91E+04	4.75E+06	3.78E+06
7.975	1.27E+05	2.65E+06	1.56E+06	3.79E+06
8.12501	9.40E+04	1.94E+06	4.89E+06	7.71E+06
8.27501	1.47E+05	7.75E+05	5.19E+06	6.01E+06
8.42501	1.07E+05	3.91E+06	3.51E+06	6.06E+06
8.575	9.81E+04	1.51E+06	3.93E+06	6.43E+06
8.725	3.44E+05	1.84E+06	4.78E+06	6.31E+06
8.87501	1.01E+05	2.92E+06	9.61E+05	2.44E+06
9.02501	1.22E+05	4.36E+05	2.66E+06	4.10E+06
9.17501	4.31E+05	1.61E+06	2.81E+06	2.08E+06
9.325	8.01E+04	1.50E+06	1.27E+06	3.51E+06
9.475	5.27E+05	2.23E+05	2.57E+06	3.97E+06
9.62501	2.23E+05	1.62E+06	1.92E+06	9.20E+05
9.77501	5.61E+04	1.09E+06	1.44E+06	1.77E+06
9.92501	1.14E+06	4.22E+05	1.57E+06	1.74E+06
10.075	4.32E+04	1.08E+06	6.20E+05	1.33E+06
10.225	1.28E+06	4.47E+05	1.48E+06	1.81E+06
10.375	6.91E+05	6.12E+05	1.33E+06	8.22E+05
10.525	9.24E+03	8.21E+05	1.46E+05	7.56E+05
10.675	1.12E+06	1.05E+05	5.50E+05	8.87E+05
10.825	1.99E+04	3.34E+05	4.83E+05	2.85E+05
10.975	1.62E+05	2.80E+05	2.12E+05	4.14E+05
11.125	9.69E+05	3.97E+04	3.84E+05	4.35E+05
11.275	4.28E+04	1.98E+05	1.78E+05	2.61E+05
11.425	2.78E+05	1.10E+05	3.03E+05	5.45E+05
11.575	4.80E+05	7.91E+04	4.10E+05	4.51E+05
11.725	3.88E+04	2.14E+05	1.88E+05	4.58E+05
11.875	3.94E+05	7.80E+04	2.87E+05	5.70E+05
12.025	1.88E+05	1.16E+05	2.26E+05	2.45E+05
12.175	3.84E+04	1.38E+05	2.31E+05	4.65E+05
12.325	2.23E+05	4.01E+04	3.41E+05	4.86E+05
12.475	1.69E+04	1.73E+05	2.83E+05	4.72E+05
12.625	2.93E+04	1.49E+05	4.61E+05	6.37E+05
12.775	1.74E+05	1.30E+05	5.97E+05	4.62E+05
12.925	2.10E+04	4.43E+05	2.34E+05	1.12E+06
13.075	3.70E+04	1.66E+05	1.24E+06	1.43E+06
13.225	7.31E+04	5.27E+05	1.42E+06	5.78E+05
13.375	3.54E+04	8.70E+05	3.43E+05	2.62E+06
13.525	4.05E+04	9.44E+04	1.94E+06	2.71E+06
13.675	5.41E+04	8.32E+05	1.54E+06	8.13E+05

13.825	6.64E+04	7.98E+05	1.90E+06	3.84E+06
13.975	5.52E+04	6.09E+05	1.76E+06	3.35E+06
14.125	7.91E+04	1.35E+06	6.77E+05	3.89E+06
14.275	9.55E+04	4.94E+05	4.22E+06	3.49E+06
14.425	1.81E+05	1.79E+06	2.93E+06	2.41E+06
14.575	1.08E+05	2.61E+06	2.28E+06	6.77E+06
14.725	9.91E+04	4.85E+05	6.11E+06	5.24E+06
14.875	1.50E+05	3.58E+06	4.28E+06	5.63E+06
15.025	1.07E+05	2.83E+06	3.88E+06	6.95E+06
15.175	1.21E+05	1.39E+06	5.29E+06	7.37E+06
15.325	3.26E+05	2.19E+06	4.88E+06	1.34E+06
15.475	1.39E+05	1.94E+06	1.78E+06	5.87E+06
15.625	1.10E+05	9.43E+05	3.08E+06	5.31E+06
15.775	4.28E+05	1.87E+06	2.42E+06	1.71E+06
15.925	1.54E+05	8.25E+05	2.24E+06	3.44E+06
16.075	9.50E+04	1.40E+06	2.25E+06	2.60E+06
16.225	6.69E+05	1.96E+06	9.17E+05	1.47E+06
16.375	7.40E+04	2.09E+05	2.09E+06	1.83E+06
16.525	7.87E+05	1.20E+06	1.78E+06	7.62E+05
16.675	2.26E+05	1.05E+06	3.77E+05	1.31E+06
16.825	1.81E+05	1.60E+05	8.94E+05	1.39E+06
16.975	1.44E+06	7.33E+05	5.64E+05	3.92E+05
17.125	3.80E+04	4.78E+05	7.54E+05	6.21E+05
17.275	1.24E+06	2.03E+05	8.42E+05	6.60E+05
17.425	3.64E+05	4.90E+05	2.04E+05	4.14E+05
17.575	6.75E+04	9.55E+04	3.39E+05	6.75E+05
17.725	8.61E+05	1.43E+05	3.67E+05	3.54E+05
17.875	9.39E+04	1.54E+05	1.14E+05	4.06E+05
18.025	1.03E+05	2.01E+04	2.72E+05	5.39E+05
18.175	8.32E+05	2.35E+05	2.58E+05	3.43E+05
18.325	1.22E+05	1.71E+05	2.04E+05	4.51E+05
18.475	1.03E+05	7.55E+04	3.49E+05	3.29E+05
18.625	5.21E+05	2.12E+05	1.78E+05	4.01E+05
18.775	1.48E+05	7.52E+04	4.20E+05	6.22E+05
18.925	9.47E+04	1.03E+05	5.53E+05	4.12E+05
19.075	2.63E+05	1.54E+05	5.41E+05	7.05E+05
19.225	6.99E+04	3.42E+04	4.14E+05	8.76E+05
19.375	1.51E+05	4.00E+05	4.46E+05	1.50E+05
19.525	1.65E+05	4.22E+05	3.70E+05	1.30E+06
19.675	4.15E+04	1.04E+05	1.19E+06	1.22E+06
19.825	7.28E+04	8.75E+05	9.68E+05	1.40E+06
19.975	3.43E+04	4.21E+05	8.49E+05	1.89E+06
20.125	2.96E+04	5.66E+05	2.28E+06	1.17E+06

20.275	5.29E+04	1.04E+06	7.49E+05	3.68E+06
20.425	7.44E+04	7.94E+04	2.62E+06	3.72E+06
20.575	7.58E+04	1.35E+06	2.66E+06	4.26E+05
20.725	8.60E+04	1.17E+06	2.67E+06	5.97E+06
20.875	1.14E+05	3.73E+05	3.07E+06	5.30E+06
21.025	1.26E+05	3.20E+06	1.40E+06	4.42E+06
21.175	1.81E+05	1.03E+06	7.10E+06	6.27E+06
21.325	2.11E+05	2.40E+06	5.37E+06	5.57E+06
21.475	2.21E+05	3.72E+06	3.35E+06	5.98E+06
21.625	1.67E+05	7.42E+05	5.38E+06	5.53E+06
21.775	1.50E+05	2.08E+06	6.76E+06	5.09E+06
21.925	1.49E+05	2.89E+06	1.03E+06	4.03E+06
22.075	1.50E+05	3.08E+05	3.36E+06	4.52E+06
22.225	1.48E+05	1.98E+06	3.75E+06	1.30E+06
22.375	1.84E+05	1.61E+06	1.03E+06	4.26E+06
22.525	2.20E+05	3.76E+05	1.90E+06	3.91E+06
22.675	2.33E+05	2.27E+06	2.11E+06	7.45E+05
22.825	1.93E+05	7.80E+05	1.18E+06	2.61E+06
22.975	1.39E+05	6.71E+05	1.70E+06	2.06E+06
23.125	1.28E+05	1.42E+06	9.71E+05	8.15E+05
23.275	1.27E+05	2.43E+05	1.15E+06	1.20E+06
23.425	1.14E+05	5.14E+05	1.22E+06	8.01E+05
23.575	9.70E+04	5.18E+05	1.71E+05	6.02E+05
23.725	8.80E+04	5.23E+04	7.52E+05	6.25E+05
23.875	1.02E+05	3.61E+05	6.80E+05	2.42E+05
24.025	9.35E+04	1.97E+05	1.57E+05	4.82E+05
24.175	8.32E+04	6.61E+04	3.41E+05	4.89E+05
24.325	1.15E+05	2.52E+05	2.74E+05	3.01E+05
24.475	8.19E+04	1.31E+05	2.19E+05	4.54E+05
24.625	7.00E+04	9.00E+04	3.38E+05	4.26E+05
24.775	7.23E+04	1.85E+05	2.01E+05	4.49E+05
24.925	1.42E+05	1.37E+05	2.75E+05	5.68E+05
25.075	1.59E+05	1.21E+05	2.11E+05	1.79E+05
25.225	9.29E+04	1.80E+05	2.38E+05	5.17E+05
25.375	7.07E+04	1.20E+05	6.31E+05	5.23E+05
25.525	6.18E+04	2.39E+05	6.73E+05	3.75E+05
25.675	6.06E+04	3.93E+05	2.37E+05	7.40E+05
25.825	8.67E+04	3.18E+05	4.82E+05	4.40E+05
25.975	1.18E+05	2.68E+05	5.10E+05	1.25E+06
26.125	1.34E+05	3.61E+05	8.99E+05	1.87E+06
26.275	1.66E+05	2.47E+05	8.83E+05	7.80E+05
26.425	1.04E+05	5.68E+05	3.77E+05	2.27E+06
26.575	1.03E+05	7.27E+05	2.05E+06	2.47E+06

26.725	6.07E+04	2.42E+05	1.66E+06	1.40E+06
26.875	5.80E+04	1.27E+06	1.64E+06	2.93E+06
27.025	6.39E+04	2.07E+05	3.40E+06	2.11E+06
27.175	6.39E+04	1.34E+06	6.75E+05	4.79E+06
27.325	6.52E+04	9.27E+05	3.43E+06	4.33E+06
27.475	6.43E+04	1.89E+06	2.83E+06	1.57E+06
27.625	7.77E+04	2.93E+06	3.98E+06	7.71E+06
27.775	1.23E+05	5.63E+05	5.36E+06	6.52E+06
27.925	1.58E+05	3.61E+06	4.31E+06	5.04E+06
28.075	1.09E+05	3.19E+06	4.14E+06	6.91E+06
28.225	8.17E+04	1.66E+06	6.03E+06	8.08E+06
28.375	7.29E+04	2.49E+06	5.88E+06	1.67E+06
28.525	7.35E+04	2.55E+06	2.66E+06	4.52E+06
28.675	7.45E+04	5.08E+05	4.97E+06	4.66E+06
28.825	6.85E+04	1.75E+06	2.81E+06	2.30E+06
28.975	1.12E+05	1.32E+06	1.86E+06	2.92E+06
29.125	1.12E+05	8.75E+05	2.90E+06	2.37E+06
29.275	9.18E+04	1.86E+06	9.20E+05	2.34E+06
29.425	9.76E+04	6.04E+05	1.30E+06	2.24E+06
29.575	1.01E+05	1.01E+06	1.35E+06	2.66E+05
29.725	1.03E+05	1.30E+06	4.88E+05	1.79E+06
29.875	1.05E+05	1.75E+05	1.15E+06	1.53E+06
30.025	1.04E+05	6.06E+05	6.21E+05	3.22E+05

Steel Cone 1

Time(s)	dx005_mises(Pa)	dx010_mises(Pa)	dx015_mises(Pa)	dx020_mises(Pa)
2.50E-02	0	0	0	0
1.75E-01	3.00E+05	1.11E+06	1.91E+06	2.72E+06
3.25E-01	1.37E+05	1.42E+06	2.19E+06	3.22E+06
4.75E-01	8.72E+05	2.31E+06	2.15E+06	2.67E+06
6.25E-01	2.76E+05	5.60E+05	8.34E+05	9.82E+05
7.75E-01	1.25E+06	3.27E+06	5.28E+06	6.03E+06
9.25E-01	6.40E+05	1.79E+06	4.09E+06	2.14E+06
1.075	4.74E+05	3.19E+06	3.72E+06	5.94E+06
1.22501	2.25E+06	5.09E+06	3.82E+06	7.17E+06
1.37501	7.22E+04	1.98E+06	4.23E+06	6.50E+06

1.525	1.04E+06	2.69E+06	5.20E+06	6.26E+06
1.67501	7.53E+05	2.80E+06	4.16E+06	6.11E+06
1.82501	1.35E+05	2.03E+05	4.83E+05	1.08E+06
1.975	1.03E+06	2.76E+06	4.70E+06	3.47E+06
2.12501	1.24E+05	1.53E+06	2.69E+06	3.82E+06
2.27501	2.41E+05	8.68E+05	1.80E+06	3.10E+06
2.425	5.93E+05	1.25E+06	3.03E+06	3.50E+06
2.575	1.33E+05	3.25E+05	6.63E+05	1.41E+06
2.72501	5.67E+05	1.11E+06	1.26E+06	2.67E+06
2.875	2.74E+05	1.00E+06	1.34E+06	2.56E+06
3.025	1.48E+05	1.83E+05	4.25E+05	3.08E+05
3.17501	5.17E+05	7.96E+05	1.07E+06	1.13E+06
3.325	1.37E+05	2.87E+05	5.56E+05	8.95E+05
3.475	1.85E+05	3.32E+05	6.47E+05	6.52E+05
3.62501	2.43E+05	3.90E+05	8.08E+05	7.71E+05
3.77501	9.34E+04	1.62E+05	2.67E+05	4.79E+05
3.925	1.93E+05	2.38E+05	3.26E+05	4.75E+05
4.07501	7.45E+04	1.12E+05	2.39E+05	3.86E+05
4.225	1.08E+05	1.06E+05	2.10E+05	3.85E+05
4.375	9.64E+04	2.43E+05	2.95E+05	7.00E+05
4.52501	7.34E+04	1.06E+05	2.62E+05	5.59E+05
4.67501	1.99E+04	1.21E+05	3.73E+05	5.34E+05
4.82501	1.37E+05	1.98E+05	3.80E+05	4.66E+05
4.97501	9.07E+04	1.21E+05	1.02E+05	2.10E+05
5.125	1.33E+05	1.97E+05	3.56E+05	3.99E+05
5.275	1.54E+05	2.08E+05	3.42E+05	2.72E+05
5.425	6.30E+04	1.29E+05	3.27E+05	6.35E+05
5.57501	8.25E+04	3.15E+05	4.04E+05	8.34E+05
5.72501	7.35E+04	9.09E+04	1.51E+05	3.57E+05
5.87501	1.64E+05	5.36E+05	9.16E+05	1.10E+06
6.02501	2.40E+05	7.05E+05	1.15E+06	8.64E+05
6.175	8.57E+04	1.06E+05	5.94E+05	6.80E+05
6.325	3.46E+05	1.17E+06	1.44E+06	3.12E+06
6.47501	9.65E+04	7.21E+05	7.94E+05	2.21E+06
6.62501	1.36E+05	9.67E+05	2.38E+06	2.72E+06
6.77501	6.94E+05	1.86E+06	3.97E+06	2.27E+06
6.92501	7.42E+04	1.10E+05	3.30E+05	5.73E+05
7.075	8.20E+05	2.39E+06	3.19E+06	6.24E+06
7.225	8.04E+05	1.90E+06	2.65E+06	4.98E+06
7.375	7.66E+04	8.96E+05	3.26E+06	4.53E+06
7.52501	2.56E+06	3.96E+06	5.81E+06	6.24E+06
7.67501	7.07E+04	1.80E+06	4.11E+06	5.64E+06
7.82501	3.56E+05	1.73E+06	4.00E+06	6.18E+06

7.97501	1.33E+06	2.14E+06	6.36E+06	5.25E+06
8.125	3.18E+04	7.54E+05	1.60E+06	3.94E+06
8.27501	8.56E+05	2.27E+06	2.62E+06	4.81E+06
8.42501	5.42E+05	2.04E+06	3.44E+06	4.71E+06
8.57501	3.50E+04	5.01E+05	1.19E+06	1.32E+06
8.72501	7.17E+05	1.94E+06	2.42E+06	4.36E+06
8.87501	4.52E+04	6.78E+05	1.46E+06	2.50E+06
9.02501	2.68E+05	7.78E+05	1.86E+06	1.47E+06
9.17501	4.30E+05	8.68E+05	2.04E+06	2.10E+06
9.32501	5.30E+04	8.90E+04	1.98E+05	1.91E+05
9.47501	4.10E+05	6.05E+05	1.05E+06	1.01E+06
9.62501	7.03E+04	3.06E+05	8.88E+05	8.76E+05
9.77501	5.18E+04	2.78E+05	3.53E+05	7.36E+05
9.92501	2.68E+05	4.42E+05	4.83E+05	9.16E+05
10.075	2.49E+04	8.43E+04	2.82E+05	4.34E+05
10.225	9.41E+04	1.68E+05	2.82E+05	4.48E+05
10.375	5.51E+04	1.74E+05	2.68E+05	4.52E+05
10.525	3.22E+04	5.90E+04	1.70E+05	3.37E+05
10.675	7.06E+04	1.34E+05	4.41E+05	5.31E+05
10.825	6.01E+04	6.52E+04	2.15E+05	4.51E+05
10.975	6.14E+04	1.60E+05	2.42E+05	5.30E+05
11.125	7.92E+04	1.49E+05	2.36E+05	4.18E+05
11.275	1.09E+05	1.79E+05	1.90E+05	2.44E+05
11.425	1.61E+05	3.47E+05	3.22E+05	5.49E+05
11.575	1.36E+05	2.18E+05	1.70E+05	2.90E+05
11.725	9.94E+04	1.51E+05	5.31E+05	6.87E+05
11.875	1.08E+05	1.98E+05	6.53E+05	7.42E+05
12.025	1.44E+05	2.76E+05	3.53E+05	6.21E+05
12.175	3.18E+05	7.22E+05	1.20E+06	1.06E+06
12.325	1.61E+05	3.10E+05	7.86E+05	7.59E+05
12.475	1.88E+05	9.38E+05	1.25E+06	2.13E+06
12.625	3.67E+05	1.29E+06	1.08E+06	1.72E+06
12.775	1.45E+05	3.55E+05	7.25E+05	1.39E+06
12.925	5.69E+05	1.56E+06	2.57E+06	3.06E+06
13.075	1.58E+05	8.06E+05	1.74E+06	1.35E+06
13.225	2.92E+05	1.49E+06	3.00E+06	5.62E+06
13.375	1.01E+06	1.85E+06	2.76E+06	5.28E+06
13.525	1.27E+05	3.53E+05	5.16E+05	2.67E+06
13.675	1.91E+06	2.88E+06	7.46E+06	7.83E+06
13.825	1.54E+05	1.92E+06	4.76E+06	6.65E+06
13.975	2.06E+05	2.02E+06	4.23E+06	6.40E+06
14.125	1.65E+06	3.45E+06	4.43E+06	5.20E+06
14.275	8.10E+04	6.63E+05	3.21E+06	4.61E+06

14.425	6.31E+05	2.50E+06	3.88E+06	5.61E+06
14.575	3.80E+05	2.21E+06	3.70E+06	5.53E+06
14.725	6.08E+04	3.72E+05	6.44E+05	1.09E+06
14.875	7.04E+05	1.59E+06	3.13E+06	3.31E+06
15.025	7.17E+04	5.46E+05	1.83E+06	2.65E+06
15.175	3.41E+05	1.04E+06	1.07E+06	1.47E+06
15.325	4.58E+05	1.25E+06	1.37E+06	1.85E+06
15.475	4.24E+04	9.65E+04	1.94E+05	2.71E+05
15.625	3.34E+05	6.32E+05	1.05E+06	1.51E+06
15.775	8.36E+04	4.11E+05	6.86E+05	1.06E+06
15.925	6.14E+04	1.59E+05	4.41E+05	5.29E+05
16.075	2.12E+05	2.60E+05	7.47E+05	9.12E+05
16.225	5.30E+04	6.08E+04	2.51E+05	5.34E+05
16.375	1.06E+05	2.46E+05	2.42E+05	2.96E+05
16.525	1.61E+05	3.19E+05	3.35E+05	3.91E+05
16.675	9.21E+04	1.60E+05	1.25E+05	2.14E+05
16.825	5.74E+04	1.64E+05	2.60E+05	4.60E+05
16.975	8.11E+04	1.86E+05	2.38E+05	4.71E+05
17.125	1.06E+05	1.32E+05	1.53E+05	4.04E+05
17.275	1.29E+05	1.78E+05	3.79E+05	6.33E+05
17.425	1.32E+05	1.93E+05	1.82E+05	3.92E+05
17.575	1.48E+05	3.06E+05	2.88E+05	3.67E+05
17.725	2.16E+05	4.15E+05	4.58E+05	5.20E+05
17.875	1.70E+05	2.78E+05	2.35E+05	3.02E+05
18.025	1.13E+05	1.55E+05	3.41E+05	5.16E+05
18.175	8.36E+04	3.23E+05	3.43E+05	3.89E+05
18.325	1.80E+05	3.05E+05	2.37E+05	3.85E+05
18.475	3.52E+05	7.02E+05	1.10E+06	1.41E+06
18.625	3.03E+05	6.36E+05	7.53E+05	8.98E+05
18.775	2.01E+05	3.24E+05	8.75E+05	1.39E+06
18.925	4.76E+05	9.41E+05	2.37E+06	2.87E+06
19.075	2.14E+05	4.78E+05	1.14E+06	1.36E+06
19.225	2.22E+05	1.08E+06	1.98E+06	2.90E+06
19.375	7.35E+05	2.11E+06	2.52E+06	3.15E+06
19.525	1.92E+05	2.73E+05	3.95E+05	4.29E+05
19.675	7.56E+05	2.21E+06	3.26E+06	4.19E+06
19.825	1.05E+06	2.40E+06	2.05E+06	2.45E+06
19.975	1.82E+05	7.12E+05	1.53E+06	3.46E+06
20.125	2.01E+06	2.59E+06	6.20E+06	6.89E+06
20.275	5.11E+05	2.03E+06	4.29E+06	5.77E+06
20.425	1.49E+05	1.21E+06	3.61E+06	5.59E+06
20.575	1.11E+06	3.07E+06	4.85E+06	5.13E+06
20.725	1.65E+05	1.67E+06	2.88E+06	5.83E+06

20.875	3.13E+05	1.57E+06	3.09E+06	4.92E+06
21.025	9.70E+05	2.20E+06	5.27E+06	6.96E+06
21.175	1.77E+05	6.95E+05	1.61E+06	3.22E+06
21.325	2.99E+05	1.39E+06	2.12E+06	2.39E+06
21.475	5.78E+05	2.29E+06	2.77E+06	3.49E+06
21.625	1.78E+05	3.21E+05	7.45E+05	1.29E+06
21.775	4.93E+05	9.01E+05	1.97E+06	2.30E+06
21.925	4.13E+05	9.33E+05	1.70E+06	2.02E+06
22.075	1.84E+05	8.67E+04	1.50E+05	1.51E+05
22.225	4.07E+05	8.08E+05	1.24E+06	1.52E+06
22.375	2.48E+05	5.57E+05	1.00E+06	1.32E+06
22.525	1.77E+05	8.81E+04	1.86E+05	3.21E+05
22.675	2.72E+05	3.31E+05	3.50E+05	6.45E+05
22.825	1.46E+05	1.18E+05	3.31E+05	6.11E+05
22.975	1.66E+05	1.93E+05	2.62E+05	3.10E+05
23.125	2.49E+05	2.73E+05	3.85E+05	4.20E+05
23.275	1.61E+05	2.28E+05	2.12E+05	2.86E+05
23.425	1.20E+05	1.34E+05	3.13E+05	5.39E+05
23.575	1.04E+05	2.00E+05	4.17E+05	6.27E+05
23.725	1.49E+05	1.66E+05	9.82E+04	3.44E+05
23.875	1.33E+05	1.92E+05	2.51E+05	4.97E+05
24.025	1.61E+05	2.07E+05	2.32E+05	4.34E+05
24.175	1.68E+05	3.07E+05	2.93E+05	3.26E+05
24.325	2.24E+05	3.95E+05	4.38E+05	4.27E+05
24.475	2.03E+05	3.64E+05	2.97E+05	3.45E+05
24.625	1.76E+05	1.68E+05	3.48E+05	5.70E+05
24.775	7.54E+04	2.15E+05	5.97E+05	5.63E+05
24.925	2.16E+05	2.98E+05	1.50E+05	8.75E+04
25.075	2.95E+05	7.46E+05	1.02E+06	1.56E+06
25.225	3.88E+05	9.78E+05	1.16E+06	1.66E+06
25.375	2.63E+05	3.08E+05	5.82E+05	7.39E+05
25.525	2.69E+05	9.03E+05	1.32E+06	2.19E+06
25.675	3.70E+05	9.08E+05	9.86E+05	2.05E+06
25.825	2.80E+05	8.04E+05	1.85E+06	2.47E+06
25.975	7.34E+05	1.29E+06	2.80E+06	2.52E+06
26.125	2.79E+05	5.65E+05	8.44E+05	1.45E+06
26.275	3.79E+05	1.98E+06	3.82E+06	5.71E+06
26.425	1.06E+06	2.82E+06	5.00E+06	5.18E+06
26.575	2.93E+05	3.77E+05	1.01E+06	1.22E+06
26.725	6.07E+05	3.20E+06	4.21E+06	7.57E+06
26.875	9.14E+05	3.12E+06	4.94E+06	6.55E+06
27.025	2.68E+05	1.32E+06	3.42E+06	5.56E+06
27.175	1.40E+06	1.87E+06	4.08E+06	6.20E+06

27.325	4.74E+05	1.92E+06	3.72E+06	7.04E+06
27.475	2.47E+05	7.11E+05	2.05E+06	2.31E+06
27.625	1.14E+06	2.44E+06	4.46E+06	3.37E+06
27.775	3.70E+05	1.35E+06	3.00E+06	3.83E+06
27.925	2.29E+05	9.52E+05	1.60E+06	2.11E+06
28.075	6.64E+05	2.08E+06	3.04E+06	3.35E+06
28.225	2.25E+05	7.12E+05	1.56E+06	2.00E+06
28.375	2.11E+05	7.23E+05	1.65E+06	2.01E+06
28.525	5.10E+05	8.68E+05	2.07E+06	2.09E+06
28.675	2.14E+05	1.69E+05	3.40E+05	7.55E+05
28.825	2.97E+05	6.76E+05	1.04E+06	1.82E+06
28.975	3.68E+05	6.69E+05	1.09E+06	1.71E+06
29.125	1.90E+05	1.54E+05	1.24E+05	2.15E+05
29.275	2.40E+05	2.26E+05	6.00E+05	5.47E+05
29.425	1.63E+05	1.18E+05	3.91E+05	6.18E+05
29.575	1.75E+05	1.78E+05	1.63E+05	2.38E+05
29.725	2.23E+05	4.00E+05	4.97E+05	5.74E+05
29.875	1.80E+05	3.01E+05	3.87E+05	3.83E+05
30.025	1.57E+05	1.49E+05	1.69E+05	3.62E+05

Steel Cone 2

Time(s)	dx005_mises(Pa)	dx010_mises(Pa)	dx015_mises(Pa)	dx020_mises(Pa)
2.50E-02	0	0	0	0
1.75E-01	5.82E+05	1.39E+06	2.13E+06	2.58E+06
3.25E-01	2.39E+05	8.23E+05	1.44E+06	1.95E+06
4.75E-01	3.76E+05	1.01E+06	1.19E+06	6.09E+05
6.25E-01	3.17E+05	7.14E+05	9.67E+05	2.27E+06
7.75E-01	2.78E+05	4.02E+05	2.01E+06	1.49E+06
9.25E-01	3.79E+05	5.14E+05	1.39E+06	3.46E+06
1.075	2.11E+05	1.11E+06	1.98E+06	2.67E+06
1.22501	1.51E+05	1.25E+06	1.50E+06	1.89E+06
1.37501	7.73E+04	3.21E+05	1.36E+06	5.78E+06
1.525	4.43E+04	1.08E+06	4.53E+06	5.19E+06
1.67501	1.80E+04	1.60E+06	1.89E+06	3.28E+06
1.82501	2.81E+04	2.47E+05	3.33E+06	6.37E+06
1.975	4.47E+04	2.54E+06	5.45E+06	6.09E+06

2.12501	2.66E+04	2.29E+06	4.11E+06	6.63E+06
2.27501	2.19E+04	8.44E+05	4.80E+06	7.51E+06
2.425	6.30E+04	3.26E+06	4.76E+06	2.38E+06
2.575	2.18E+05	1.56E+06	1.14E+06	5.06E+06
2.72501	4.86E+05	1.89E+06	4.82E+06	6.00E+06
2.875	5.19E+05	4.14E+06	4.51E+06	1.22E+06
3.025	4.50E+05	7.22E+05	1.02E+06	3.02E+06
3.17501	3.37E+05	2.02E+06	2.10E+06	2.64E+06
3.325	5.07E+04	1.96E+06	1.67E+06	2.12E+06
3.475	1.33E+04	1.92E+05	1.83E+06	3.09E+06
3.62501	8.46E+03	1.88E+06	2.18E+06	1.34E+06
3.77501	1.13E+04	8.77E+05	3.66E+05	9.01E+05
3.925	2.16E+05	4.33E+05	1.02E+06	1.18E+06
4.07501	3.99E+05	1.39E+06	9.86E+05	2.02E+05
4.225	6.43E+05	3.28E+05	2.22E+05	6.71E+05
4.375	6.88E+05	4.05E+05	3.94E+05	6.88E+05
4.52501	1.58E+05	4.11E+05	4.15E+05	2.38E+05
4.67501	1.51E+04	5.90E+04	2.27E+05	5.25E+05
4.82501	2.30E+04	3.89E+05	3.78E+05	3.83E+05
4.97501	1.45E+04	2.96E+05	1.82E+05	4.04E+05
5.125	6.84E+05	5.72E+04	3.03E+05	6.42E+05
5.275	9.08E+05	2.61E+05	4.03E+05	3.37E+05
5.425	5.00E+05	1.48E+05	1.91E+05	4.20E+05
5.57501	2.58E+04	8.14E+04	3.46E+05	4.11E+05
5.72501	3.98E+04	2.06E+05	3.06E+05	2.81E+05
5.87501	4.59E+04	7.12E+04	1.68E+05	4.70E+05
6.02501	8.37E+05	1.55E+05	2.63E+05	3.73E+05
6.175	1.48E+06	1.49E+05	2.02E+05	6.10E+05
6.325	7.95E+05	6.64E+04	5.62E+05	7.10E+05
6.47501	7.05E+04	2.15E+05	5.84E+05	3.39E+05
6.62501	7.31E+04	1.74E+05	1.88E+05	1.48E+06
6.77501	1.12E+05	1.32E+05	1.23E+06	1.66E+06
6.92501	1.24E+06	4.72E+05	1.29E+06	4.93E+05
7.075	2.49E+06	1.69E+05	4.66E+05	2.66E+06
7.225	1.71E+06	4.85E+05	2.05E+06	2.44E+06
7.375	8.78E+04	8.00E+05	1.63E+06	2.43E+06
7.52501	9.00E+04	9.15E+04	1.83E+06	2.65E+06
7.67501	9.08E+04	7.94E+05	2.04E+06	1.45E+06
7.82501	5.62E+05	6.88E+05	1.14E+06	4.72E+06
7.97501	1.10E+06	4.69E+05	3.54E+06	3.03E+06
8.125	1.13E+06	1.61E+06	2.16E+06	2.14E+06
8.27501	4.80E+05	4.08E+05	2.60E+06	7.88E+06
8.42501	1.07E+05	2.08E+06	6.14E+06	6.27E+06

8.57501	1.06E+05	2.69E+06	4.47E+06	6.64E+06
8.72501	1.07E+05	6.68E+05	4.12E+06	8.04E+06
8.87501	1.59E+05	3.10E+06	6.03E+06	5.87E+06
9.02501	3.72E+05	2.10E+06	6.46E+05	3.14E+06
9.17501	7.14E+05	1.82E+06	2.97E+06	5.14E+06
9.32501	7.47E+05	2.06E+06	3.31E+06	8.70E+05
9.47501	8.74E+05	9.81E+05	9.55E+05	4.36E+06
9.62501	6.49E+05	1.57E+06	3.22E+06	3.37E+06
9.77501	4.82E+05	2.12E+06	2.01E+06	1.16E+06
9.92501	3.35E+05	2.25E+05	1.12E+06	2.47E+06
10.075	2.46E+05	1.35E+06	1.39E+06	1.38E+06
10.225	1.40E+05	1.00E+06	5.65E+05	1.45E+06
10.375	1.49E+05	6.65E+05	1.29E+06	1.26E+06
10.525	1.21E+05	1.48E+06	1.10E+06	1.70E+05
10.675	1.21E+05	3.09E+05	2.17E+05	1.01E+06
10.825	1.22E+05	5.71E+05	5.95E+05	7.52E+05
10.975	1.22E+05	6.21E+05	3.24E+05	2.85E+05
11.125	1.25E+05	9.79E+04	3.36E+05	4.57E+05
11.275	1.25E+05	3.84E+05	4.02E+05	2.92E+05
11.425	1.28E+05	2.18E+05	2.30E+05	4.21E+05
11.575	1.29E+05	1.20E+05	3.06E+05	4.11E+05
11.725	1.35E+05	2.71E+05	2.44E+05	2.96E+05
11.875	1.33E+05	1.17E+05	2.40E+05	5.29E+05
12.025	1.46E+05	1.43E+05	4.10E+05	2.38E+05
12.175	1.79E+05	1.70E+05	1.17E+05	4.95E+05
12.325	1.38E+05	9.73E+04	2.85E+05	6.12E+05
12.475	1.72E+05	1.89E+05	2.78E+05	2.99E+05
12.625	1.33E+05	1.17E+05	4.32E+05	7.05E+05
12.775	1.28E+05	1.92E+05	5.21E+05	6.69E+05
12.925	1.28E+05	2.60E+05	4.11E+05	1.00E+06
13.075	1.24E+05	7.52E+04	9.03E+05	9.73E+05
13.225	1.22E+05	4.04E+05	1.16E+06	3.23E+05
13.375	1.18E+05	2.82E+05	2.66E+05	2.65E+06
13.525	1.10E+05	3.20E+05	2.10E+06	1.98E+06
13.675	3.62E+05	7.67E+05	2.16E+06	2.02E+06
13.825	6.80E+05	1.32E+05	1.21E+06	4.31E+06
13.975	5.04E+05	7.51E+05	2.84E+06	1.53E+06
14.125	3.55E+05	6.75E+05	1.72E+06	4.77E+06
14.275	8.53E+04	4.68E+05	2.84E+06	4.43E+06
14.425	8.65E+04	1.85E+06	2.17E+06	3.72E+06
14.575	7.16E+04	2.77E+05	2.98E+06	5.08E+06
14.725	1.87E+05	2.12E+06	5.25E+06	5.74E+06
14.875	9.93E+05	2.91E+06	4.39E+06	6.27E+06

15.025	9.91E+05	6.76E+05	4.64E+06	6.24E+06
15.175	8.86E+05	3.38E+06	6.06E+06	5.48E+06
15.325	2.60E+05	2.41E+06	1.09E+06	5.28E+06
15.475	6.03E+04	1.64E+06	3.74E+06	5.84E+06
15.625	6.79E+04	2.15E+06	3.98E+06	5.94E+05
15.775	6.89E+04	5.91E+05	9.83E+05	4.08E+06
15.925	9.90E+05	1.99E+06	1.89E+06	3.32E+06
16.075	2.54E+06	2.15E+06	1.90E+06	1.25E+06
16.225	2.60E+06	1.66E+05	1.30E+06	1.95E+06
16.375	2.75E+06	2.12E+06	1.50E+06	1.43E+06
16.525	1.89E+06	1.76E+06	8.46E+05	1.21E+06
16.675	4.66E+05	9.35E+04	7.83E+05	1.68E+06
16.825	4.66E+05	1.23E+06	8.98E+05	6.38E+05
16.975	4.83E+05	8.17E+05	6.29E+05	4.39E+05
17.125	7.29E+05	1.51E+05	4.61E+05	5.89E+05
17.275	6.01E+05	8.48E+05	4.17E+05	1.80E+05
17.425	4.01E+05	2.73E+05	1.27E+05	5.89E+05
17.575	1.07E+06	2.38E+05	5.89E+05	5.68E+05
17.725	1.51E+06	4.47E+05	6.53E+05	2.00E+05
17.875	2.16E+06	1.47E+05	2.81E+05	6.03E+05
18.025	1.22E+06	1.21E+05	2.88E+05	5.80E+05
18.175	2.39E+06	2.09E+05	2.86E+05	3.30E+05
18.325	9.88E+05	6.12E+04	1.75E+05	3.60E+05
18.475	1.30E+05	2.13E+05	3.54E+05	2.86E+05
18.625	7.12E+04	2.60E+05	2.21E+05	3.84E+05
18.775	6.98E+04	9.50E+04	3.58E+05	4.89E+05
18.925	7.12E+04	1.83E+05	5.62E+05	2.63E+05
19.075	7.36E+04	1.40E+05	3.94E+05	8.91E+05
19.225	7.38E+04	8.20E+04	3.53E+05	1.08E+06
19.375	4.57E+05	2.10E+05	4.70E+05	2.61E+05
19.525	1.91E+05	1.83E+05	1.64E+05	1.29E+06
19.675	7.12E+05	1.28E+05	8.54E+05	1.40E+06
19.825	4.52E+05	5.49E+05	6.85E+05	8.11E+05
19.975	4.02E+05	3.50E+05	2.44E+05	1.98E+06
20.125	5.31E+05	2.44E+05	2.07E+06	1.54E+06
20.275	3.46E+05	7.68E+05	1.74E+06	2.42E+06
20.425	3.43E+05	2.78E+05	9.38E+05	3.40E+06
20.575	6.29E+04	6.82E+05	3.32E+06	1.49E+06
20.725	7.23E+04	8.86E+05	2.52E+06	5.13E+06
20.875	7.58E+04	1.66E+05	2.48E+06	5.99E+06
21.025	7.57E+04	1.52E+06	3.49E+06	1.67E+06
21.175	7.59E+04	1.53E+06	2.16E+06	6.75E+06
21.325	1.73E+05	2.49E+05	4.38E+06	6.66E+06

21.475	8.22E+05	3.09E+06	3.40E+06	6.15E+06
21.625	1.85E+06	2.09E+06	3.76E+06	5.97E+06
21.775	2.69E+06	1.11E+06	5.15E+06	6.74E+06
21.925	2.25E+06	3.40E+06	5.24E+06	2.50E+06
22.075	2.29E+06	1.86E+06	1.75E+06	3.36E+06
22.225	1.50E+06	1.75E+06	4.32E+06	4.29E+06
22.375	2.22E+06	2.21E+06	4.35E+06	7.14E+05
22.525	1.05E+06	9.28E+05	4.24E+05	3.81E+06
22.675	2.35E+06	1.42E+06	2.65E+06	3.34E+06
22.825	2.01E+06	2.33E+06	2.61E+06	5.90E+05
22.975	1.22E+06	6.21E+05	7.82E+05	2.91E+06
23.125	2.68E+06	1.60E+06	1.29E+06	2.24E+06
23.275	1.30E+06	1.89E+06	1.14E+06	6.00E+05
23.425	1.61E+06	1.76E+05	8.24E+05	1.53E+06
23.575	1.88E+06	1.08E+06	1.14E+06	1.22E+06
23.725	9.13E+05	9.82E+05	6.07E+05	3.70E+05
23.875	6.95E+04	1.31E+05	4.55E+05	5.45E+05
24.025	6.25E+04	5.13E+05	6.95E+05	3.86E+05
24.175	6.03E+04	3.47E+05	2.71E+05	4.18E+05
24.325	1.92E+05	1.53E+05	3.35E+05	5.76E+05
24.475	2.91E+05	4.41E+05	4.41E+05	2.52E+05
24.625	9.80E+05	2.04E+05	3.08E+05	4.26E+05
24.775	1.30E+06	1.21E+05	3.37E+05	4.79E+05
24.925	5.67E+05	1.95E+05	4.53E+05	3.85E+05
25.075	7.80E+04	1.20E+05	1.89E+05	6.80E+05
25.225	9.05E+04	1.26E+05	2.60E+05	5.20E+05
25.375	9.27E+04	2.29E+05	2.18E+05	1.99E+05
25.525	9.72E+04	1.06E+05	2.58E+05	4.94E+05
25.675	9.68E+04	1.65E+05	5.02E+05	4.00E+05
25.825	9.88E+04	1.93E+05	3.67E+05	7.69E+05
25.975	1.00E+05	9.30E+04	2.78E+05	7.54E+05
26.125	9.93E+04	1.98E+05	7.27E+05	5.50E+05
26.275	9.57E+04	2.07E+05	4.99E+05	1.30E+06
26.425	9.35E+04	9.17E+04	7.19E+05	1.58E+06
26.575	8.87E+04	4.24E+05	8.02E+05	3.68E+05
26.725	8.08E+04	3.90E+05	4.47E+05	2.69E+06
26.875	4.82E+05	1.92E+05	1.65E+06	2.87E+06
27.025	1.03E+06	6.46E+05	1.37E+06	1.13E+06
27.175	1.24E+06	4.24E+05	8.92E+04	3.29E+06
27.325	1.06E+06	5.16E+05	3.28E+06	2.89E+06
27.475	5.30E+05	8.22E+05	2.87E+06	3.57E+06
27.625	6.36E+04	3.07E+05	1.33E+06	4.03E+06
27.775	6.79E+04	1.30E+06	4.46E+06	2.23E+06

27.925	6.84E+04	1.70E+06	3.43E+06	7.08E+06
28.075	6.66E+04	1.63E+05	3.86E+06	6.31E+06
28.225	6.67E+04	2.61E+06	3.63E+06	6.22E+06
28.375	1.27E+05	2.45E+06	4.39E+06	7.34E+06
28.525	1.45E+06	8.12E+05	4.64E+06	8.60E+06
28.675	1.73E+06	2.82E+06	3.68E+06	6.41E+06
28.825	2.19E+06	2.43E+06	2.85E+06	3.86E+06
28.975	1.83E+06	1.67E+06	3.57E+06	6.03E+06
29.125	1.76E+06	2.14E+06	4.34E+06	2.46E+06
29.275	9.11E+05	1.75E+06	1.22E+06	2.25E+06
29.425	2.53E+05	1.01E+06	2.98E+06	3.20E+06
29.575	6.36E+04	2.54E+06	3.28E+06	1.21E+06
29.725	6.22E+04	1.04E+06	4.13E+05	2.00E+06
29.875	6.69E+04	1.07E+06	1.40E+06	1.93E+06
30.025	7.04E+04	2.02E+06	1.52E+06	3.42E+05

Carbon Fiber Cone 1

Time(s)	dx005_mises(Pa)	dx010_mises(Pa)	dx015_mises(Pa)	dx020_mises(Pa)
2.50E-02	0	0	0	0
1.75E-01	3.57E+05	5.69E+05	8.70E+05	1.32E+06
3.25E-01	3.16E+05	1.25E+06	2.51E+06	4.12E+06
4.75E-01	7.04E+05	1.32E+06	2.71E+06	3.77E+06
6.25E-01	6.23E+04	3.84E+05	1.96E+06	2.24E+06
7.75E-01	1.01E+06	3.04E+06	2.96E+06	6.17E+06
9.25E-01	1.56E+05	1.55E+06	2.08E+06	5.18E+06
1.075	2.79E+05	1.76E+06	4.98E+06	4.64E+06
1.22501	1.32E+06	3.64E+06	4.31E+06	6.47E+06
1.37501	1.11E+05	8.53E+05	4.41E+06	6.36E+06
1.525	1.20E+06	2.22E+06	4.62E+06	6.11E+06
1.675	6.57E+05	1.96E+06	5.78E+06	7.80E+06
1.825	1.47E+05	7.04E+05	7.25E+05	1.80E+06
1.975	9.89E+05	2.61E+06	3.82E+06	6.37E+06
2.125	1.44E+05	9.03E+05	3.14E+06	3.98E+06
2.275	2.69E+05	1.49E+06	1.54E+06	2.37E+06
2.425	6.72E+05	1.88E+06	2.04E+06	3.86E+06
2.575	1.58E+05	1.88E+05	7.61E+05	9.32E+05

2.725	6.55E+05	1.04E+06	2.05E+06	1.49E+06
2.87501	2.16E+05	6.84E+05	1.48E+06	1.60E+06
3.02501	2.09E+05	3.56E+05	5.84E+05	1.05E+06
3.175	4.15E+05	6.42E+05	1.30E+06	1.46E+06
3.325	2.16E+05	2.99E+05	6.45E+05	9.44E+05
3.475	2.45E+05	3.48E+05	3.08E+05	7.21E+05
3.625	1.50E+05	3.01E+05	3.93E+05	7.30E+05
3.775	1.99E+05	1.85E+05	2.01E+05	2.37E+05
3.925	2.70E+05	3.79E+05	4.20E+05	5.38E+05
4.075	1.95E+05	2.94E+05	3.43E+05	5.10E+05
4.225	1.64E+05	1.20E+05	2.72E+05	3.80E+05
4.37501	1.32E+05	1.34E+05	4.25E+05	4.48E+05
4.52501	2.17E+05	1.55E+05	1.38E+05	3.39E+05
4.675	2.37E+05	2.97E+05	4.18E+05	6.64E+05
4.825	2.14E+05	2.46E+05	3.39E+05	4.37E+05
4.975	1.93E+05	2.47E+05	3.46E+05	4.41E+05
5.125	2.28E+05	4.05E+05	3.64E+05	6.15E+05
5.275	1.53E+05	1.93E+05	2.40E+05	2.70E+05
5.425	1.38E+05	8.53E+04	4.80E+05	6.68E+05
5.575	9.67E+04	1.25E+05	3.89E+05	6.51E+05
5.725	1.39E+05	2.85E+05	4.99E+05	6.64E+05
5.875	3.76E+05	8.17E+05	8.87E+05	1.77E+06
6.02501	1.51E+05	3.91E+05	4.55E+05	1.16E+06
6.17501	1.17E+05	6.78E+05	1.58E+06	1.85E+06
6.325	2.81E+05	9.91E+05	2.08E+06	1.40E+06
6.475	1.47E+05	2.57E+05	1.06E+06	1.06E+06
6.625	8.21E+05	2.40E+06	2.65E+06	4.86E+06
6.775	1.56E+05	1.50E+06	1.49E+06	2.90E+06
6.925	3.05E+05	1.27E+06	3.58E+06	4.01E+06
7.075	9.61E+05	2.47E+06	5.39E+06	3.40E+06
7.225	1.56E+05	2.56E+05	1.13E+06	1.56E+06
7.375	2.23E+06	3.57E+06	3.28E+06	6.97E+06
7.525	1.02E+06	2.99E+06	4.61E+06	6.21E+06
7.67501	2.12E+05	1.06E+06	4.80E+06	6.98E+06
7.82501	1.50E+06	3.58E+06	6.44E+06	7.93E+06
7.975	2.38E+05	1.33E+06	4.85E+06	6.28E+06
8.125	5.77E+05	1.34E+06	4.17E+06	3.41E+06
8.275	1.12E+06	1.92E+06	5.20E+06	5.72E+06
8.425	2.23E+05	9.71E+05	1.08E+06	2.31E+06
8.575	4.67E+05	1.54E+06	2.99E+06	2.04E+06
8.725	5.08E+05	1.72E+06	3.18E+06	2.79E+06
8.875	2.44E+05	2.30E+05	2.89E+05	5.26E+05
9.025	6.90E+05	1.11E+06	1.33E+06	2.33E+06

9.175	3.57E+05	9.04E+05	1.47E+06	2.01E+06
9.325	2.80E+05	2.87E+05	5.31E+05	5.01E+05
9.475	4.64E+05	6.69E+05	9.77E+05	1.73E+06
9.625	2.99E+05	5.05E+05	6.91E+05	1.32E+06
9.775	2.89E+05	1.20E+05	3.92E+05	2.87E+05
9.925	3.55E+05	2.44E+05	7.31E+05	6.08E+05
10.075	2.91E+05	9.74E+04	3.27E+05	5.38E+05
10.225	3.17E+05	3.79E+05	3.92E+05	4.72E+05
10.375	3.75E+05	5.37E+05	5.41E+05	5.31E+05
10.525	3.03E+05	2.72E+05	2.93E+05	3.93E+05
10.675	2.65E+05	7.59E+04	2.19E+05	5.64E+05
10.825	2.66E+05	1.34E+05	2.49E+05	6.19E+05
10.975	3.39E+05	1.74E+05	1.86E+05	4.67E+05
11.125	3.64E+05	2.64E+05	4.73E+05	7.53E+05
11.275	3.43E+05	2.54E+05	3.91E+05	7.32E+05
11.425	3.16E+05	2.09E+05	3.82E+05	3.33E+05
11.575	3.40E+05	3.46E+05	6.62E+05	3.94E+05
11.725	2.89E+05	3.03E+05	5.47E+05	3.95E+05
11.875	2.43E+05	1.26E+05	1.34E+05	9.89E+05
12.025	1.50E+05	2.29E+05	2.13E+05	1.08E+06
12.175	2.59E+05	9.12E+04	1.22E+05	7.11E+05
12.325	3.21E+05	4.86E+05	1.02E+06	1.35E+06
12.475	4.61E+05	5.60E+05	1.14E+06	1.52E+06
12.625	2.63E+05	2.48E+05	3.63E+05	4.52E+05
12.775	1.39E+05	8.00E+05	1.48E+06	2.17E+06
12.925	2.09E+05	1.02E+06	1.71E+06	2.19E+06
13.075	2.55E+05	3.09E+05	1.38E+06	9.54E+05
13.225	7.76E+05	1.83E+06	2.49E+06	4.41E+06
13.375	2.45E+05	1.54E+06	2.35E+06	3.71E+06
13.525	2.42E+05	8.01E+05	2.36E+06	3.13E+06
13.675	1.32E+06	3.91E+06	4.52E+06	4.35E+06
13.825	2.54E+05	1.36E+06	2.54E+06	3.04E+06
13.975	7.22E+05	2.26E+06	6.47E+06	7.37E+06
14.125	2.36E+06	5.13E+06	6.05E+06	7.09E+06
14.275	3.05E+05	2.89E+06	3.61E+06	7.31E+06
14.425	1.05E+06	2.36E+06	5.44E+06	7.11E+06
14.575	1.13E+06	3.68E+06	7.61E+06	8.23E+06
14.725	3.55E+05	7.56E+05	1.32E+06	4.25E+06
14.875	9.85E+05	2.19E+06	2.96E+06	2.79E+06
15.025	7.46E+05	2.27E+06	4.10E+06	4.25E+06
15.175	3.51E+05	2.87E+05	9.63E+05	1.35E+06
15.325	6.24E+05	1.73E+06	2.56E+06	4.08E+06
15.475	3.51E+05	1.58E+06	2.19E+06	3.63E+06

15.625	3.87E+05	2.40E+05	9.82E+05	3.76E+05
15.775	8.05E+05	1.29E+06	2.13E+06	2.64E+06
15.925	4.09E+05	7.37E+05	1.13E+06	2.38E+06
16.075	4.04E+05	3.85E+05	8.22E+05	7.01E+05
16.225	5.33E+05	7.88E+05	1.28E+06	1.20E+06
16.375	4.10E+05	2.99E+05	1.95E+05	6.19E+05
16.525	4.26E+05	1.91E+05	2.97E+05	5.60E+05
16.675	3.96E+05	1.62E+05	2.81E+05	5.32E+05
16.825	4.34E+05	4.84E+05	4.99E+05	5.51E+05
16.975	4.36E+05	5.76E+05	5.25E+05	6.90E+05
17.125	3.96E+05	2.87E+05	1.81E+05	3.34E+05
17.275	3.14E+05	1.79E+05	3.57E+05	6.82E+05
17.425	4.20E+05	1.90E+05	1.71E+05	5.77E+05
17.575	4.45E+05	3.35E+05	5.05E+05	6.13E+05
17.725	4.22E+05	3.46E+05	4.73E+05	5.41E+05
17.875	3.98E+05	1.31E+05	5.15E+05	3.34E+05
18.025	4.09E+05	2.81E+05	4.99E+05	4.55E+05
18.175	3.69E+05	1.88E+05	1.96E+05	5.01E+05
18.325	2.71E+05	6.49E+05	6.27E+05	1.15E+06
18.475	3.55E+05	3.75E+05	2.45E+05	8.66E+05
18.625	4.74E+05	3.11E+05	1.06E+06	1.01E+06
18.775	4.71E+05	6.38E+05	9.51E+05	1.15E+06
18.925	3.50E+05	5.19E+05	9.45E+05	1.14E+06
19.075	2.85E+05	1.20E+06	1.73E+06	2.00E+06
19.225	3.58E+05	4.59E+05	4.65E+05	1.05E+06
19.375	8.63E+05	2.03E+06	3.33E+06	4.37E+06
19.525	3.77E+05	1.94E+06	2.60E+06	3.11E+06
19.675	4.19E+05	1.65E+06	3.00E+06	4.27E+06
19.825	8.98E+05	3.51E+06	2.50E+06	5.28E+06
19.975	3.89E+05	9.88E+05	3.61E+06	1.52E+06
20.125	2.86E+06	4.39E+06	4.48E+06	6.91E+06
20.275	4.35E+05	3.16E+06	3.94E+06	5.70E+06
20.425	1.32E+06	3.20E+06	5.29E+06	5.68E+06
20.575	4.88E+05	2.49E+06	4.24E+06	9.03E+06
20.725	5.31E+05	6.40E+05	2.78E+06	1.86E+06
20.875	1.37E+06	2.50E+06	4.85E+06	4.27E+06
21.025	4.66E+05	1.22E+06	1.19E+06	4.20E+06
21.175	6.22E+05	1.03E+06	3.71E+06	4.42E+06
21.325	4.56E+05	1.27E+06	2.67E+06	4.50E+06
21.475	5.71E+05	8.26E+05	1.15E+06	8.30E+05
21.625	7.67E+05	1.39E+06	1.26E+06	1.86E+06
21.775	4.86E+05	7.33E+05	4.31E+05	7.23E+05
21.925	5.85E+05	1.35E+06	1.23E+06	1.35E+06

22.075	4.70E+05	9.71E+05	6.13E+05	1.19E+06
22.225	4.77E+05	6.97E+05	5.52E+05	5.18E+05
22.375	4.32E+05	7.04E+05	4.56E+05	8.08E+05
22.525	4.27E+05	4.89E+05	4.03E+05	2.79E+05
22.675	4.82E+05	6.37E+05	6.30E+05	6.61E+05
22.825	4.08E+05	4.43E+05	4.10E+05	5.48E+05
22.975	3.42E+05	1.39E+05	2.67E+05	4.47E+05
23.125	3.98E+05	1.07E+05	2.61E+05	5.47E+05
23.275	4.22E+05	2.52E+05	5.16E+05	4.28E+05
23.425	4.28E+05	4.35E+05	6.32E+05	5.32E+05
23.575	3.93E+05	3.13E+05	4.65E+05	2.58E+05
23.725	4.42E+05	3.25E+05	6.94E+05	6.86E+05
23.875	3.64E+05	3.84E+05	4.86E+05	4.97E+05
24.025	2.80E+05	7.51E+05	1.58E+05	6.46E+05
24.175	3.09E+05	9.85E+05	1.15E+05	6.82E+05
24.325	3.52E+05	6.76E+05	1.01E+06	5.29E+05
24.475	5.98E+05	5.33E+05	1.40E+06	1.04E+06
24.625	3.73E+05	6.67E+05	4.04E+05	6.27E+05
24.775	4.13E+05	1.24E+06	1.87E+06	2.34E+06
24.925	3.76E+05	1.08E+06	1.25E+06	2.51E+06
25.075	5.26E+05	9.31E+05	2.24E+06	2.38E+06
25.225	7.52E+05	2.46E+06	1.73E+06	3.06E+06
25.375	4.06E+05	4.25E+05	2.56E+06	1.35E+06
25.525	1.21E+06	2.18E+06	4.57E+06	8.00E+06
25.675	4.37E+05	1.06E+06	8.75E+05	6.05E+06
25.825	2.23E+06	4.88E+06	7.18E+06	8.67E+06
25.975	4.25E+05	4.33E+06	5.13E+06	8.98E+06
26.125	4.39E+05	2.35E+06	4.10E+06	6.83E+06
26.275	1.32E+06	3.98E+06	4.16E+06	6.52E+06
26.425	5.41E+05	1.18E+06	4.49E+05	5.05E+06
26.575	1.46E+06	2.04E+06	3.67E+06	5.70E+06
26.725	5.47E+05	2.32E+06	3.06E+06	6.27E+06
26.875	4.91E+05	6.14E+05	2.58E+06	1.53E+06
27.025	6.12E+05	1.45E+06	3.08E+06	3.83E+06
27.175	5.39E+05	6.79E+05	6.45E+05	2.38E+06
27.325	7.31E+05	1.63E+06	1.59E+06	2.74E+06
27.475	5.48E+05	1.51E+06	6.60E+05	2.04E+06
27.625	5.55E+05	7.87E+05	1.48E+06	9.77E+05
27.775	5.42E+05	9.32E+05	1.28E+06	1.60E+06
27.925	5.29E+05	6.73E+05	3.02E+05	4.87E+05
28.075	4.12E+05	8.32E+05	4.44E+05	5.01E+05
28.225	4.99E+05	5.36E+05	2.52E+05	4.56E+05
28.375	5.31E+05	5.81E+05	7.01E+05	7.47E+05

28.525	4.82E+05	5.81E+05	5.77E+05	8.39E+05
28.675	4.39E+05	3.16E+05	2.64E+05	3.59E+05
28.825	4.17E+05	1.26E+05	3.85E+05	5.30E+05
28.975	4.76E+05	1.32E+05	3.73E+05	4.22E+05
29.125	5.01E+05	3.53E+05	5.16E+05	4.71E+05
29.275	4.66E+05	3.59E+05	4.94E+05	3.96E+05
29.425	4.50E+05	1.94E+05	6.29E+05	6.22E+05
29.575	4.41E+05	2.53E+05	5.39E+05	6.90E+05
29.725	4.33E+05	4.25E+05	1.54E+05	3.09E+05
29.875	3.19E+05	8.96E+05	3.29E+05	7.67E+05
30.025	4.43E+05	6.02E+05	5.94E+05	4.16E+05

Carbon Fiber Cone 2

Time(s)	dx005_mises(Pa)	dx010_mises(Pa)	dx015_(Pa)	dx020_mises(Pa)
2.50E-02	0	0.00E+00	0	0
1.75E-01	3.78E+05	7.18E+05	1.22E+06	1.30E+06
3.25E-01	2.13E+05	6.03E+05	8.41E+05	1.56E+06
4.75E-01	3.38E+05	1.93E+05	1.63E+06	1.66E+06
6.25E-01	2.16E+05	8.66E+05	1.23E+06	9.26E+05
7.75E-01	4.49E+04	7.24E+05	1.02E+06	3.33E+06
9.25E-01	2.92E+04	4.33E+05	3.36E+06	4.15E+06
1.075	2.02E+04	1.73E+06	1.40E+06	3.88E+06
1.22501	2.90E+04	6.04E+05	3.87E+06	5.61E+06
1.37501	8.39E+04	1.96E+06	4.33E+06	5.22E+06
1.525	4.84E+05	2.89E+06	1.03E+06	6.18E+06
1.675	5.48E+05	4.72E+05	4.23E+06	7.00E+06
1.825	3.00E+04	2.99E+06	4.43E+06	5.63E+06
1.975	4.64E+04	2.63E+06	4.06E+06	8.02E+06
2.125	4.82E+05	1.36E+06	6.23E+06	9.34E+06
2.275	3.54E+05	3.70E+06	4.45E+06	2.07E+06
2.425	5.58E+04	1.70E+06	2.32E+06	3.67E+06
2.575	4.04E+05	1.50E+06	3.22E+06	4.83E+06
2.725	4.57E+05	2.59E+06	1.98E+06	3.08E+06
2.87501	1.50E+05	2.00E+05	3.24E+06	4.05E+06
3.02501	1.75E+05	1.84E+06	2.96E+06	2.02E+06
3.175	6.24E+05	1.24E+06	5.52E+05	2.28E+06

3.325	3.72E+05	2.49E+05	2.06E+06	2.65E+06
3.475	2.01E+05	1.64E+06	1.58E+06	5.72E+05
3.625	1.40E+05	3.36E+05	7.09E+05	9.69E+05
3.775	6.04E+05	4.44E+05	7.33E+05	1.05E+06
3.925	7.39E+05	5.07E+05	3.59E+05	6.08E+05
4.075	1.64E+04	1.24E+05	6.89E+05	8.41E+05
4.225	9.28E+04	3.54E+05	5.77E+05	6.07E+05
4.37501	6.63E+05	2.66E+05	1.26E+05	5.17E+05
4.52501	7.20E+05	1.23E+05	4.34E+05	6.49E+05
4.675	7.33E+05	3.59E+05	3.16E+05	2.77E+05
4.825	4.38E+04	3.20E+05	2.99E+05	6.81E+05
4.975	1.59E+04	1.30E+05	4.57E+05	6.88E+05
5.125	5.50E+05	2.41E+05	3.57E+05	5.37E+05
5.275	7.55E+05	1.36E+05	4.48E+05	4.86E+05
5.425	8.58E+04	1.74E+05	4.24E+05	3.46E+05
5.575	1.51E+05	1.90E+05	2.60E+05	4.61E+05
5.725	1.46E+05	1.64E+05	4.31E+05	4.05E+05
5.875	8.50E+04	2.94E+05	4.58E+05	5.65E+05
6.02501	7.42E+05	2.43E+05	5.72E+05	1.11E+06
6.17501	5.63E+05	9.28E+04	1.04E+06	9.24E+05
6.325	1.23E+04	3.92E+05	1.10E+06	1.02E+06
6.475	5.45E+04	9.09E+04	4.66E+05	1.63E+06
6.625	2.86E+05	7.24E+05	1.46E+06	7.72E+05
6.775	2.26E+05	8.19E+05	1.73E+06	2.14E+06
6.925	4.80E+04	1.99E+05	9.84E+05	2.04E+06
7.075	2.21E+04	8.54E+05	2.18E+06	1.96E+06
7.225	2.56E+05	4.35E+05	1.21E+06	3.03E+06
7.375	9.03E+05	1.23E+06	2.32E+06	1.77E+06
7.525	2.34E+05	1.52E+06	2.09E+06	5.80E+06
7.67501	1.59E+05	1.24E+05	3.52E+06	5.35E+06
7.82501	5.68E+05	2.65E+06	3.75E+06	1.42E+06
7.975	7.65E+05	2.32E+06	1.27E+06	8.56E+06
8.125	2.69E+04	4.05E+05	8.50E+06	7.06E+06
8.275	6.51E+04	2.84E+06	6.30E+06	5.97E+06
8.425	9.33E+04	3.77E+06	4.17E+06	6.03E+06
8.575	8.09E+04	1.21E+06	3.84E+06	7.73E+06
8.725	3.41E+04	3.37E+06	4.51E+06	1.92E+06
8.875	5.64E+05	4.64E+06	2.15E+06	3.34E+06
9.025	7.47E+05	3.89E+06	2.50E+06	4.32E+06
9.175	6.37E+05	7.46E+05	2.43E+06	1.69E+06
9.325	7.89E+05	1.63E+06	1.76E+06	4.13E+06
9.475	5.64E+05	4.07E+05	2.59E+06	3.39E+06
9.625	5.41E+04	1.67E+06	1.17E+06	1.26E+06

9.775	9.29E+04	1.61E+06	1.68E+06	1.69E+06
9.925	8.42E+04	3.73E+05	1.56E+06	1.76E+06
10.075	4.03E+04	1.41E+06	7.03E+05	1.64E+06
10.225	4.91E+05	2.32E+05	1.57E+06	1.89E+06
10.375	7.15E+05	1.08E+06	1.50E+06	1.13E+06
10.525	3.15E+05	7.66E+05	3.83E+05	6.45E+05
10.675	5.69E+05	2.48E+05	4.65E+05	8.23E+05
10.825	9.44E+05	2.37E+05	4.09E+05	4.40E+05
10.975	2.29E+05	1.68E+05	2.40E+05	4.54E+05
11.125	6.47E+04	3.36E+05	5.00E+05	4.97E+05
11.275	9.13E+04	5.71E+05	4.38E+05	3.16E+05
11.425	8.40E+04	5.37E+05	9.14E+04	5.66E+05
11.575	4.70E+04	3.55E+05	4.53E+05	5.68E+05
11.725	3.56E+04	3.18E+05	4.65E+05	3.14E+05
11.875	8.21E+05	3.12E+05	3.36E+05	6.34E+05
12.025	5.08E+05	2.91E+05	5.39E+05	6.22E+05
12.175	2.71E+05	2.96E+05	5.43E+05	1.57E+05
12.325	7.89E+05	2.84E+05	2.82E+05	4.73E+05
12.475	6.39E+05	3.56E+05	3.33E+05	3.92E+05
12.625	4.05E+04	5.08E+05	4.13E+05	5.48E+05
12.775	6.80E+04	5.25E+05	5.31E+05	8.21E+05
12.925	8.00E+04	3.03E+05	8.97E+05	6.86E+05
13.075	6.37E+04	2.03E+05	8.68E+05	6.27E+05
13.225	3.94E+04	3.83E+05	8.12E+05	1.31E+06
13.375	2.63E+05	2.86E+05	1.17E+06	8.28E+05
13.525	8.69E+05	8.49E+05	1.25E+06	2.23E+06
13.675	2.84E+05	1.21E+06	1.05E+06	2.96E+06
13.825	1.54E+05	3.78E+05	1.86E+06	1.85E+06
13.975	9.49E+04	9.18E+05	1.98E+06	3.70E+06
14.125	9.87E+05	1.54E+06	6.05E+05	4.32E+06
14.275	2.97E+05	4.13E+05	3.34E+06	1.90E+06
14.425	3.60E+04	1.34E+06	3.44E+06	4.81E+06
14.575	4.90E+04	2.32E+06	1.43E+06	4.28E+06
14.725	1.87E+05	6.25E+05	3.92E+06	1.03E+06
14.875	3.19E+05	1.14E+06	2.58E+06	6.34E+06
15.025	1.27E+05	1.82E+06	8.63E+06	5.57E+06
15.175	4.33E+04	7.98E+05	6.29E+06	6.32E+06
15.325	1.34E+05	2.31E+06	4.12E+06	6.98E+06
15.475	9.57E+05	2.16E+06	5.52E+06	6.62E+06
15.625	7.63E+05	1.12E+06	4.29E+06	9.71E+05
15.775	1.09E+05	3.29E+06	2.64E+06	6.46E+06
15.925	1.20E+05	2.73E+06	3.75E+06	6.68E+06
16.075	5.09E+05	1.61E+06	3.03E+06	1.20E+06

16.225	8.44E+05	9.28E+05	1.64E+06	3.86E+06
16.375	4.48E+04	1.19E+06	1.82E+06	3.42E+06
16.525	4.81E+04	1.78E+06	1.63E+06	1.44E+06
16.675	5.62E+04	5.95E+05	2.13E+06	1.88E+06
16.825	5.38E+04	8.39E+05	6.00E+05	6.57E+05
16.975	5.17E+04	6.62E+05	9.33E+05	1.82E+06
17.125	3.34E+05	2.94E+05	6.80E+05	9.68E+05
17.275	9.72E+05	2.02E+05	4.30E+05	4.66E+05
17.425	4.45E+05	4.23E+05	6.14E+05	4.96E+05
17.575	6.05E+05	5.89E+05	1.39E+05	4.63E+05
17.725	8.13E+05	4.94E+05	4.85E+05	7.66E+05
17.875	5.09E+04	3.58E+05	5.28E+05	4.10E+05
18.025	5.47E+04	4.69E+05	1.99E+05	6.37E+05
18.175	6.99E+04	4.64E+05	4.67E+05	6.36E+05
18.325	5.81E+04	3.37E+05	6.08E+05	3.32E+05
18.475	6.45E+04	3.16E+05	4.83E+05	3.53E+05
18.625	6.99E+05	3.30E+05	6.48E+05	2.42E+05
18.775	6.62E+05	4.14E+05	6.15E+05	5.39E+05
18.925	5.58E+05	4.38E+05	3.93E+05	4.29E+05
19.075	7.63E+05	4.22E+05	4.55E+05	4.89E+05
19.225	6.51E+04	3.96E+05	5.83E+05	1.12E+06
19.375	7.57E+04	5.79E+05	1.21E+06	8.35E+05
19.525	7.44E+04	6.54E+05	1.24E+06	1.40E+06
19.675	7.04E+04	5.71E+05	5.06E+05	1.63E+06
19.825	6.34E+05	4.81E+05	1.01E+06	1.02E+06
19.975	7.04E+05	3.91E+05	5.16E+05	2.05E+06
20.125	7.81E+05	3.71E+05	1.46E+06	1.17E+06
20.275	7.31E+05	4.03E+05	1.07E+06	3.11E+06
20.425	2.05E+05	3.83E+05	2.94E+06	2.08E+06
20.575	6.99E+04	3.99E+05	2.63E+06	5.16E+06
20.725	7.84E+04	4.45E+05	1.49E+06	5.94E+06
20.875	7.02E+04	6.15E+05	5.26E+06	1.37E+06
21.025	7.55E+04	5.58E+05	6.68E+05	8.35E+06
21.175	6.16E+05	5.55E+05	6.82E+06	6.49E+06
21.325	6.59E+05	4.67E+05	6.76E+06	6.21E+06
21.475	2.94E+05	3.99E+05	5.14E+06	6.69E+06
21.625	3.56E+05	3.95E+05	3.79E+06	2.06E+06
21.775	9.38E+05	3.98E+05	3.34E+06	3.83E+06
21.925	4.10E+05	4.55E+05	4.78E+06	3.89E+06
22.075	9.00E+04	4.83E+05	4.75E+05	3.88E+06
22.225	1.04E+05	5.46E+05	2.60E+06	3.69E+06
22.375	4.79E+05	4.57E+05	1.93E+06	1.44E+06
22.525	3.94E+05	4.04E+05	1.40E+06	2.85E+06

22.675	1.66E+05	4.07E+05	1.54E+06	1.09E+06
22.825	9.50E+04	4.08E+05	5.21E+05	1.30E+06
22.975	8.29E+04	4.37E+05	9.97E+05	1.34E+06
23.125	7.12E+05	5.50E+05	3.25E+05	5.19E+05
23.275	2.08E+05	4.97E+05	9.94E+05	6.21E+05
23.425	1.31E+05	4.56E+05	1.02E+06	2.29E+05
23.575	1.40E+05	4.05E+05	3.32E+05	5.91E+05
23.725	1.42E+05	4.02E+05	3.78E+05	4.53E+05
23.875	1.31E+05	3.98E+05	3.37E+05	4.72E+05
24.025	3.93E+05	4.67E+05	6.88E+05	4.89E+05
24.175	8.54E+05	5.86E+05	7.91E+05	1.68E+05
24.325	1.03E+05	5.21E+05	5.44E+05	5.36E+05
24.475	7.94E+04	5.36E+05	7.26E+05	4.31E+05
24.625	8.26E+04	4.21E+05	6.32E+05	7.44E+05
24.775	8.32E+04	4.30E+05	2.21E+05	9.18E+05
24.925	8.52E+04	4.28E+05	2.08E+05	1.05E+06
25.075	8.98E+04	4.98E+05	3.69E+05	7.00E+05
25.225	9.19E+04	5.36E+05	1.04E+06	9.35E+05
25.375	6.61E+05	5.13E+05	9.88E+05	1.22E+06
25.525	6.24E+05	4.78E+05	6.45E+05	1.09E+06
25.675	1.38E+05	3.97E+05	1.24E+06	1.62E+06
25.825	1.49E+05	4.10E+05	4.94E+05	1.58E+06
25.975	1.44E+05	5.09E+05	1.49E+06	9.28E+05
26.125	1.06E+05	5.74E+05	1.28E+06	2.44E+06
26.275	1.04E+06	6.12E+05	2.27E+06	1.96E+06
26.425	5.03E+05	4.34E+05	2.24E+06	3.68E+06
26.575	9.31E+04	3.99E+05	7.51E+05	2.38E+06
26.725	9.13E+04	4.03E+05	4.88E+06	4.76E+06
26.875	8.95E+04	4.14E+05	2.82E+06	6.69E+06
27.025	9.13E+04	5.51E+05	7.22E+06	6.90E+06
27.175	9.52E+04	5.51E+05	7.08E+06	9.96E+06
27.325	4.51E+05	6.53E+05	4.64E+06	7.22E+06
27.475	6.84E+05	5.68E+05	3.70E+06	5.09E+06
27.625	3.80E+05	4.43E+05	2.01E+06	4.16E+06
27.775	1.20E+05	4.25E+05	4.03E+06	5.59E+06
27.925	1.24E+05	4.48E+05	1.59E+06	5.62E+06
28.075	1.23E+05	4.88E+05	3.29E+06	1.96E+06
28.225	1.17E+05	5.81E+05	2.61E+06	4.45E+06
28.375	1.00E+06	5.30E+05	1.31E+06	3.47E+06
28.525	9.27E+05	5.48E+05	1.59E+06	1.53E+06
28.675	8.51E+05	4.42E+05	4.11E+05	1.98E+06
28.825	9.77E+05	4.30E+05	9.45E+05	7.07E+05
28.975	9.36E+05	4.11E+05	6.24E+05	1.22E+06

29.125	8.87E+05	4.68E+05	7.31E+05	7.94E+05
29.275	1.13E+06	5.49E+05	9.16E+05	1.35E+06
29.425	1.14E+06	5.67E+05	4.43E+05	1.25E+06
29.575	9.13E+05	4.86E+05	2.59E+05	5.34E+05
29.725	7.77E+05	4.27E+05	2.78E+05	5.94E+05
29.875	8.13E+05	4.19E+05	4.47E+05	6.45E+05
30.025	3.55E+05	4.34E+05	6.46E+05	8.48E+05

BIBLIOGRAPHY

1. Mahjoubi H., Byl K.: Modeling Synchronous Muscle Function in Insect Flight: a Bio-Inspired Approach to Force Control in Flapping Wing MAVs, J Intell Robot Syst. 70, 181-202(2012)
2. Ratti, J., Vachtsevanos, G.: Inventing a Biological Inspired, Energy Efficient Micro Aerial Vehicle, J Intell Robot Syst. 65, 437-455(2012)
3. Fenelon, M., Furukawa, T.: Design of an active Flapping wing mechanism and a micro aerial vehicle using a rotary actuator, Mechanism and Machine Theory, 45, 137-146(2010)
4. Gauthier JP., Micheau P.: Adaptive control of a continuously variable transmission subject to wear, Control Engineering Practice, 20 , 569-574 (2012)
5. Park JK., Park Y.: Design, Analysis and Control of a Wheeled Mobile Robot with a Nonholonomic Spherical CVT, The International Journal of Robotics Research, (2002)
6. DiLeo C., Deng X.: Design of and Experiments on a Dragonfly-Inspired Robot, Advanced Robotics 23, 1003-1021 (2009)
7. Hesselberg T.: Sensors and control systems for micro-air vehicles: lessons from flies, Sensor Review, 120-126 (2009)
8. Taha HE., Hajj MR.,Nayfeh AH.: Flight dynamics and control of flapping-wing MAVs: a review, Nonlinear Dynamics 70, 907-939 (2012).
9. Doman, D.B., Oppenheimer, M.W., Sigthorsson, D.O.: Dynamics and control of a minimally actuated biomimetic vehicle, Part I—Aerodynamic model. In: AIAA Guidance, Navigation, and Control Conference. Chicago, Illinois 2009-6160
10. Doman, D.B., Oppenheimer, M.W., Sigthorsson, D.O.: Dynamics and Control of a Biomimetic Vehicle Using Biased Wingbeat forcing Functions: Part II: Controller. AIAA, Washington. 2010-1024
11. Benvenuto, A., Sergi F., Pino G., Seidl T., Campolo D., Accoto D., Guglielmelli E.: Beyond Biomimetics: Towards Insect/Machine Hybrid Controllers for Space Applications. Advanced Robotics 23, 939-953. (2009)