Z-FORCE
DIY Turbo Jet Engine : Z-GS1

Agricultural University of Georgia,
Mechanical engineering department

Authors: Giorgi Gvasalia,
Beqa Sanodze

Main purpose

- Build operating downscale jet engine for model jet aircraft.

NOTE

- we don’t show all sketches in this presentation because the project is in progress and some parts must be changed.

Construction of each part

- Running and sliding fits

More Clearance (Close to Top of The Chart)	Clearance Fits	Description	Hole Basis	Shaft Basis
		Free Running	H9/d9	D9/h9
		Loose Running	H11/c11	C11/h11
		Easy Running	H8/f8	F8/h8
		Sliding	H7/g6	G7/h6
		Close Clearance	H8/f7	F8/h7
		Locational Clearance	H7/h6	H6/h7
	Transition Fits	Location- slight interference	H7/k6	K7/h7
		Location/Transition	H7/n6	N7/h6
More Interference (Close to Bottom of The Chart)	Interference Fits	Location/Interference	H7/p6	P7/h6
		Medium Drive Fit	H7/s6	S7/h6
		Force Fit	H7/u6	U7/h6

ISO shaft Tolerances

Example: Nominal Size 3mm-6mm; -270μm= -270(10^{-3})=-0.270mm

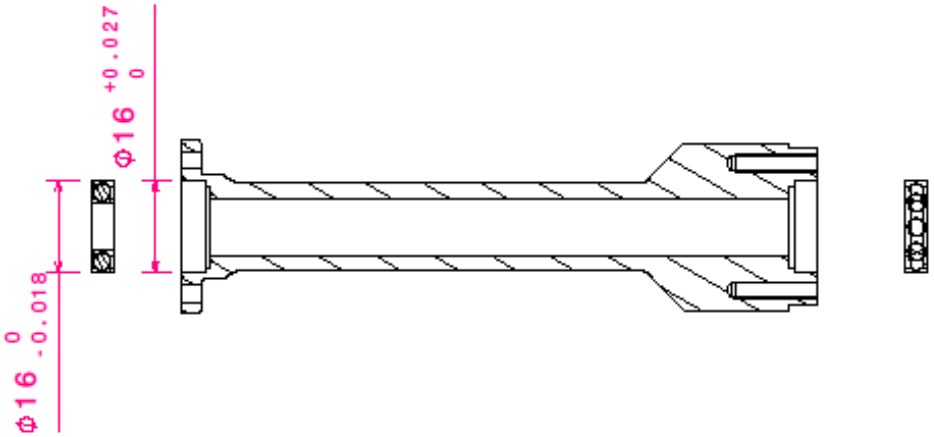
Grade	NOMINAL SHAFT SIZES (mm)																			
Over	3	6	10	18	30	40	50	65	80	100	120	140	160	180	200	225	250	280	315	355
Up to and incl.	6	10	18	30	40	50	65	80	100	120	140	160	180	200	225	250	280	315	355	400
a12	-270 -390	-280 -430	-290 -470	-300 -510	-310 -560	-320 -570	-340 -640	-360 -660	-380 -730	-410 -760	-460 -860	-520 -920	-580 -980	-660 -1120	-740 -1200	-820 -1280	-920 -1440	-1050 -1570	-1200 -1770	-1350 -1920
d6	-30 -38	-40 -49	-50 -61	-65 -78	-80 -96		-100 -119		-120 -142		-145 -170			-170 -199			-190 -222		-210 -246	
e6	-20 -28	-25 -34	-32 -43	-40 -53	-50 -66		-60 -79		-72 -94		-85 -110			-100 -129			-110 -142		-125 -161	
e13	-20 -200	-25 -245	-32 -302	-40 -370	-50 -440		-60 -520		-72 -612		-85 -715			-100 -820			-110 -920		-125 -1015	
f5	-10 -15	-13 -19	-16 -24	-20 -29	-25 -36		-30 -43		-36 -51		-43 -61			-50 -70			-56 -79		-62 -87	
f6	-10 -18	-13 -22	-16 -27	-20 -33	-25 -41		-30 -49		-36 -58		-43 -68			-50 -79			-56 -88		-62 -98	
f7	-10 -22	-13 -28	-16 -34	-20 -41	-25 -50		-30 -60		-36 -71		-43 -83			-50 -96			-56 -108		-62 -119	
g5	-4 -9	-5 -11	-6 -14	-7 -16	-9 -20		-10 -23		-12 -27		-14 -32			-15 -35			-17 -40		-18 -43	
g6	-4 -12	-5 -14	-6 -17	-7 -20	-9 -25		-10 -29		-12 -34		-14 -39			-15 -44			-17 -49		-18 -54	
g7	-4 -16	-5 -20	-6 -24	-7 -28	-9 -34		-10 -40		-12 -47		-14 -54			-15 -61			-17 -69		-18 -75	
h4	0 -4	0 -4	0 -5	0 -6	0 -7		0 -8		0 -10		0 -12			0 -14			0 -16		0 -18	
h5	0 -5	0 -6	0 -8	0 -9	0 -11		0 -13		0 -15		0 -18			0 -20			0 -23		0 -25	
h6	0 -8	0 -9	0 -11	0 -13	0 -16		0 -19		0 -22		0 -25			0 -29			0 -32		0 -36	
h7	0 -12	0 -15	0 -18	0 -21	0 -25		0 -30		0 -35		0 -40			0 -46			0 -52		0 -57	
h8	0 -18	0 -22	0 -27	0 -33	0 -39		0 -46		0 -54		0 -63			0 -72			0 -81		0 -89	
h9	0 -30	0 -36	0 -43	0 -52	0 -62		0 -74		0 -87		0 -100			0 -115			0 -130		0 -140	
h10	0 -48	0 -58	0 -70	0 -84	0 -100		0 -120		0 -140		0 -160			0 -185			0 -210		0 -230	

ISO Hole Tolerances

Example: Nominal Size 3mm-6mm; 28µm = 28x(10^{-3})=0.028mm

Grade	NOMINAL HOLE SIZES (mm)																			
over	3	6	10	18	30	40	50	65	80	100	120	140	160	180	200	225	250	280	315	355
inc.	6	10	18	30	40	50	65	80	100	120	140	160	180	200	225	250	280	315	355	400
E6	+28 +20	+34 +25	+43 +32	+53 +40	+66 +50		+79 + 60		+94 +72		+110 +85			+129 +100			+142 +110		+161 +125	
E7	+32 +20	+40 +25	+50 +32	+61 +40	+75 +50		+90 + 60		+107 +72		+125 +85			+146 +100			+162 +110		+185 +125	
E11	+95 +20	+115 +25	+142 +32	+170 +40	+210 +50		+250 + 60		+292 +72		+335 +85			+390 +100			+430 +110		+485 +125	
E12	+140 +20	+175 +25	+212 +32	+250 +40	+300 +50		+360 + 60		+422 +72		+485 +85			+560 +100			+630 +110		+695 +125	
E13	+200 +20	+245 +25	+302 +32	+370 +40	+440 +50		+520 + 60		+612 +72		+715 +85			+820 +100			+920 +110		+1 015 +125	
F6	+18 +10	+22 +13	+27 +16	+33 +20	+41 +25		+49 + 30		+58 +36		+68 43			+79 +50			+88 +56		+98 +62	
F7	+22 +10	+28 +13	+34 +16	+41 +20	+50 +25		+60 + 30		+71 +36		+83 43			+96 +50			+108 +56		+119 +62	
F8	+28 +10	+35 +13	+43 +16	+53 +20	+64 +25		+76 + 30		+90 +36		+106 43			+122 +50			+137 +56		+151 +62	
G6	+12 +4	+14 +5	+17 +6	+20 +7	+25 +9		+29 +10		+34 + 12		+39 +14			+44 +15			+49 +17		+54 +18	
G7	+16 +4	+20 +5	+24 +6	+28 +7	+34 +9		+40 +10		+47 + 12		+54 +14			+61 +15			+69 +17		+75 +18	
G8	+22 +4	+27 +5	+33 +6	+40 +7	+48 +9		+56 +10		+66 + 12		+77 +14			+87 +15			+98 +17		+107 +18	
H6	+8 0	+9 0	+11 0	+13 0	+16 0		+19 0		+22 0		+25 0			+29 0			+32 0		+36 0	
H7	+12 0	+15 0	+18 0	+21 0	+25 0		+30 0		+35 0		+40 0			+46 0			+52 0		+57 0	
H8	+18 0	+22 0	+27 0	+33 0	+39 0		+46 0		+54 0		+63 0			+72 0			+81 0		+89 0	
H9	+30 0	+36 0	+43 0	+52 0	+62 0		+74 0		+87 0		+100 0			+115 0			+130 0		+140 0	
H10	+48 0	+58 0	+70 0	+84 0	+100 0		+120 0		+140 0		+160 0			+185 0			+210 0		+230 0	
H11	+75 0	+90 0	+110 0	+130 0	+160 0		+190 0		+220 0		+250 0			+290 0			+320 0		+360 0	

Static rod and bearing fitting



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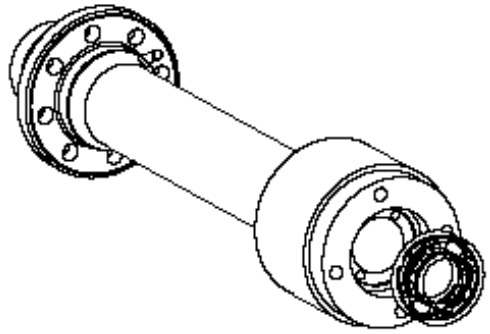
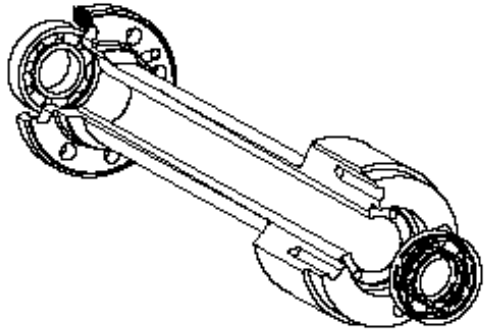


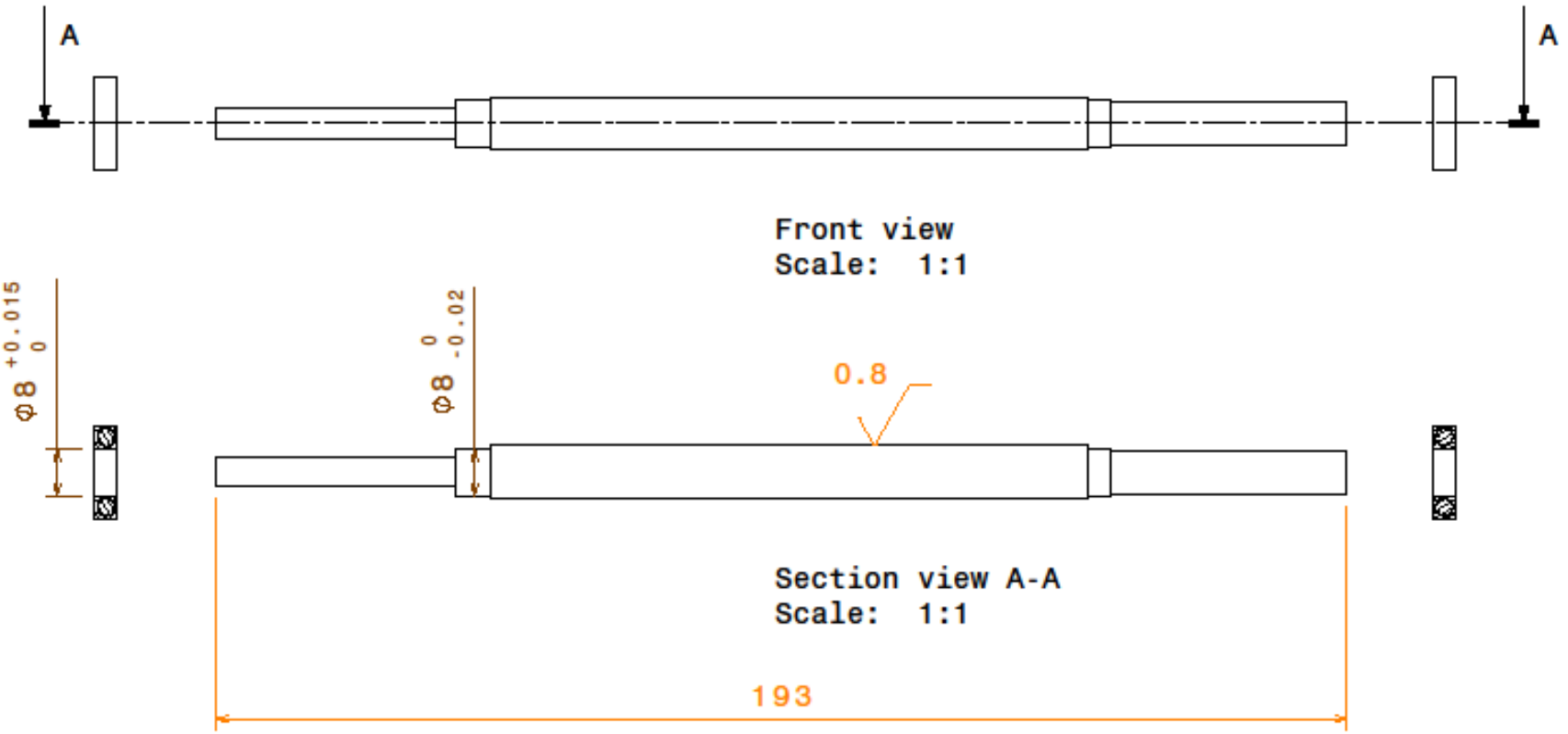
Isometric view
Scale: 1:1

Section view A-A
Scale: 1:1

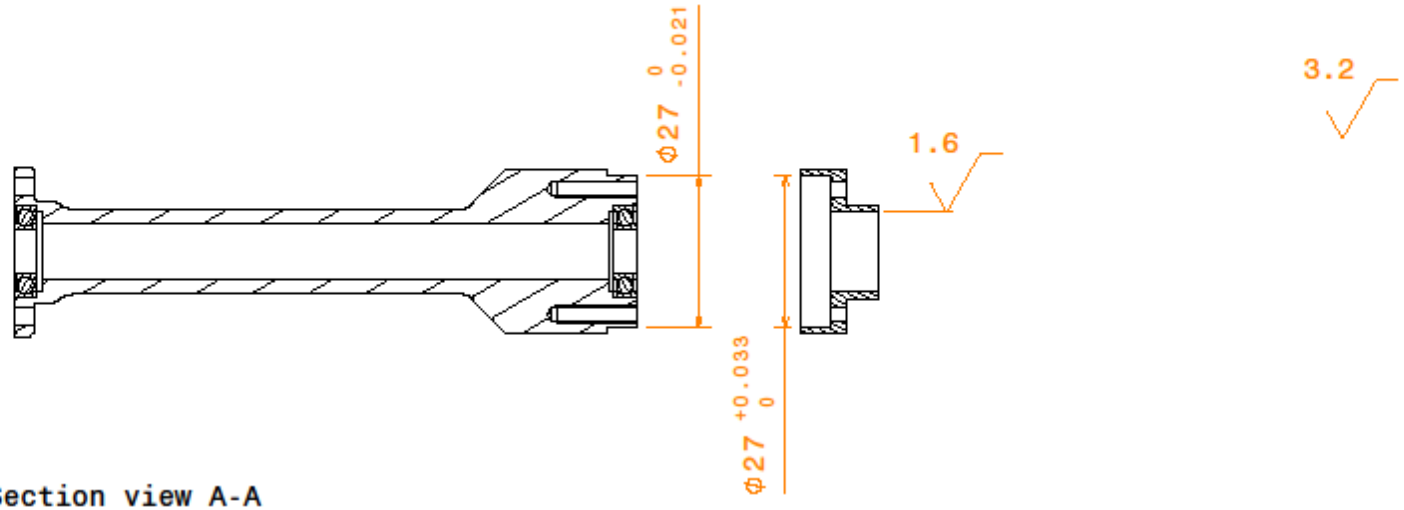


Isometric view
Scale: 1:1

Shaft and Bearing fitting



Static rod and Oil seal fitting



Section view A-A
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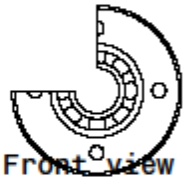

Front view
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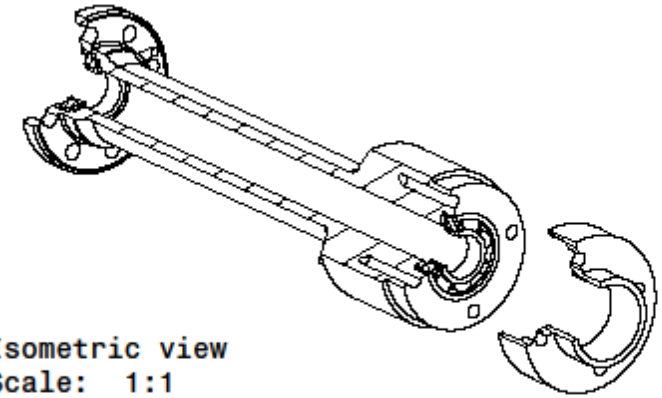
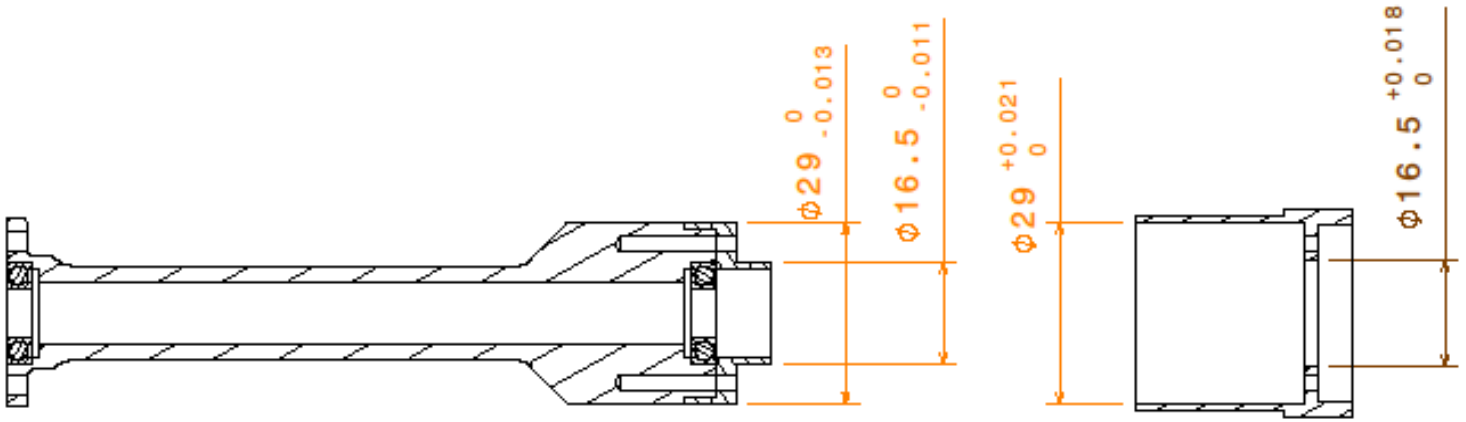


Isometric view
Scale: 1:1

turbine stator fitting



Section view A-A
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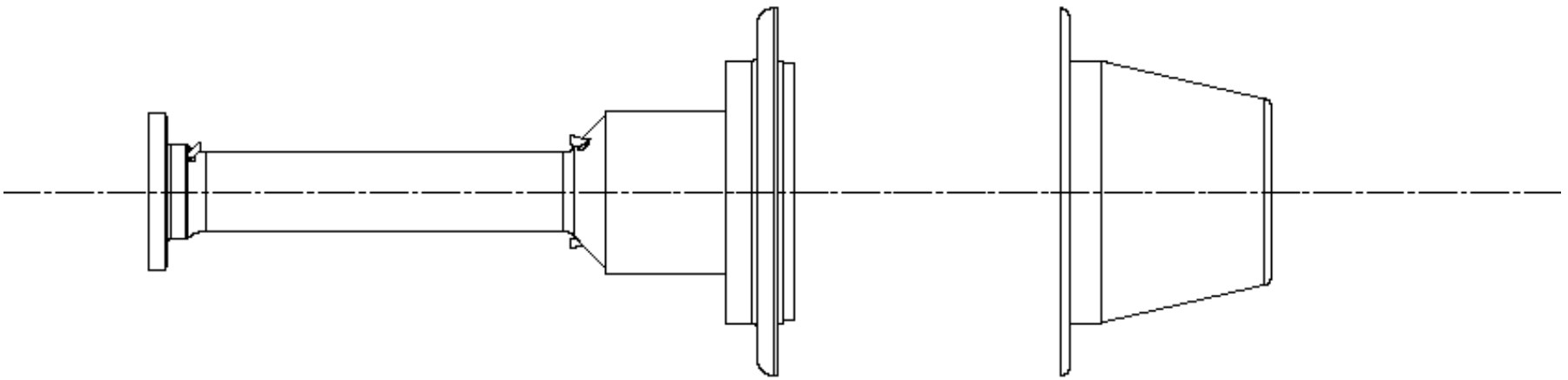

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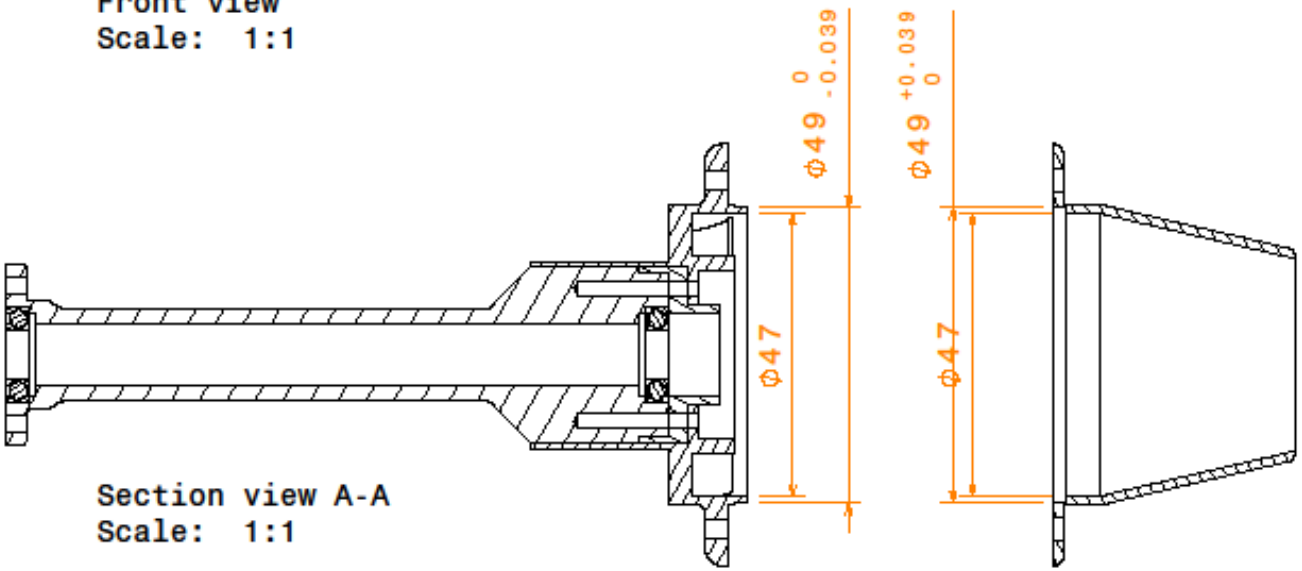
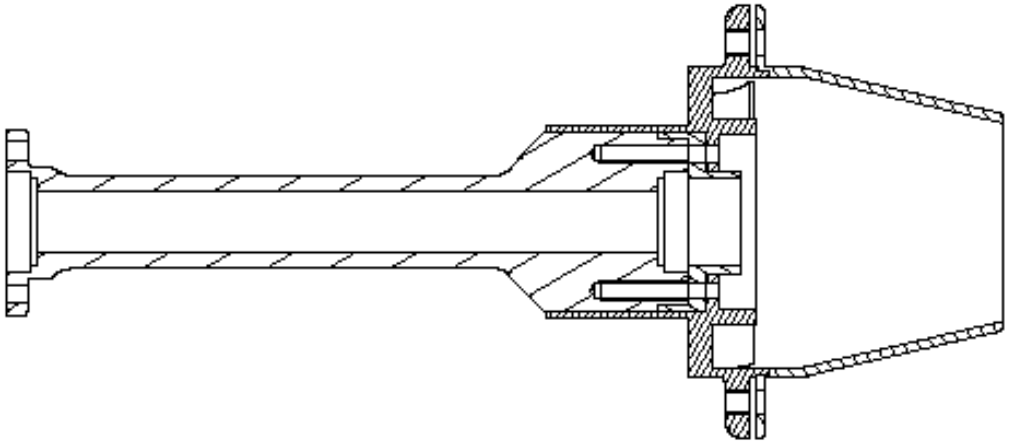
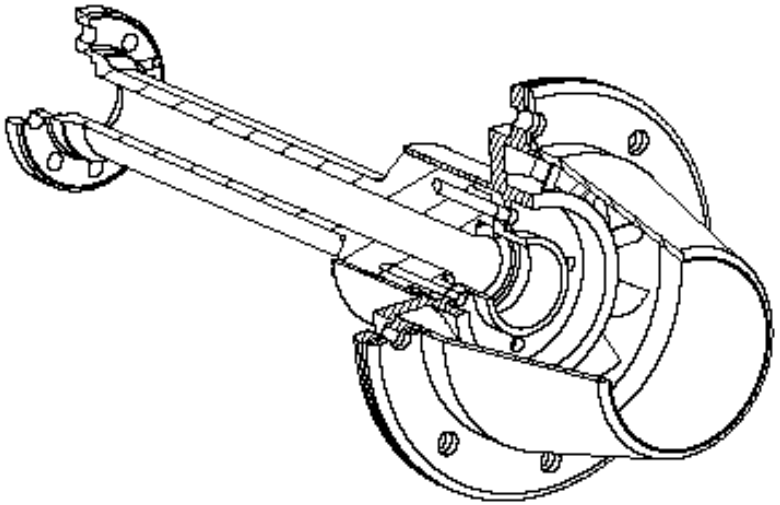


Section view A-A
Scale: 1:1



Section view A-A
Scale: 1:1



Isometric view
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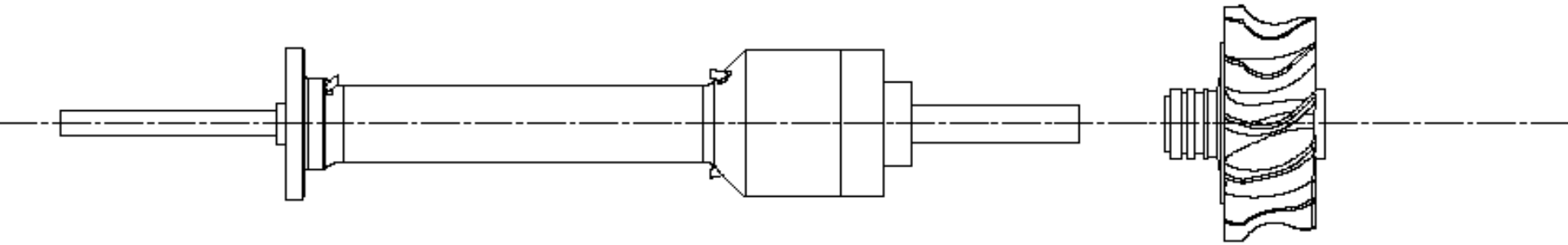
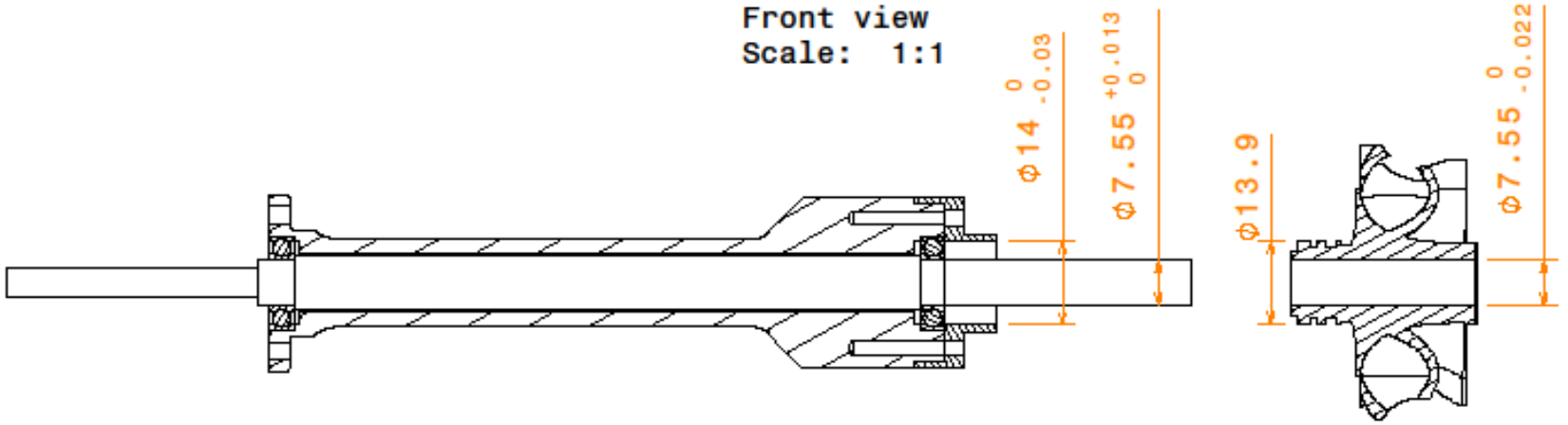
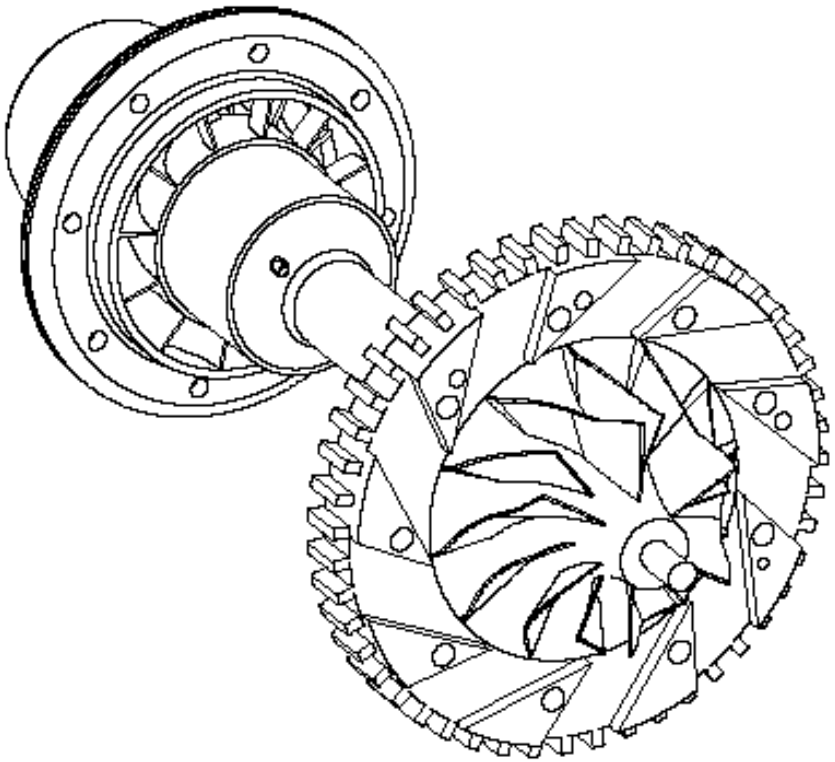


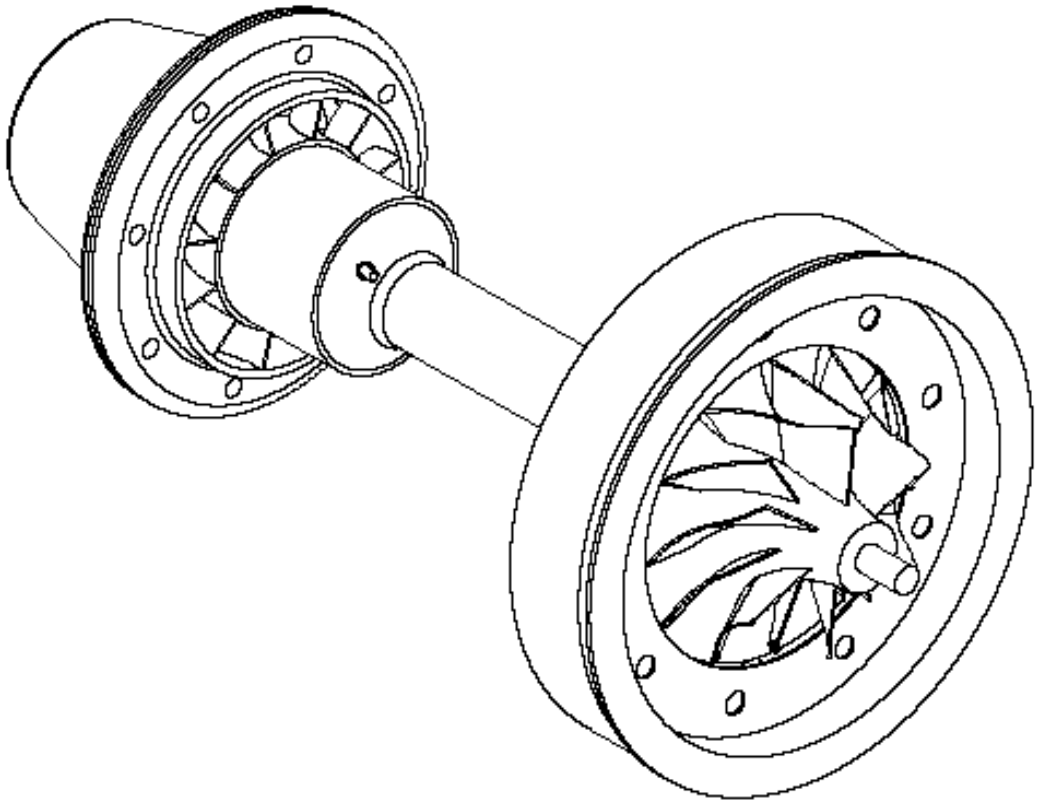
Front view
Scale: 1:1



Section view A-A
Scale: 1:1



Isometric view
Scale: 1:1



Isometric view
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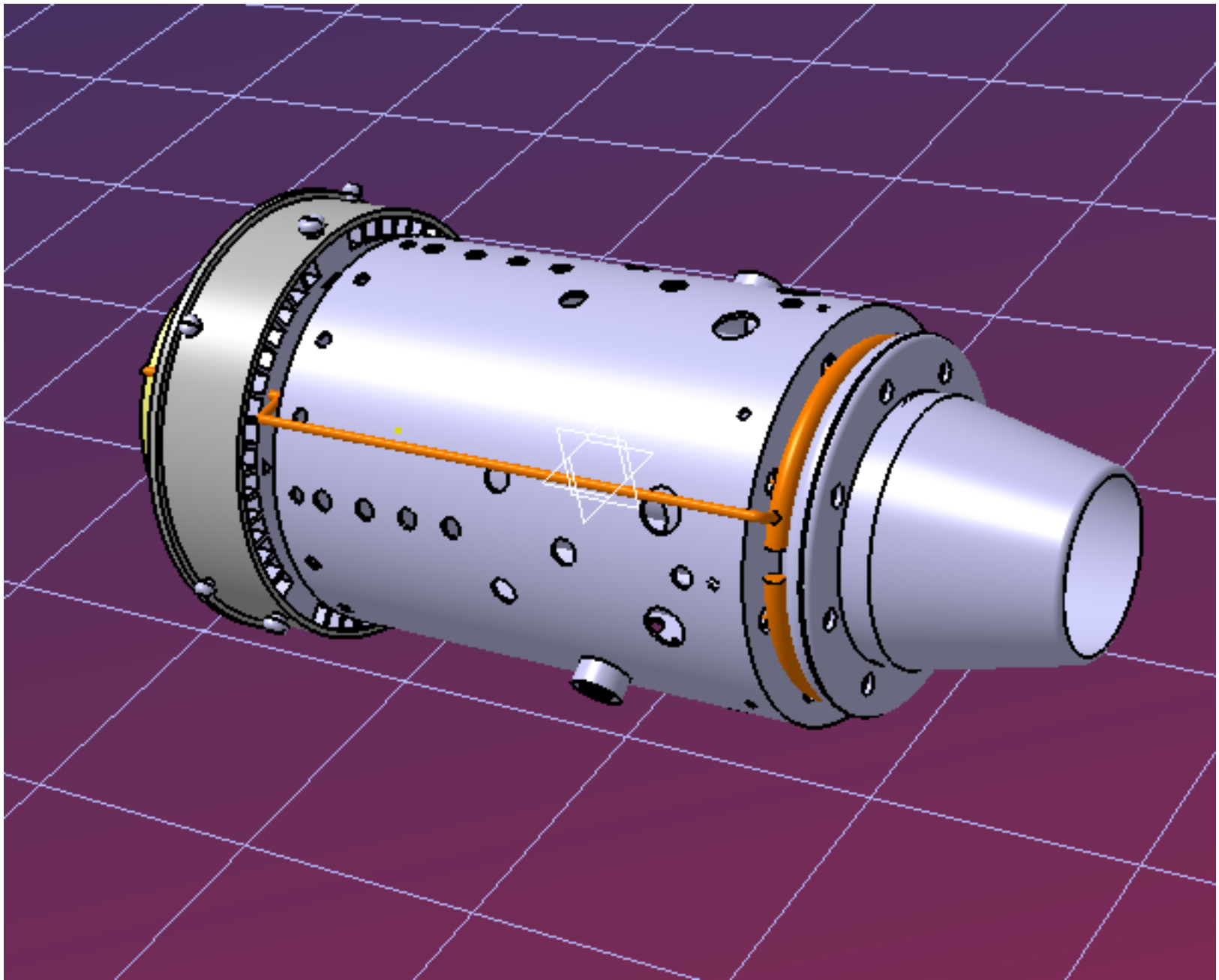
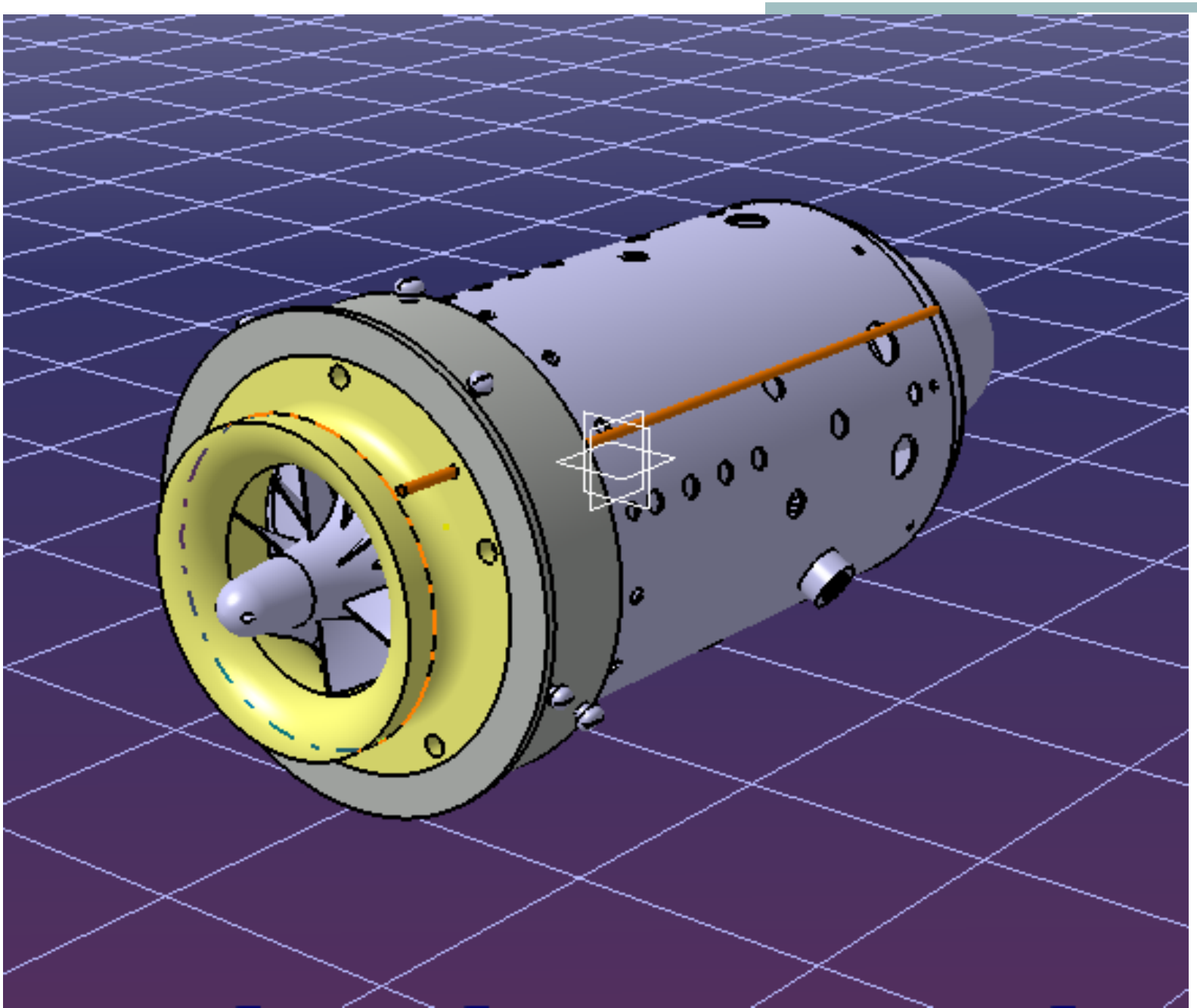
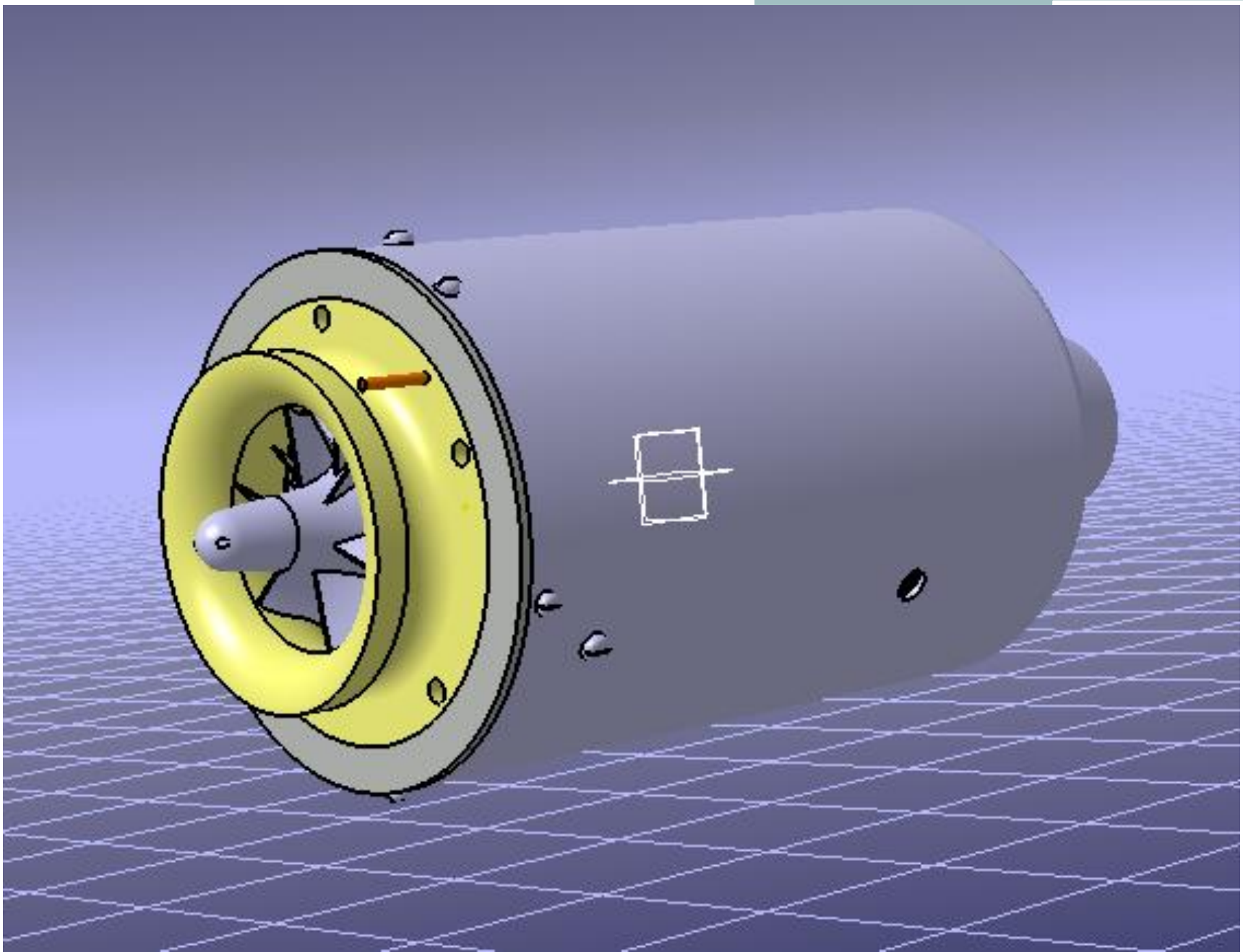
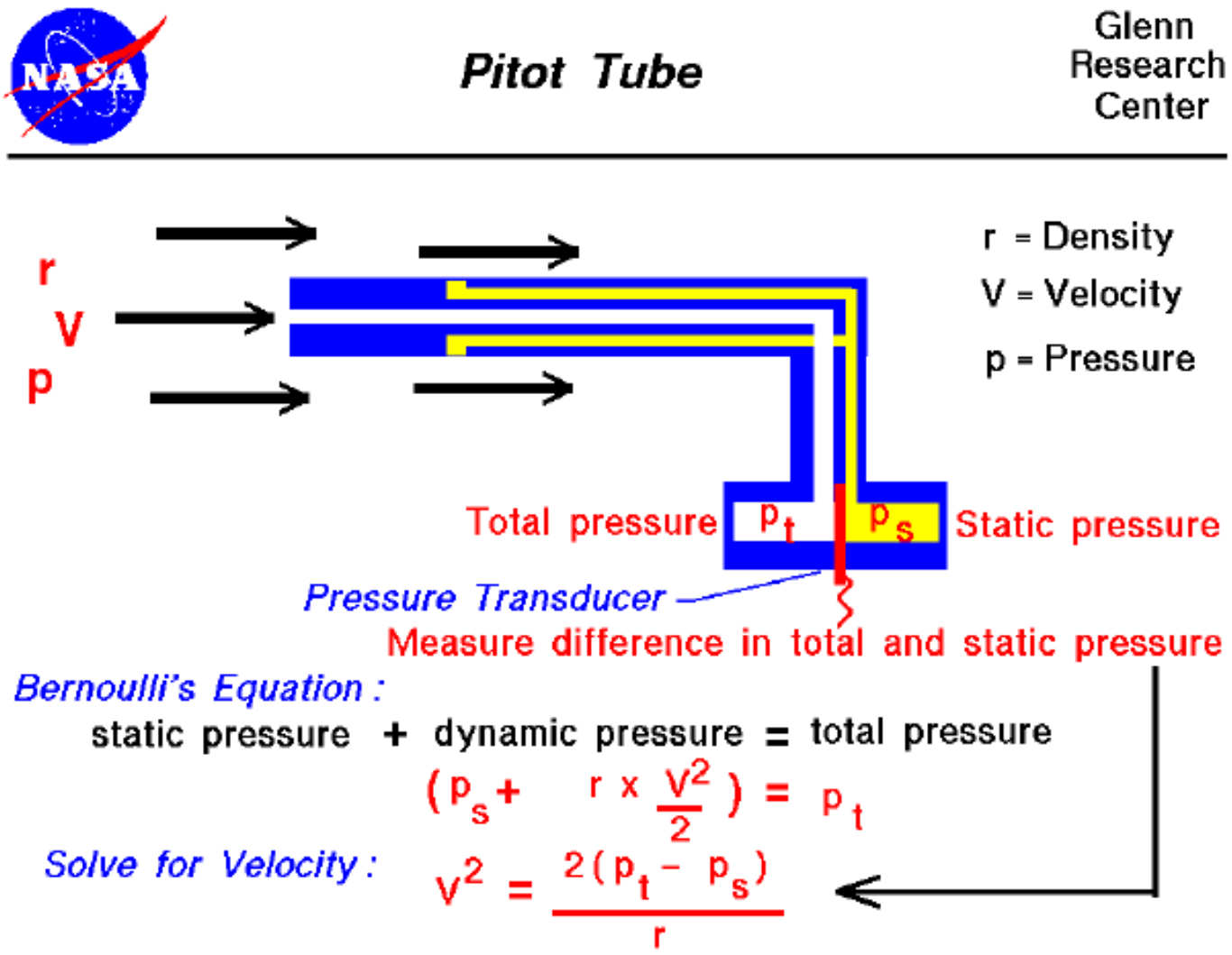






Mass Flow Rate



Mass Flow Rate

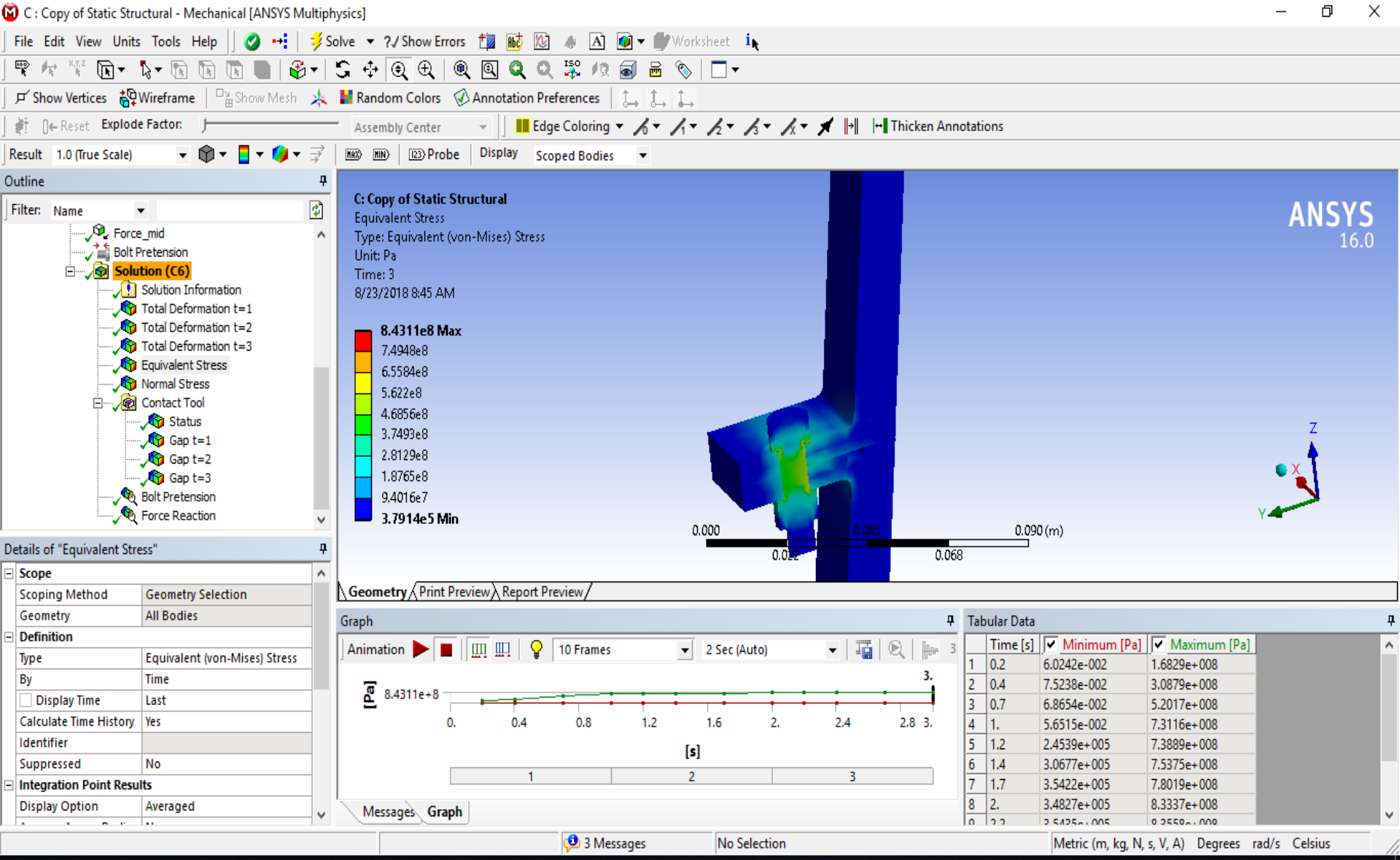
- M_dot = rho*V*S
- rho is density
- V is velocity
- S is section area

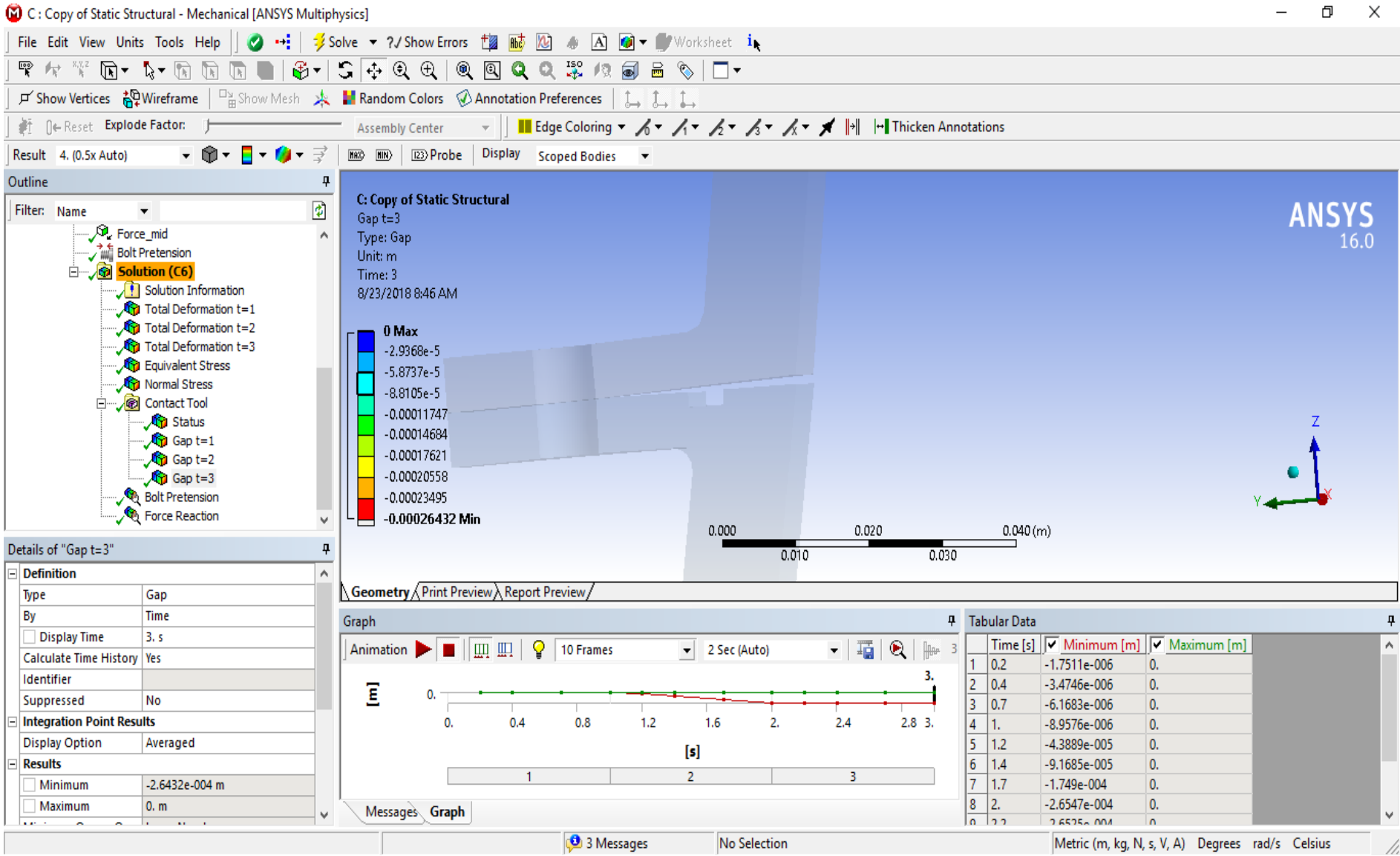
- Another way to calculate MFR

Stoichiometric Ratio

- Kerosene: $C_{12}H_{26}$ alkane or cycloalkane
- Kerosene: C_xH_y x ranges from 6 to 16
- Alkanes C_nH_{2n+2}
- $C_xH_y + (x+(y/4))O_2 = xCO_2 + (y/2)H_2O$
- Balance: $2C_{12}H_{26} + 37O_2 = 24CO_2 + 26H_2O$
- Molar mass: Carbon(C) = 12.01
- Molar mass: Oxygen(O) = 16
- Molar mass: hydrogen(H) = 1.008
- Molecular weight of kerosene: 170.34 g/mol
- Molecular weight of oxygen: 32g/mol
- 3.47 kg of air to burn 1kg kerosene
- 3.47/0.23 = 15.11 air/fuel ratio

Nozzle Flange Gap (example Saturn V)

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Assembly Center
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Thicken Annotations
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Bolt Pretension
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Maximum
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Type: Gap
Unit: m
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8/23/2018 8:46 AM
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-5.8737e-5
-8.8105e-5
-0.00011747
-0.00014684
-0.00017621
-0.00020558
-0.00023495
-0.00026432 Min
ANSYS
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0.020
0.040 (m)
0.010
0.030
Z
Y
X
Geometry
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Report Preview
Graph
Animation
10 Frames
2 Sec (Auto)
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0.
0.
0.4
0.8
1.2
1.6
2.
2.4
2.8
3.
[s]
1
2
3
Messages
Graph
Tabular Data
Time [s]
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Maximum [m]
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2 0.4 -3.4746e-006 0.
3 0.7 -6.1683e-006 0.
4 1. -8.9576e-006 0.
5 1.2 -4.3889e-005 0.
6 1.4 -9.1685e-005 0.
7 1.7 -1.749e-004 0.
8 2. -2.6547e-004 0.
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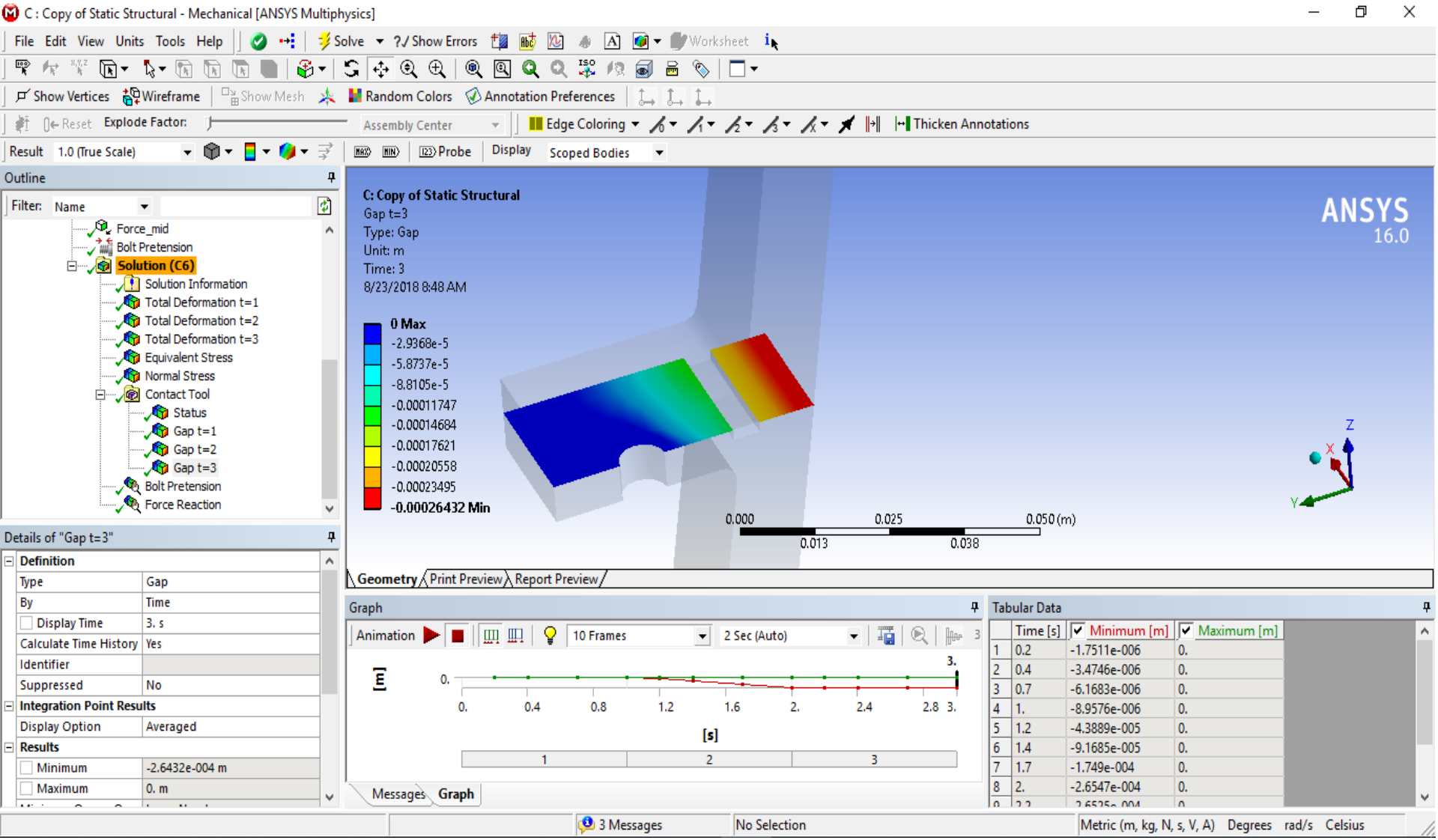
No Selection
Metric (m, kg, N, s, V, A) Degrees rad/s Celsius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Annotation Preferences
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Assembly Center
Edge Coloring
Thicken Annotations
Result 1.0 (True Scale)
Probe
Display
Scoped Bodies
Outline
Filter: Name
Force_mid
Bolt Pretension
Solution (C6)
Solution Information
Total Deformation t=1
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Total Deformation t=3
Equivalent Stress
Normal Stress
Contact Tool
Status
Gap t=1
Gap t=2
Gap t=3
Bolt Pretension
Force Reaction
C: Copy of Static Structural
Gap t=3
Type: Gap
Unit: m
Time: 3
8/23/2018 8:48 AM
0 Max
-2.9368e-5
-5.8737e-5
-8.8105e-5
-0.00011747
-0.00014684
-0.00017621
-0.00020558
-0.00023495
-0.00026432 Min
ANSYS
16.0
0.000
0.025
0.050 (m)
0.013
0.038
Z
X
Y
Geometry
Print Preview
Report Preview
Details of "Gap t=3"
Definition
Type Gap
By Time
Display Time 3. s
Calculate Time History Yes
Identifier
Suppressed No
Integration Point Results
Display Option Averaged
Results
Minimum -2.6432e-004 m
Maximum 0. m
Graph
Animation
10 Frames
2 Sec (Auto)
3.
0.
0. 0.4 0.8 1.2 1.6 2. 2.4 2.8 3.
[s]
1 2 3
Messages
Graph
Tabular Data
Time [s] Minimum [m] Maximum [m]
1 0.2 -1.7511e-006 0.
2 0.4 -3.4746e-006 0.
3 0.7 -6.1683e-006 0.
4 1. -8.9576e-006 0.
5 1.2 -4.3889e-005 0.
6 1.4 -9.1685e-005 0.
7 1.7 -1.749e-004 0.
8 2. -2.6547e-004 0.
3 Messages
No Selection
Metric (m, kg, N, s, V, A) Degrees rad/s Celsius

Future plans

- Finish manufacturing processes
- Make the engine start manually
- Working on ECU (electronic control unit)
- Estimate optimal working condition of the whole system

Thanks for listening