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Technologies for Clean Environment

Challenges and Solutions in designing EATS for Off-road and Stationary Applications

Shashank Sahai, Yogeshwar Singh & Alok Trigunayat

7th & 8th October ECT 2025

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- Ecocat Innovative Emission Control Technologies
- Challenges & Solutions in Off-road (TREM V & CEV V) & Stationary Segments
- Summary & Conclusion

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COMPLETE SYSTEM DESIGN & DEVELOPMENT

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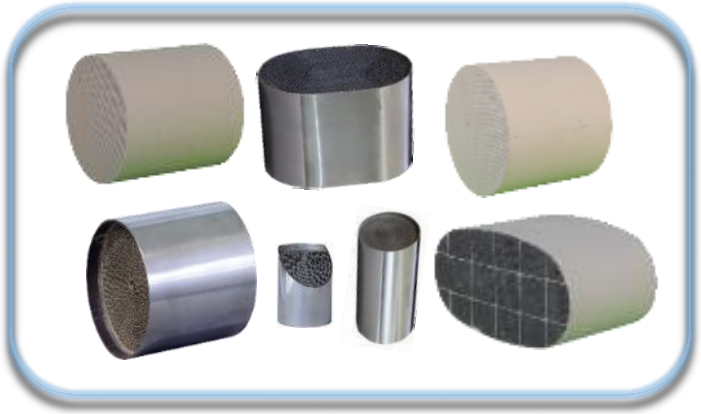
OUR MISSION

Clean the Environment for the World by providing innovative technological solutions to reduce pollution

SUBSTRATE TECHNOLOGY

Metallic Substrate
- Brazed Substrates
- VIKPIC®-D (DOC)
- VIKPIC®-F (POC)

Ceramic Substrate
- Flow through
- PFF
- DPF

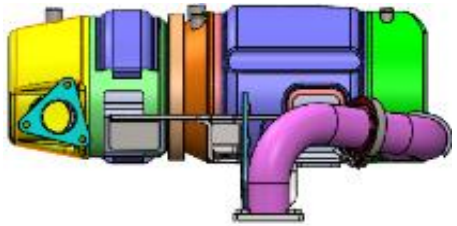


CATALTST/COATING TECHNOLOGY

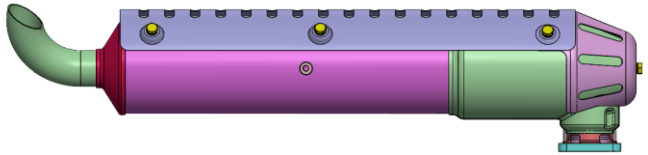
DIESEL
- Diesel Oxidation Catalyst
- Coated DPF (Diesel Particulate Filter)
- SCR (Vanadia/Cu Zeolite)
- Ammonia Slip
- LNT (Lean NOx Trap)

GASOLINE/CNG/BIFUEL
- Three Way Catalyst (Gasoline)
- Three Way Catalyst (CNG/HCNG)
- Three Way Catalyst (Bi fuel)
- Hydrogen Oxidation catalyst

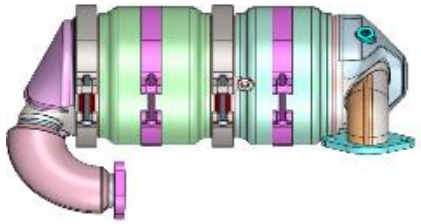
AFTER TREATMENT SYSTEM



DOC + DPF



DOC with integrated muffler



DOC + cDPF ASSY

COMPLETE EXHAUST SYSTEM

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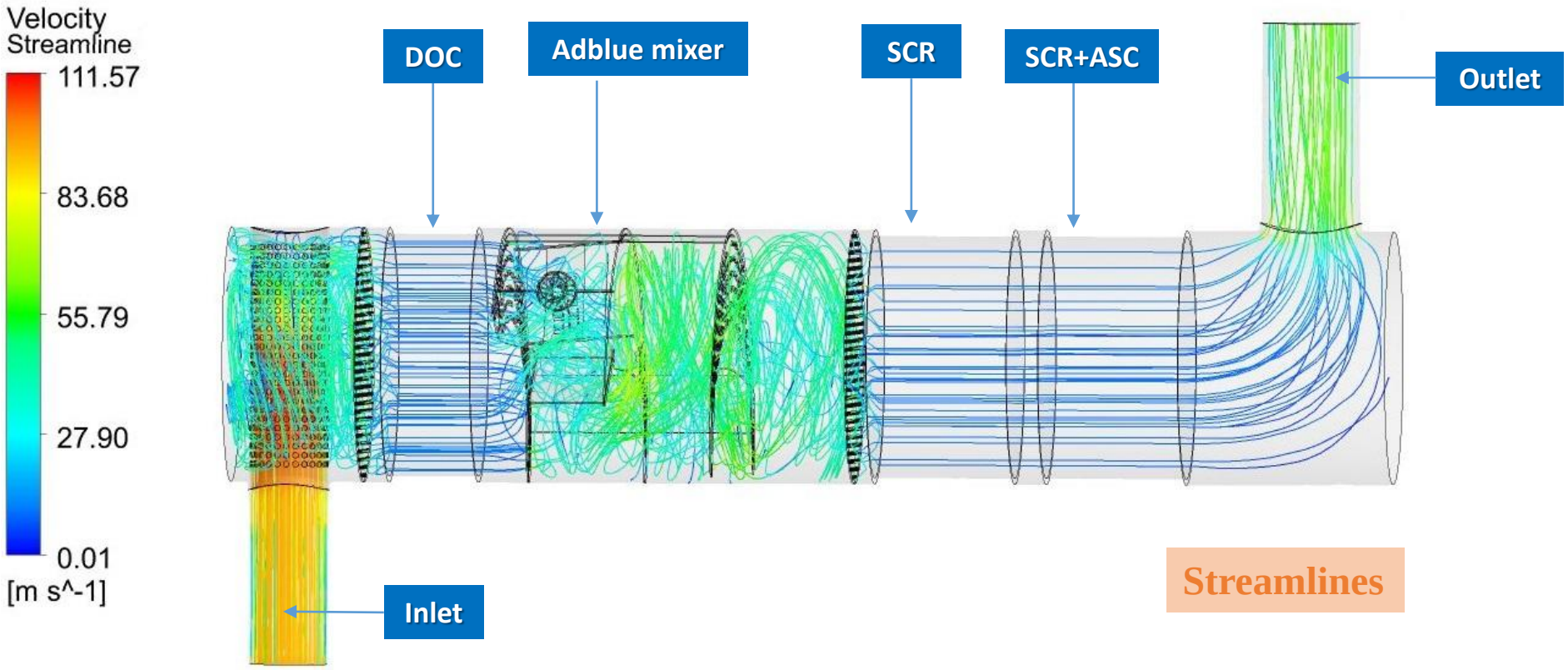
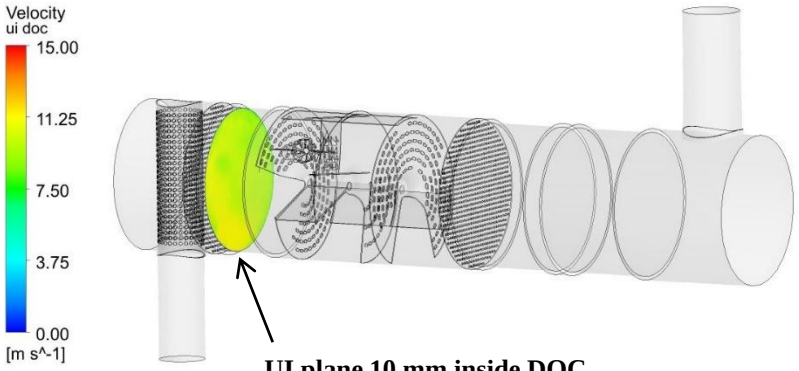
Application: Genset EATS to meet CPCB 4+ Norms

Challenge

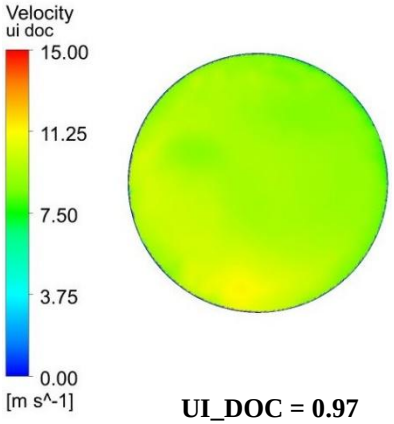
- Meet uniformity index >0.95
- Meets backpressure targets
- Easily serviceable design



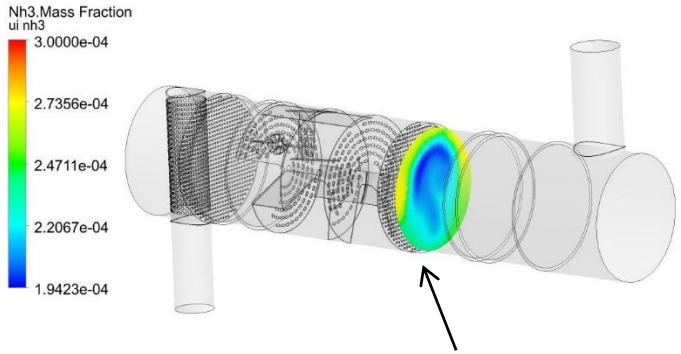
COMPLETE SYSTEM DESIGN & DEVELOPMENT



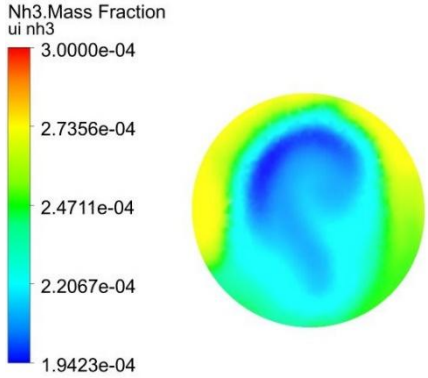
UI plane 10 mm inside DOC



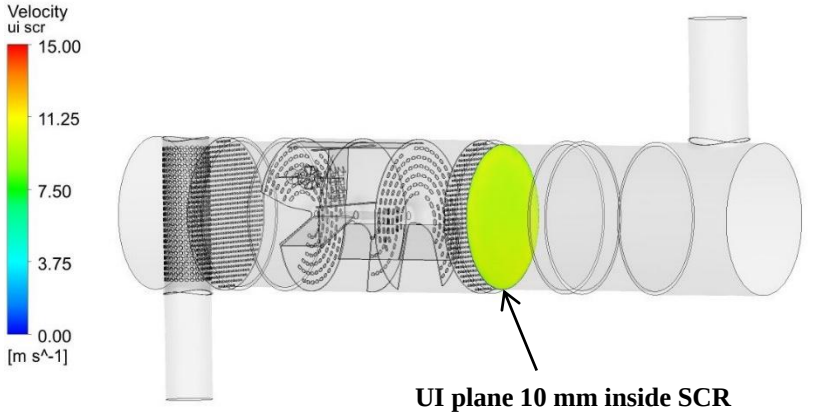
UI_DOC = 0.97



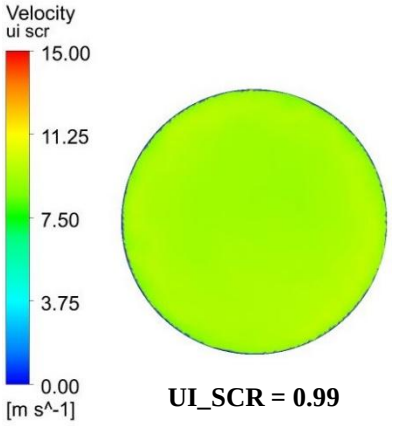
UI plane 10 mm inside SCR



UI_NH3 = 0.96



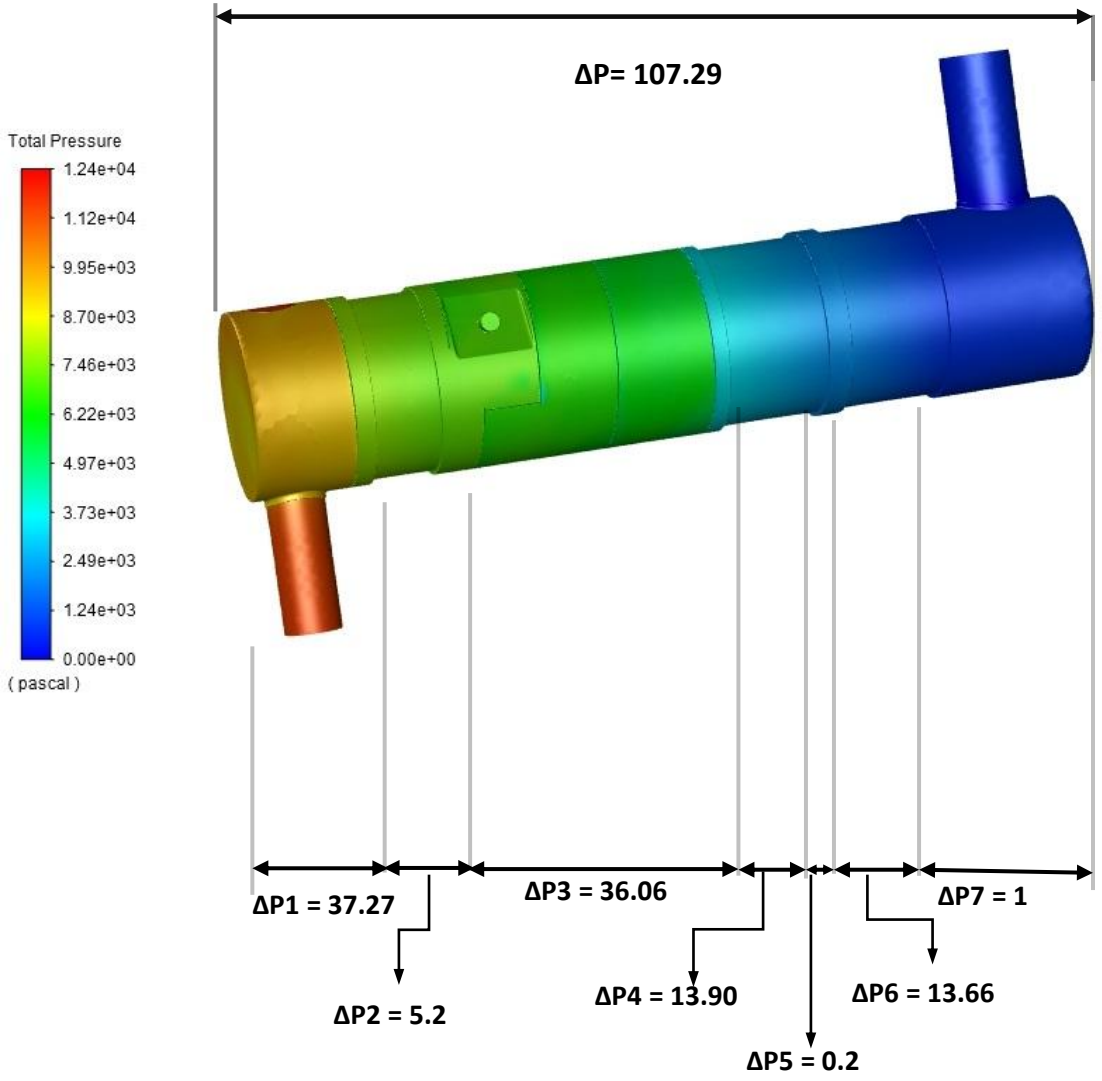
UI plane 10 mm inside SCR



UI_SCR = 0.99

- Max mass flow : 725 kg/hr
- Max temperature : 480 °C

COMPLETE SYSTEM DESIGN & DEVELOPMENT



Pressure drop values (in mbar)	
Inlet Cone , **ΔP1**	37.27
DOC , **ΔP2**	5.2
Mixer Region, **ΔP3**	36.06
SCR , **ΔP4**	13.90
Space, **ΔP5**	0.2
SCR /ASC, **ΔP6**	13.66
Outlet Cone , **ΔP7**	1
Pressure, **ΔP**	107.29

COMPLETE SYSTEM DESIGN & DEVELOPMENT

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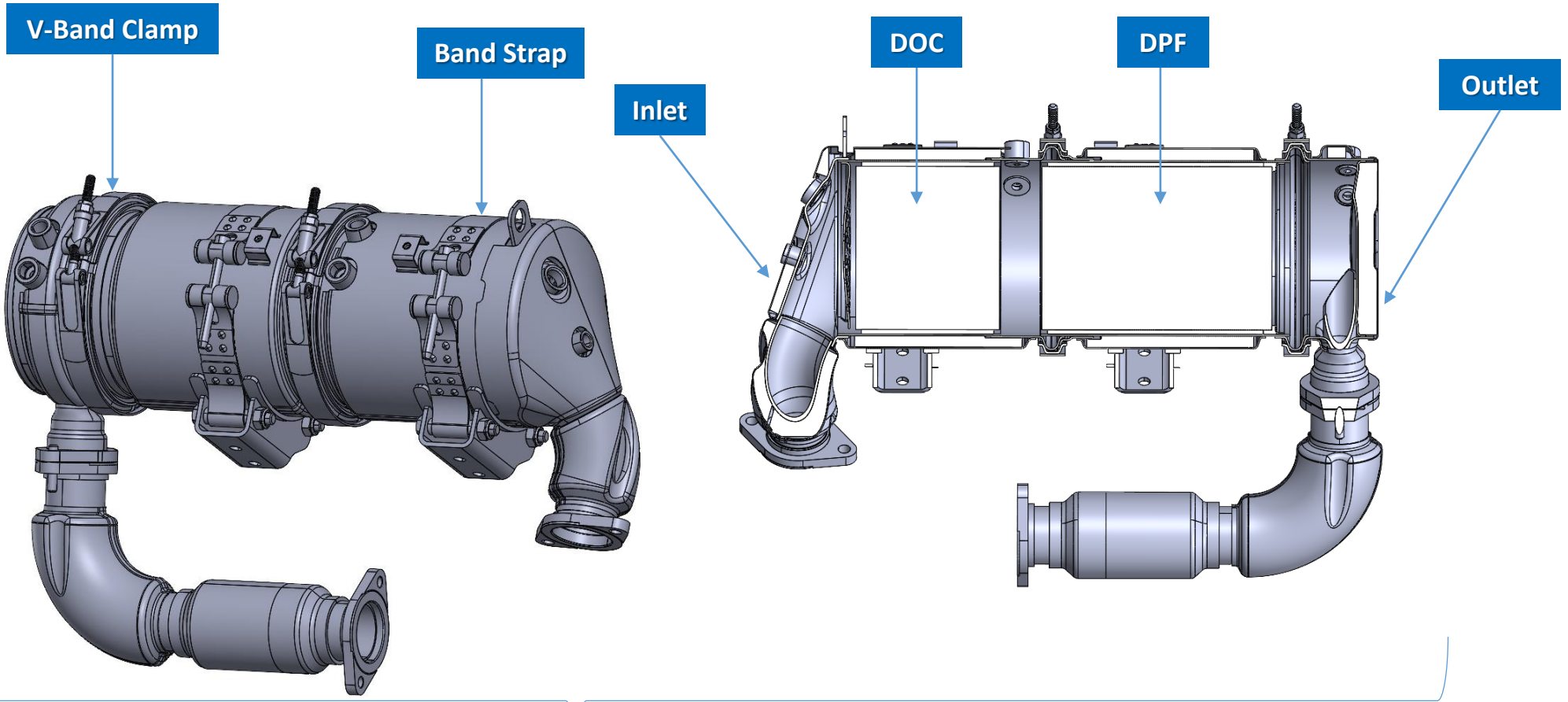
Tractor EATS to meet TREM – V/CEV – 5 Norms

Challenge

- Surface Temperature< **200°C**
- Meets backpressure targets
- Easily serviceable design



Max skin temperature controlled under **200°C** @ Max flow of 301kg/hr and max exhaust gas temperature of 650°C.

COMPLETE SYSTEM DESIGN & DEVELOPMENT

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Tractor EATS to meet Trem V Norms

Parameters	Value					
DPF material	Cordierite					
Soot mass loading (g/L)	3 and 4					
Mass flow rate, (kg/h)	225					
Temperature (°C)	590					
Lube oil consumption (g/hr)	6					
Ash content in oil	1%					
Ash finding factor	0.6					
Proposal	Option-1	Option-2	Option-3	Option-4	Option-5	Option-6
Diameter, mm	197x102.2(Oval)	197x102.2(Oval)	143.8(Round)	143.8(Round)	143.8(Round)	207x160(Oval)
Length, mm	203.2 (8″)	254(10″)	203.2(8″)	254(10″)	241.3(9.5″)	150.5
CPSI/mil	300/9	300/9	300/9	300/9	300/9	300/9
Volume, L	3.452	4.314	3.295	4.123	3.917	3.926

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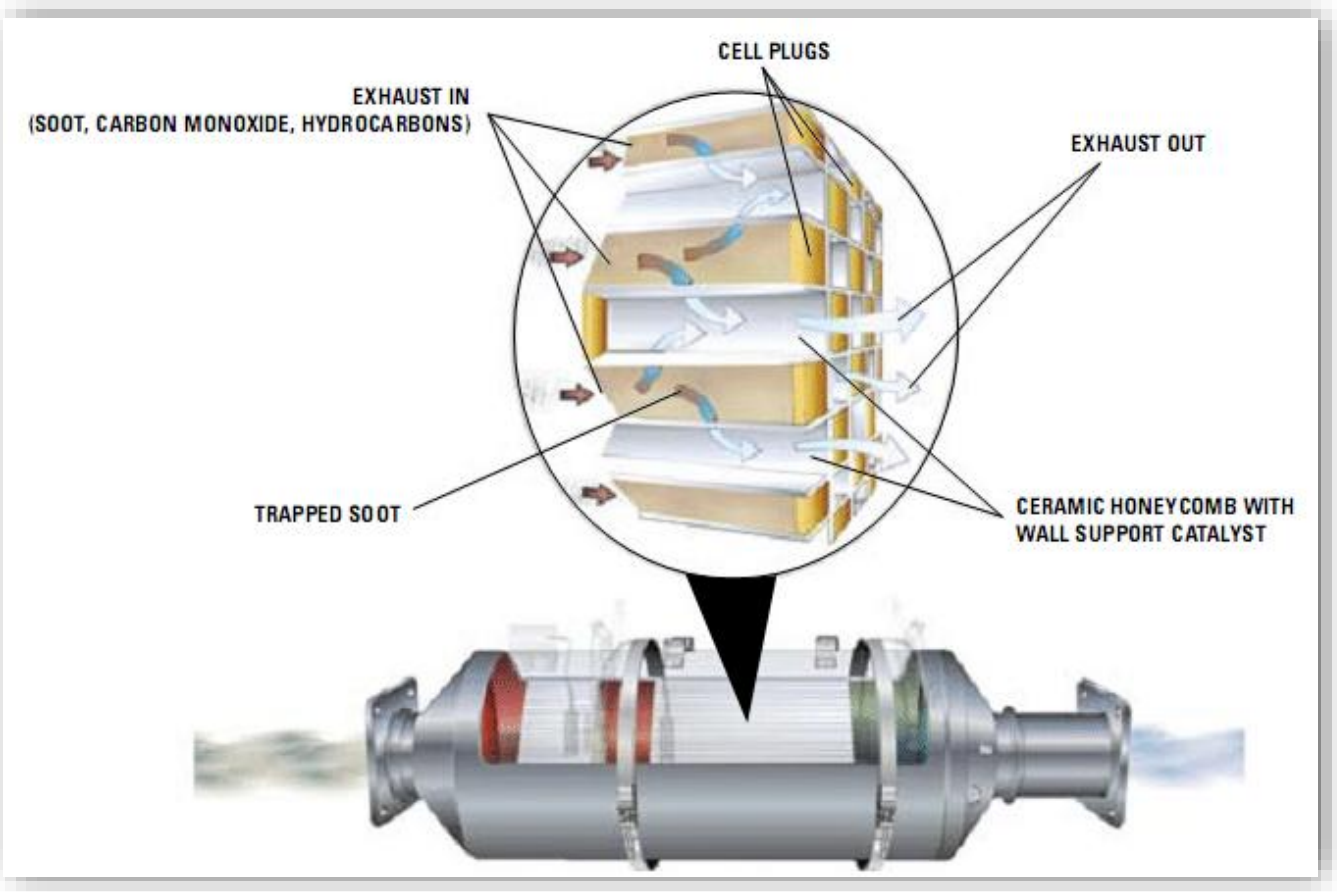
Following parameters are the assumed DPF BP calculations:

Parameter	Value	Unit
Plug Length	7.5	mm
Pore Diameter of PF	10	micron
Porosity of PF	51	%
Ratio of Channel diameters	1.31	-
Ash packing Density	217	kg/m^3
Ash Permeability	5.56E-13	m^2
Wall Permeability of PF	4.00E-12	m^2
Soot cake packing density	110	kg/m^3
Soot cake permeability	3.21E-14	m^2
Ash layer/plug distribution factor	0.18	-



*PF= Particulate filter

COMPLETE SYSTEM DESIGN & DEVELOPMENT

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Tractor EATS to meet Trem V Norms

Ash cleaning interval calculation

			Time Interval [hrs] at SML 3 g/L								
Option	DPF description	Clean	0	1000	2000	3000	4000	5000	6000	7000	8000
1	Oval (197x102.2) x 203.2	31.0178	54.832	62.6474	71.7844	83.1479	98.1505	119.188	151.886	210.476	336.038
2	Oval (197x102.2) x 254	35.1547	56.9272	63.3502	70.3071	78.1883	87.3692	98.5217	112.808	132.267	160.751
3	Round 143.8 x 203.2	32.8049	57.6664	66.6974	77.6014	91.5558	110.89	140.178	191.116	300.422	-
4	Round 143.8 x 254	37.1161	59.8426	67.2383	75.4428	84.8539	96.1507	112.516	129.888	158.421	206.85
5	Round 143.8 x 241.3	36.0445	59.142	66.8301	75.4979	85.6563	98.1803	114.638	138	174.616	242.814
6	Oval (207.6x160) x 150.5	15.7999	35.0499	40.0908	46.2547	54.0881	64.5042	79.0535	100.858	136.943	204.915

			Time Interval [hrs] at SML 4 g/L								
Option	DPF description	Clean	0	1000	2000	3000	4000	5000	6000	7000	8000
1	Oval (197x102.2) x 203.2	31.0178	62.3644	71.4984	82.5464	96.578	115.382	142.321	184.797	261.467	428.997
2	Oval (197x102.2) x 254	35.1547	63.2818	70.4502	78.4771	87.7251	98.7569	112.523	130.428	155.238	192.371
3	Round 143.8 x 203.2	32.8049	65.5264	76.1424	89.3083	106.647	131.052	168.853	235.313	379.188	-
4	Round 143.8 x 254	37.1161	66.4804	74.7867	84.2215	95.3248	109.039	126.815	151.343	188.358	251.573
5	Round 143.8 x 241.3	36.0445	66.015	74.7387	84.8221	96.9552	112.374	132.965	162.748	210.394	300.225
6	Oval (207.6x160) x 150.5	15.7999	41.7797	48.0374	55.8185	65.8488	79.3044	98.377	127.194	174.632	264.767

COMPLETE SYSTEM DESIGN & DEVELOPMENT

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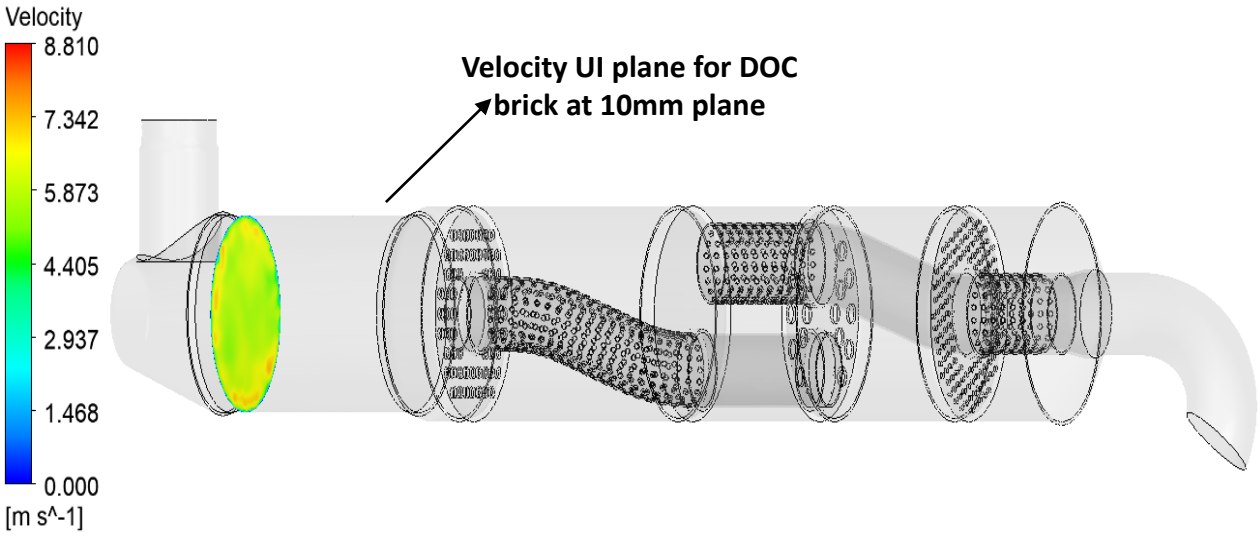
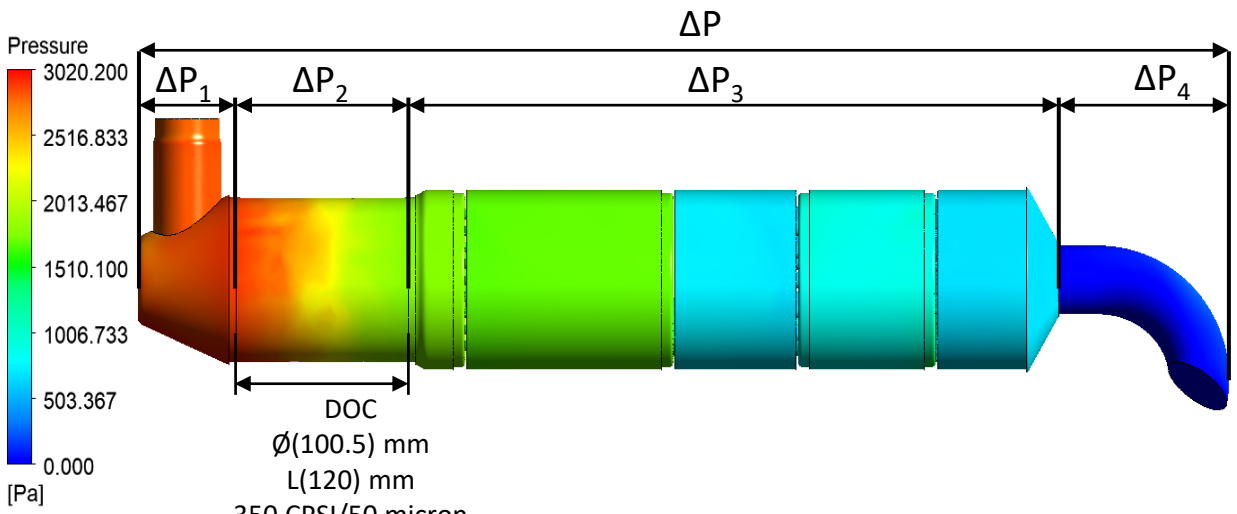
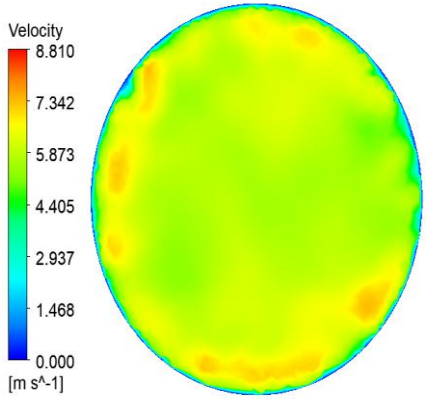
Application: INTERIM TREM-V TRACTORS with integrated muffler

Challenge

- Meet uniformity index >0.95
- Meets backpressure targets
- Acoustic Attenuation







UI_DOC = 0.96; Target UI_DOC ≥ 0.95

- Max mass flow : 65 kg/hr
- Max temperature : 650°C

Pressure Drop	ΔP_1 (Inlet Cone)	ΔP_2 (DOC)	ΔP_3 (Muffler)	ΔP_4 (Outlet Pipe)	ΔP (System)
Values (mbar)	1.145	10.77	13.738	1.381	**27.034**

COMPLETE SYSTEM DESIGN & DEVELOPMENT

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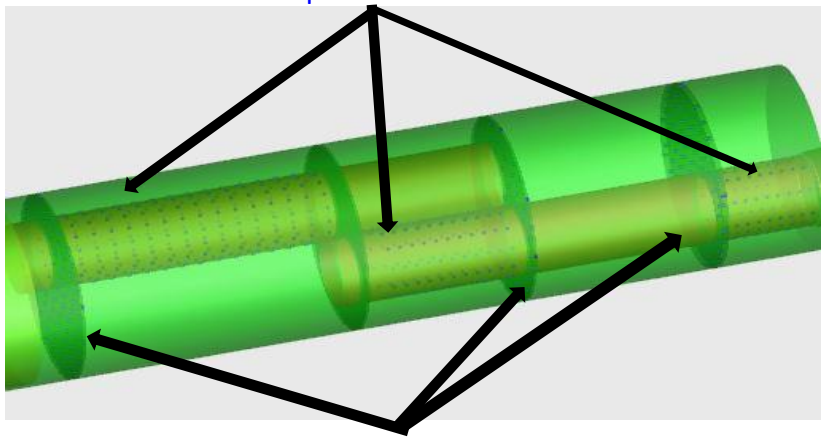
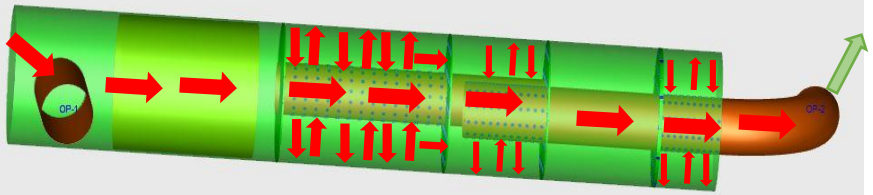
Application: TREM-V TRACTORS with integrated muffler

PATENT No.- 368279

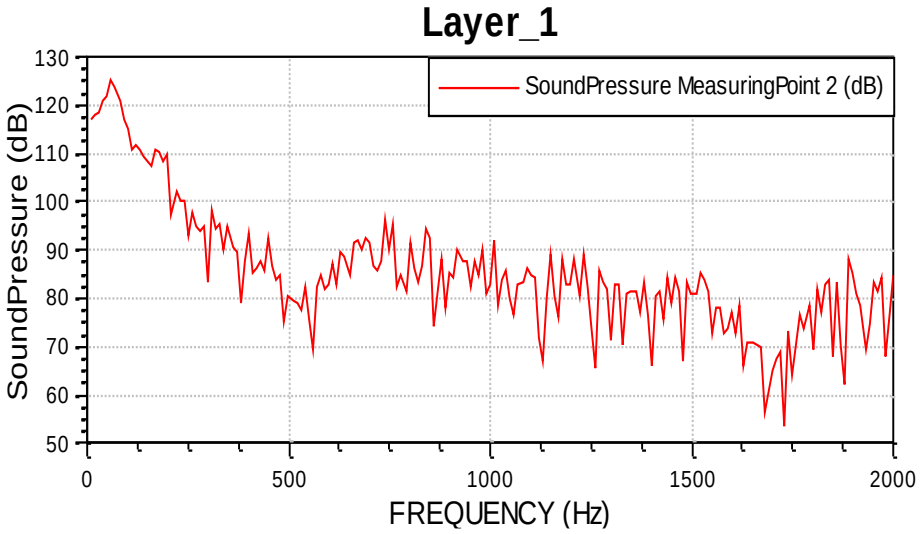
Pipe Perforation

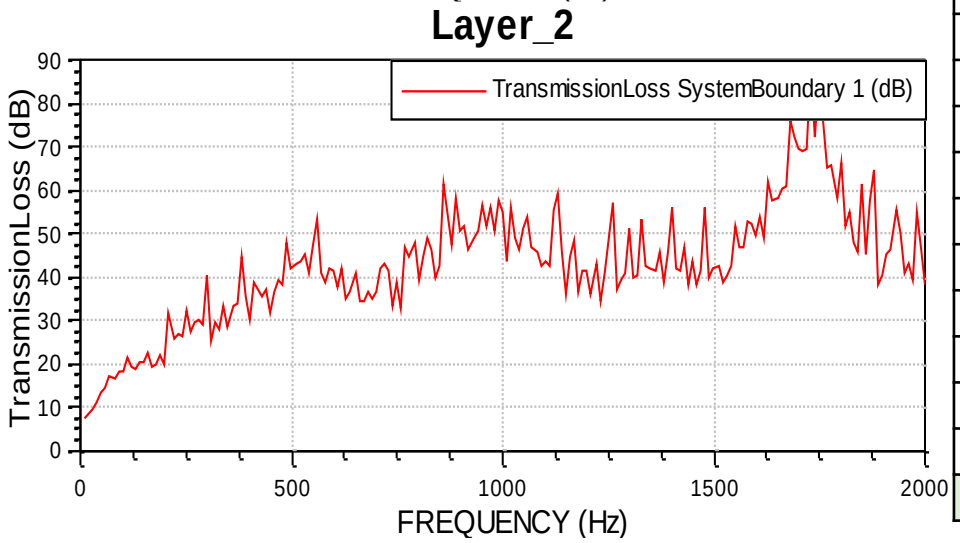


Baffle Pipes



Fluid Flow Vector





Frequency [Hz]	Sound Pressure [dB]	Transmission Loss [dB]
10	117.07	7.45996
100	115.253	17.9738
200	109.878	19.9207
300	83.3928	40.396
400	93.6282	30.2442
500	80.5737	42.1742
600	82.6457	41.555
700	91.6207	36.502
800	91.6926	39.2824
900	85.0639	50.7485
1000	83.0813	54.7712
1100	84.562	43.3816
1200	82.7639	41.3415
1300	71.451	51.2487
1400	66.2009	56.2688
1500	81.1287	42.1132
1600	76.9105	49.4568
1700	65.2919	69.5769
1800	69.2584	66.3372
1900	85.4006	40.6264
2000	84.6783	37.9998
Average	85.7879	41.87518

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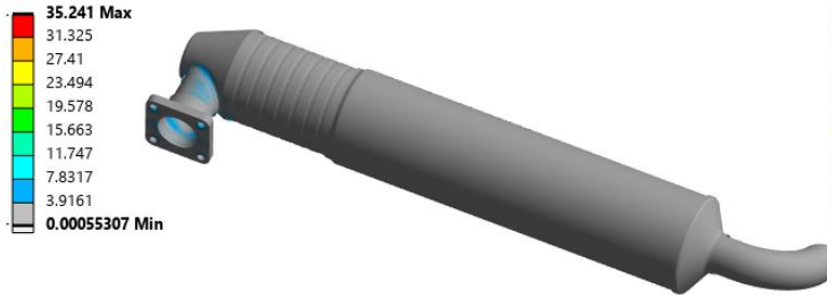
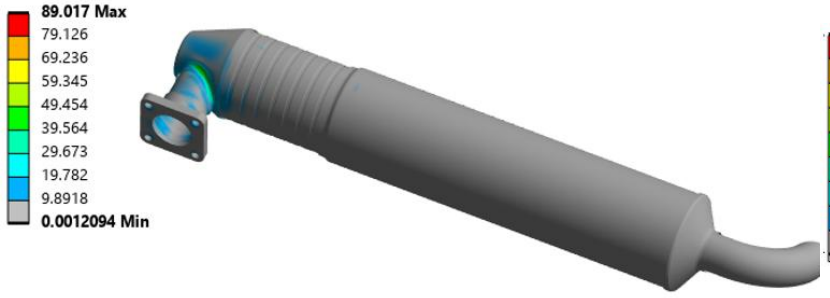
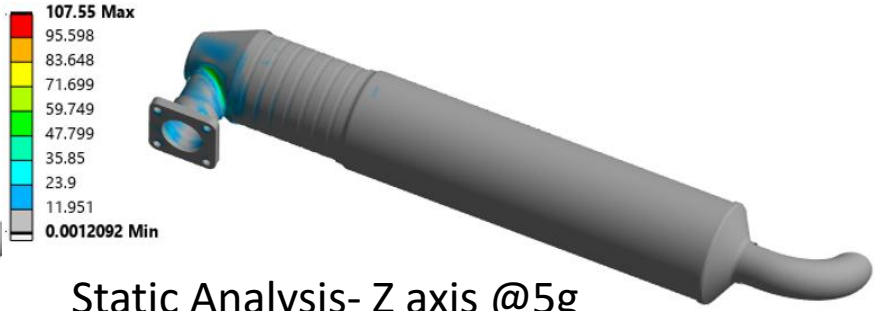
Application: INTERIM TREM-V TRACTORS with integrated muffler



Static Analysis- X axis @4g

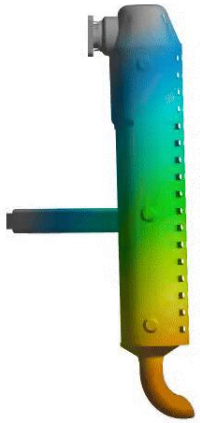


Static Analysis- Y axis @4g

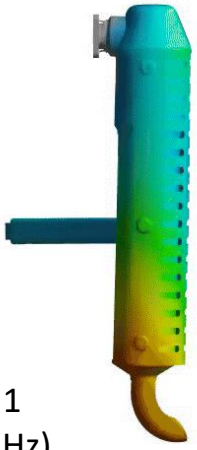


Static Analysis- Z axis @5g

Modal Analysis



Mode 1
@ 45.4 (Hz)

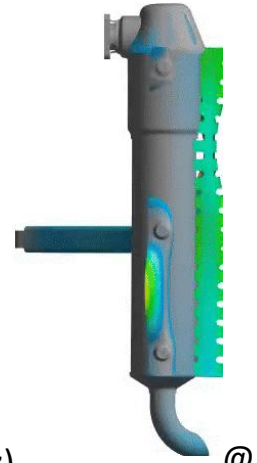


Mode 2
@ 179.5 (Hz)

Mode 3
@ 253.4 (Hz)

Mode 4
@ 321.6 (Hz)

Mode 5
@ 337.2 (Hz)



Mode 6
@ 355.8 (Hz)

COMPLETE SYSTEM DESIGN & DEVELOPMENT

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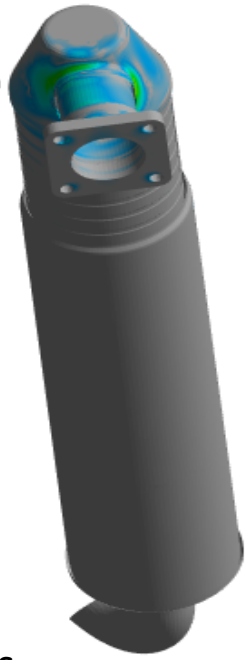
Application: INTERIM TREM-V TRACTORS with integrated muffler

Harmonic Analysis

Stress @ 45.4Hz

Equivalent (von-Mises) Stress - 45.481 Hz - Catcon
Type: Equivalent (von-Mises) Stress - Top/Bottom
Frequency: 45.383 Hz
Amplitude
Unit: MPa
Solution Coordinate System

52.385 Max
46.564
40.744
34.923
29.103
23.282
17.462
11.641
5.8208
0.00035421 Min



X-Axis

Equivalent (von-Mises) Stress - 45.481 Hz - Catcon
Type: Equivalent (von-Mises) Stress - Top/Bottom
Frequency: 45.383 Hz
Amplitude
Unit: MPa
Solution Coordinate System

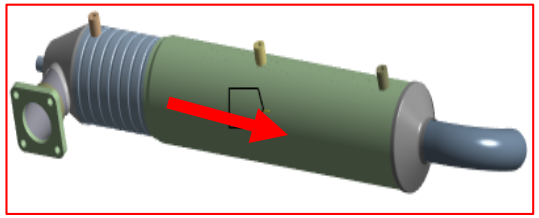
249.5 Max
108
94.5
81
67.501
54.001
40.501
27.001
13.501
0.0017133 Min

Y-Axis

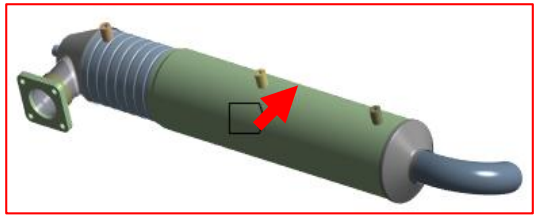
Equivalent (von-Mises) Stress - 45.481 Hz - Catcon
Type: Equivalent (von-Mises) Stress - Top/Bottom
Frequency: 45.383 Hz
Amplitude
Unit: MPa
Solution Coordinate System

266.15 Max
108
94.5
81
67.501
54.001
40.501
27.001
13.502
0.0017384 Min

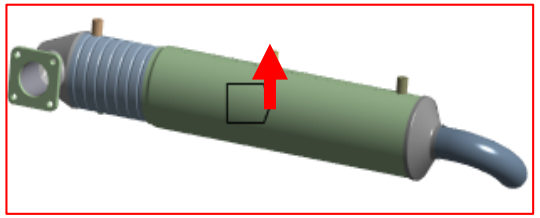
Z-Axis



X-Axis



Y-Axis



Z-Axis

Other Challenges & Solutions

1	**Increased Packaging Complexity**	**Compact & Integrated muffler After-treatment System Design**
2	**Particulate Matter (PM) Reduction**	**Advance Particulate Filters**
3	**Regeneration Strategies**	**Advanced Catalysts (Exotherm Generation)**
4	**Stricter NOx Limits**	**Advanced SCR Catalysts (NOx Reduction)**
5	**Thermal Management**	**Technological Innovation**

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Summary & Conclusions

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- To meet stricter norms in same packaging space challenges us to make innovative compact designs. For which accurate CFD & FEA needs to be done.
- New technology like DPF (specially for TREM-V norm), DFM and DFA is strictly followed to design easy serviceable canning options.
- Harmonic analysis needs to be done to ensure and extend the endurance limit designs of the catcon.

Thanks !