Shock Transient Analysis on Wabtec Diesel Engines for Naval Vessels



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Marine Engine Barge Test Simulation





Marine Engine Barge Test Simulation - Overview

➢ For Naval applications (NVR)

➢ Show case the engine structural integrity

- near to ship non-contact explosion.

Barge Test

≻ MIL-DTL-901D/E





Marine Engine Barge Test Simulation - Overview Continuation



High Deformation Mount (HDM) between the engine system and the Deck of the vessel





Marine Engine Barge Test Simulation : Process flow Chart

- Have engine ready for Barge Test / Shock Qualification
- Correlation with simulation



Marine Engine Barge Test Simulation : Two Stage Analysis



Stage 1 : Simplified model with engine and alternator as Inertia elements



Stage 2 : Full 3D Engine and alternator simulated using SOLID elements

Total # Nodes:~2.8mlnTotal # Elements:~2.4mln

Marine Engine Barge Test Simulation : LS Dyna Inputs

Pre and Postprocessing:LS Prepost V4.8Solver:LS Solver R11.2.0

- SHELL / SOLID / INERTIA Elements
- Reuse of existing ANSYS Model.
- MAT024 PIECEWISE LINEAR PLASTICITY and MAT001 LINEAR ELASTIC.
- MAT067 NONLINEAR ELASTIC DISCRETE BEAM HDMs
- 25+ equipment Merged nodes / Tied Contacts
- Modal Analysis in LS Dyna
- Dynamic Relaxation to preload the model

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Marine Engine Barge Test Simulation : LS Dyna Inputs High Deflection Isolator Mounts



Deformation, mm

- Preliminary 1D calculation
- Normalized stiffness curve is shown here. Constant damping inputs were given.

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EQ.5: Belytschko-Schwer tubular beam with cross-section integration, EQ.6: discrete beam/cable,

EQ.7: 2D plane strain shell element (xy plane),

EQ.8: 2D axisymmetric volume weighted shell element (xy plane),

Marine Engine Barge Test Simulation : LS Dyna Inputs High Deflection Isolator Mounts

Normalized shock pulse



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- BOUNDARY PRESCRIBED MOTION SET Input velocity impulse -
- No secondary / tertiary motion is considered

Fullmodel 16V250 LCSYS DynStf 10.5Dmp Trelleborg - Transient

Z - Displacement, mm- Animation contour

Deformation response of the system for 750ms for the shock impulse given for 50ms

Z Deformation @ one of the mount



Z - Acceleration (g), mm/s2 @ all 4 engine feet





Effective plastic Strain over time



Stabilization of the plastic strain over time

Marine Engine Barge Test Simulation : Infra & Risk Matrix.

Risk matrix :

Response acceleration

Stress/Strain magnitude

Wabtec's past analysis and field experience.

SI, No Y	Equipment Name *	Materia *	Vendor/ Inhouse * 'g" @ Mouri *		loun -	Remarks / Risks	Recommended Action	Risk
				Z	Y			
1	Engine Feet	GJS500-7	Inhouse	6.2	2.6	Load is considered as global load for the entite engine as a single component. In LSDana run, Feets shows stresses were within yield limit of 300MPa and no plastic strain is reported.	Engine Feet analysis done in the past to be looked at for "g" load an alyzed in vertical deciton and the margins reported. Sign failure mode – even signs, the lips can hold it. Need to relook at the lip stresses in non-linear analysis.	high
2	Turbo Mounts (Pedestals)	GJS500-7	Inhouse	6.9	1.7	Max stress reported on the pedestals very less than 31MP a. Zero plastic strain reported. Casting parts show very/ow stress.	Check the past analysis done on the mounts with operating loads. Bolled joints of Turbo to Pedestals (Hidd-down bolts -2 ho be checked.	nedun
3	Turbo Components	Steel	MAN	- do -	- do -	Marc stress reported on blades : 110MPa. No plastic strain is observed. "g" loads measured at the pedestails to be considered for Turbo.	To be checked with Suppler	lov
4	Heat Exhangers	Aluminum	Kelvion	7.6	1.9	considered as simplified bases. No direct streas/strains can be extracted. 32MPa is maximum observed in housing a huminum mech, properties were applied, mass of the components were matched by adjusting the density. "I loads extracted near the Hear Eschanger mounting bolts to PE. Maximum of two interecoders and	Tobe of works for the supplier. Populativy of inhaler year?	lov
5	Oil Cooler & mounts	GJS 450	Alfa laval	6.62	2.92	Only the outer casing of of occient were modeled. It is internal parts were considered, simplified as box. Though Mounts were considered with coarse menh. CF loads were envised at their occuring bracket bits Wh IPE. Marchans observed on the of cooler reconting brackets in SS/IPA. Lating parts inforwelps to mesh, fronding coarse mesh to used on the insunting bracket.	Of cooler topsaff coold not be evaluated in LSDma. Need to be checked with supplex. Develwarging can transmit weakaned in the parts at ratic to be oncerner warliers. With Higher "g" load, then need to be evaluate the cast bracket with a been sprocession of codes (con-homogeneous model). Readeby of halast rest?	nedur
6	EGR	GJS400-15	Kelvion	7.4	2.9	Max stream is S2MPa. No plants strain based on yield considered, 300MPa. ICSR cooler is faitly represented through the internal deals are en on consurved accurately in LS Dyna model. Max stream seem the paper wild part which is much lower than the yield. "I loads entransid were at the ECP mounts.	ECRI internal parts need to be assessed ? Need to confamithe material and check with supplier for Higher "g" loads	lov
7	EGR Mount brackets	GJS450-10	Inhouse	- do -	- do -	Streazes were leaz than 35 MPa Low risk as the capting mount show very low stress levels.	Check for any past analysis done on the DGR mount brackers if available?	low
8	EGR Pipes	Steel	inhouse	7.62	4.9	Max stress of 41MPa against the material yield of 250 MPa. No plastic strain, "g" loads extracted after mounting points to crankcase (not on the pipe)	Material property to be continued. Pipe joints / interfaces with cooler are a known weak points. They need to be studied in detail if the higher "g" loads causing higher deflections and	nedun
9	Water Pipes between HE and Intel®Dutlet to Waterpump	Steel	Inhouse	8	3.6	the join: Though most of the joints shows relatively higher stress, except two joints, no plastic strain is reported any where on the pipes. All of there pipes were considered structural streal. Werylow plastic strain of U.S.C. considering yield of 2000PA. Maintrum of "a plaste ensated ou our strain of the initis UE & water purrol is reported in summare.	A babanchills the pipes night be required. Depending on the EGR pipe analysis six would be re-evaluated and the need for analysis robe material. Table worksid clearly during terring on the parts to leakage. <i>Material yield</i> of these pipes robe occiment.	nedur
10	Exh. Manifold	HS Steel	Inhouse	6.9	3	Marsteess of 109 NPa. No plastic brain consisting 350 MPa yeld. Stress is an on the bellow region in LSDyns, which could be sputcus. Considering manifolds alone, stresses were much lesses in the code of 25MPa. "If loads estimated were at the cylinder head treat alone and tubbo interface, maxwake is resported.	HS Seek namerial need to be continued. Though low strees in "g" load alone, past analysis terular margin to be relocked at including operating loads.	kov
n	Cil filter & Mounts	GJ5450	Alfa Laval I Boll n Kirch	6.9	2.72	Connect and the control of the control was an end of the mounting backets are control was and the control of th	Consisting a low stress values, enzy past analysis on five mounting brackets can be looked into. Need to get continuation from fifter applier for "g" badd. 300 poncerem on the blockforms - Diship me valuation meed to be looked into for higher "g" loads.	nedun
12	Lube Pump	Steel	Rickmeier	7.5	4.8	Lube pump is modeled in simplified coarse mesh. No internal parts were captured. Nex stress of 10MPa is observed. No plastic main's seen active masselay/eldused is 20MPa. "g" loads were entraced at the mounting points on engine.	Need to be checked with the supplier. Rabbit fits were used and less risk on bolied joints.	lov
13	Water Pump	Steel	Gilkes	7.3	4.5	Model with 3D elements for the housing. No internal parts were not considered in simulation. 40 MPa is the maintain stream observed on the parts housing. No plants main observed.	Need to be checked with the supplier. Rabbit fits were used and less risk on bolled joints.	lov
и	SEA water pump	Steel	Gilkes?	7.1	2.4	In T4 NBD DL, SEA vases purplin not available. However PE model used for inhubition had it. Model with 30 determined for the purple housing. No inhumal parts were not considered in simulation, 53 MPa is the materizem stress observed, considering 25 MPa as yield of material.	Need for SEA wave pump to be somed out. To be checked with suppler for high "g" loads. Rabbit its vere used and less tilk on boked joints	low

Snapshot of Risk Matrix

INFRASTRUCTURE:

- Solved in On-Prem HPC as well as in AWS Cloud solution.
- 64 cores to 96 cores were used
- dp_mpp double precision / multiprocessor
- Intel Xeon Platinum processors of 2.1GHz with 1TB RAM were used
- 5 to 7 days were solver time to complete the 750ms response.

Back up

~50 hours with 96 cores in hpc

Marine Engine Barge Test Simulation : LS Dyna Learnings.

- No ramping to be used to apply the self weight (pre-load) in transient analysis. 100% to be applied at time zero.
- SCOOR Parameter in isolator DISCRETE BEAM modelling in LSDyna has notable impact on the results. This is basically defining the location of the Triad for tracking the rotation of the discrete beam element. Unless required to be moved the Triad, keep them as default.
- Flexible coupling can be simulated using 066_LINEAR DISCRETE BEAM material model (spring) with stiffness input in required direction
- Time step adjustment: Parameter "DT2MS" in the control card *CONTROL_TIMESTEP to get the balance between solver run time to the added mass of the model (accuracy).

"DT2MS" value used in this analysis is -1.03e-7

"added mass" during the solution is 47e-3 kg on the entire assembly mass of 70 tonnes.

Marine Engine Barge Test Simulation : Modal.

Fundamental modes

