



Larsen & Toubro

Heavy Engineering



Coke Drum - Engineering & Manufacturing Challenges



Hari Ravindran
At Galveston Tx

It's all about imagineering ®



L&T Heavy Engineering

L&T at a Glance



Founded

1938

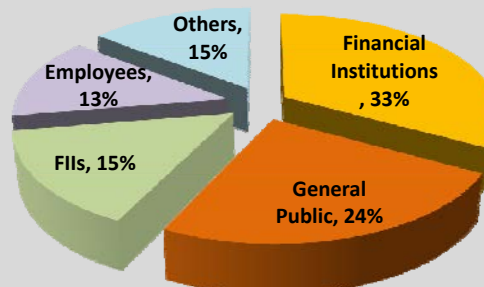
Number of Emp.

50,000+

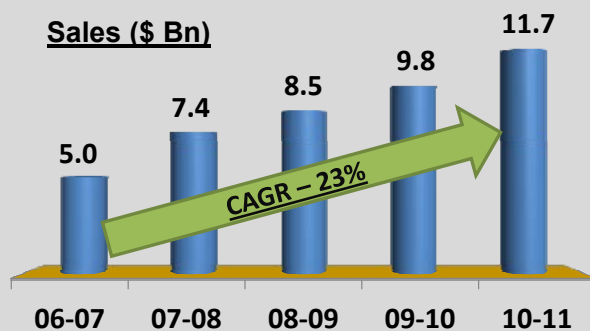
Market Cap

USD 20+ Bn

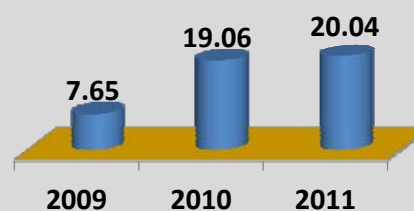
Share Holders



Sales (\$ Bn)

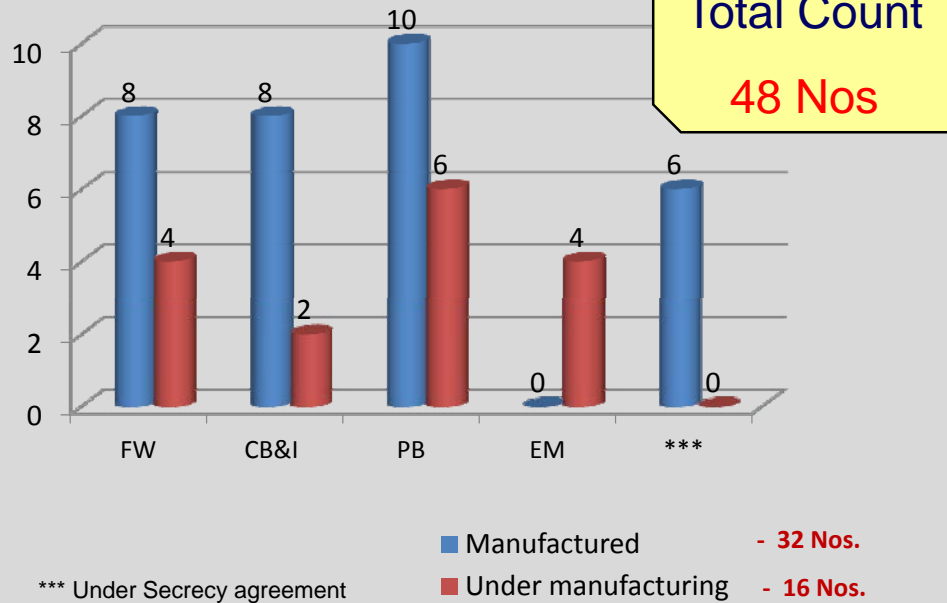


Market Cap (\$ Bn)





Our Experience – Licenser wise



Coke Drum And L&T

☐ Coke Drum Technical Challenges

➤ Design

- Creep – Fatigue Analysis
- Skirt Optimization - Seismic and Fatigue
- Banana Movement – Top Dished Nozzle
- Feed Spool Bolting - Gasket Relaxation

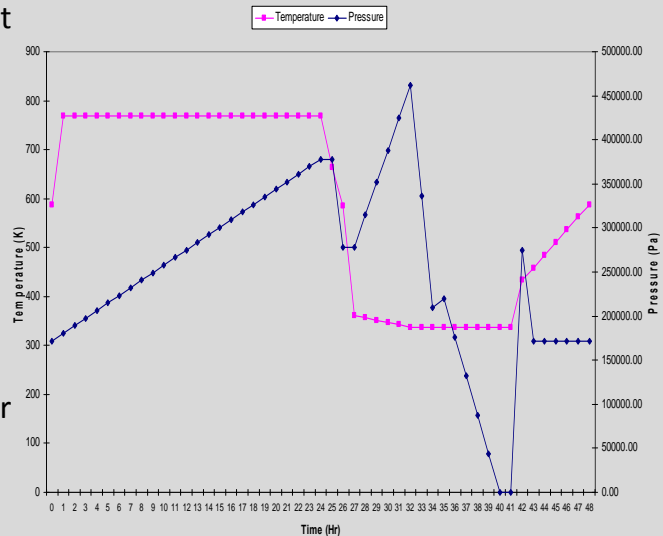
➤ Manufacturing

- Automatic Welding & Grinding
- Latest NDE Techniques – TOFD
- Distortion Control at Weld Joints
- Skirt # Cone Junction
- Expertise in Heat Treatment
- Welding Capabilities

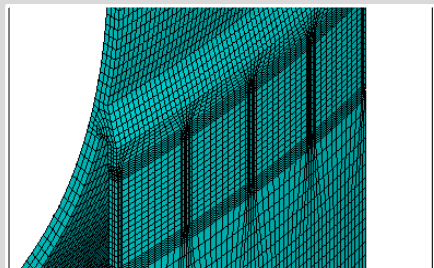


Design Capabilities

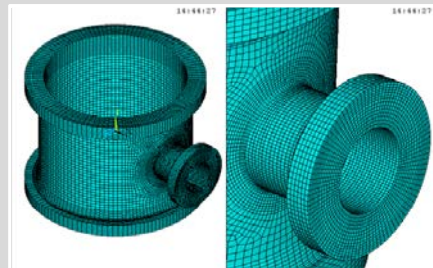
- ❑ High cyclic loading at elevated temperature
- ❑ Design by Analysis – Not empirical formulas
 - Creep
 - Fatigue
 - Buckling
- ❑ L&T's In-house capabilities for Finite Element Analysis.



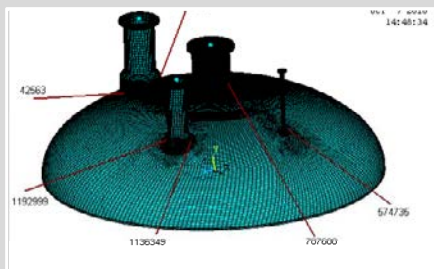
Unique FEA capabilities – Creep Fatigue



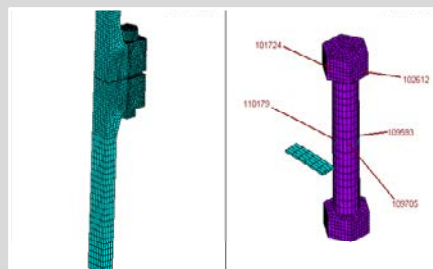
Hotbox



Feed Nozzle



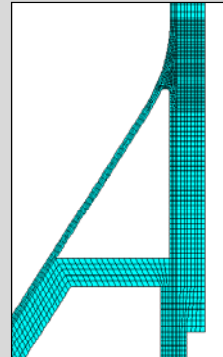
Banana Analysis



Feed Bolting



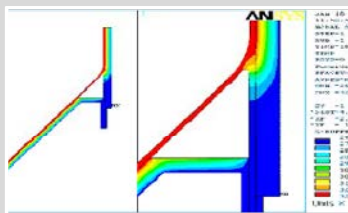
Creep Fatigue Analysis of Skirt Joint (Hot Box)



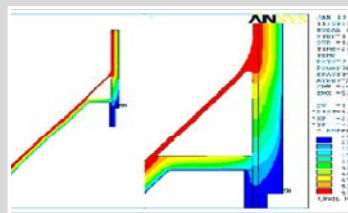
- ☐ Segmental 3-D model : *Determining effect of slots in skirt*
- ☐ Axi-symmetric analysis : *Skirt without slots*
- ☐ In house FORTRAN program : *Determining radiation effect in Hotbox*



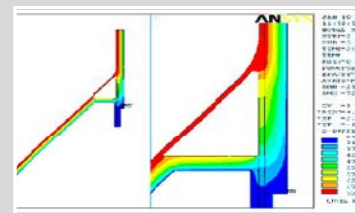
Temperature Plots



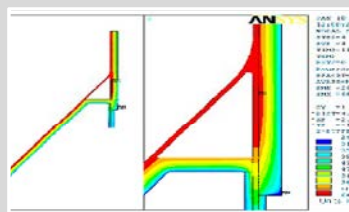
Warm Up (329.2K)



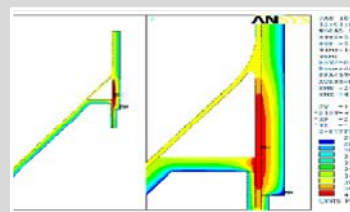
Oil in (533K)



Start Coking (727.4K)



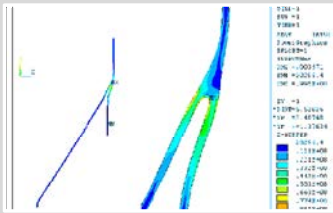
Start Quenching (643.9K)



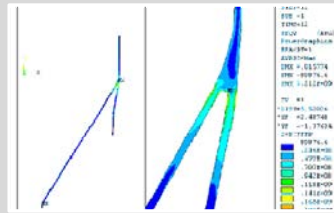
End Cutting (414.6K)



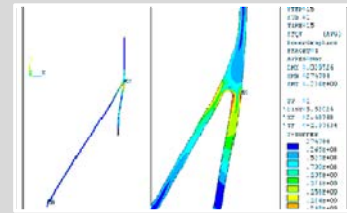
Stress Plots



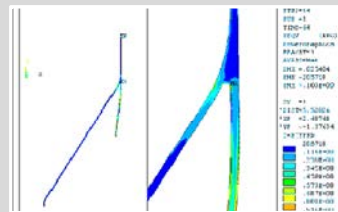
Warm up (99.5 MPa)



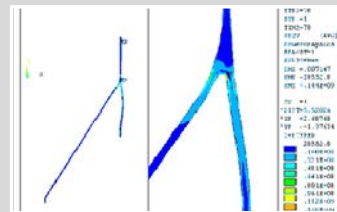
Oil in (212 MPa)



Start Coking (236 MPa)



Start Quenching (103 MPa)



End Cutting (144 MPa)



Fatigue Life Study - Skirt Joint

Skirt MOC	Skirt thk. (mm)	Inside radius of crotch (mm)	Hotbox Height (mm)	Fatigue life* (Years)	Fatigue life# (Years)	Remarks
SA 387 Gr 11 Cl 2	28.5	R12	638	19.2	4.75	Slotted Skirt Creep Range
SA 387 Gr 11 Cl 1	40.0	R12	665	22.2	4.55	Slotted Skirt
SA 387 Gr 11 Cl 1	40.0	R25	665	45.9	2.52	Slotted Skirt
SA 387 Gr 11 Cl 2	32.0	R13	582	6.5	-	Without slot
SA 387 Gr 11 Cl 2	25.4	R25	925	17.3	-	Without slot
SA 387 Gr 11 Cl 2	40.0	R32	857	44.2	-	Without slot

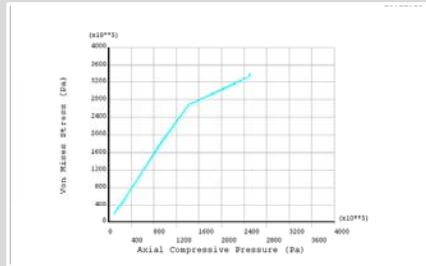
*Fatigue life at Skirt # Toricone joint ; # Fatigue life at slot tip

Conclusion :

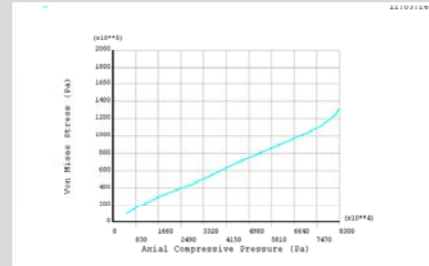
- Increase in radius and hotbox height improve s fatigue life
- Lower skirt thickness gives flexibility & thus improving fatigue life



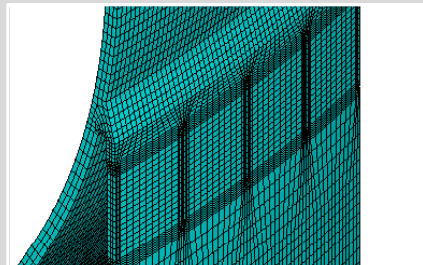
Creep Buckling of Skirt



Allowable comp. stress for 1 Hr



Allowable comp. stress for 0.1mn Hr



FEA Model

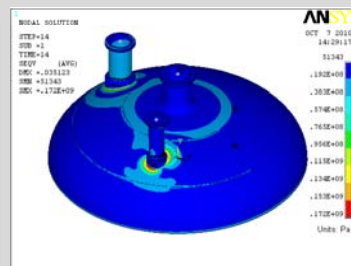
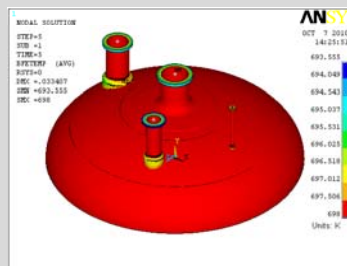
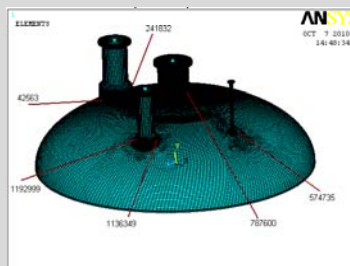


Creep Fatigue Analysis - Nozzle Attachments

FE Model

Temp-Coking

Stress-Coking



Analysis

- Fluctuating piping loads
- pressure and temperature
- Banana Effect - Horizontal moment of drum

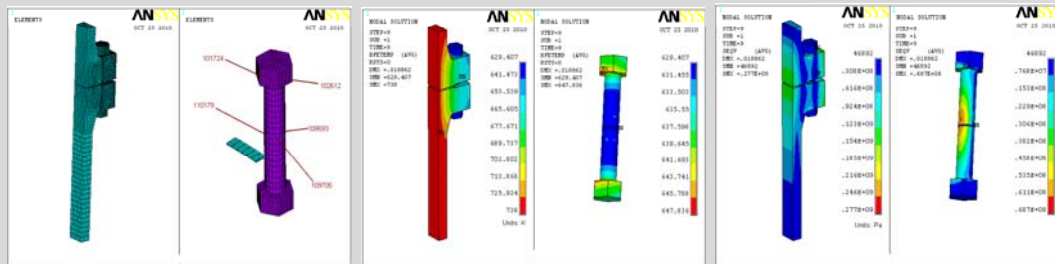


Creep Fatigue Analysis - Feed Spool Bolts

FE Model

Temp-Coking

Stress-Coking



Analysis

- Fluctuating pressure and temperature
- Model includes Effect of bolt pre-load
- Creep relaxation and gasket relaxation



Manufacturing Capabilities-Enhancing Coke Drum Life

- SAW welding
- Automatic grinding
- Distortion control at weld joints
- Latest NDE Techniques
 - TOFD on Less Thickness
- Skirt # Cone Junction
- Expertise in Heat Treatment
- Welding Capabilities



Hazira Manufacturing Complex



15-May-12

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15 / 28



Automatic Welding



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16 / 28



Automatic Grinding



Chipback Grinding



Clad stripping



Cone C-Seam Grinding



Distortion Control



Welding Fixture



Set up Fixture



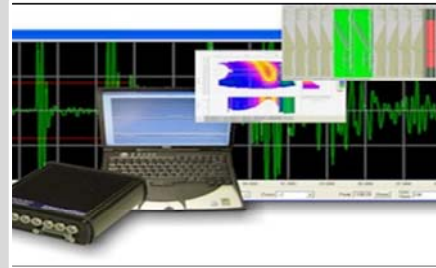
Cone Rolling



Latest NDE Techniques - TOFD



8 CHANNEL TD POCKET SCAN



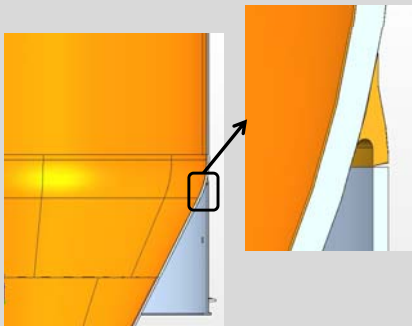
8 CHANNEL TD POCKET SCAN



On Job TOFD



Skit # Cone Junction



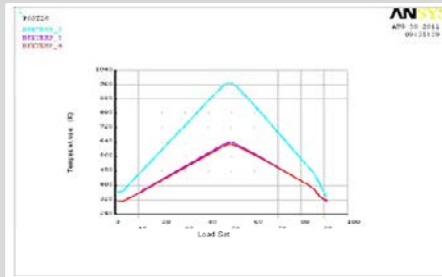
Weld build up



In house machining $\leq 10\text{m } \varnothing$



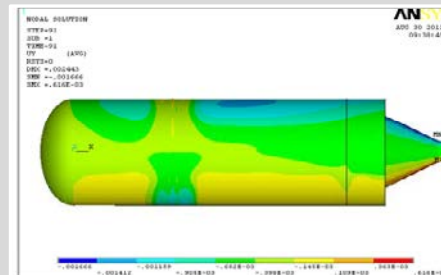
Expertise in Heat Treatment



Temperature Profile



Local PWHT



Vertical Deformation



Welding Capabilities

- More than 6000 qualified welding procedure
- Team of 500 + qualified welders

- Narrow Groove Submerged Arc Welding
- Gas Tungsten Arc Welding
- Shielded Metal Arc Welding
- Submerged arc Strip/ Electro Slag Strip cladding
- Flux Cored Arc welding
- Gas Metal Arc Welding
- Automatic inside overlay

- Carbon-Steels
- Low Alloys Steels (Cr-Mo / Cr-Mo-V)
- Quenched & Tempered Steel
- Low temp Nickel steel
- Inconel Chemistry



Conclusion

- ✚ L&T has developed all technical capabilities under one roof to meet technical challenges in Coke Drum manufacturing and increase life span of Coke Drum. Some of which mentioned below:
 - Skirt optimization considering fatigue and buckling at elevated temperature
 - Shape control of coke drum during manufacturing including Out-of-Roundness and peaking
 - SAW welding and automated clad stripping operation to increase fatigue life at weld seam
 - Alternative weld build up design to increase fatigue life



Contribution to International Society

- “Creep-Fatigue Interaction in Coke Drums: An Approach Based on API 579-1/ ASME FFS-2007”, ASME PVP 2009.
- “Numerical Simulation of Transient Temperature in SMAW”, ASME PVP 2009.
- “Simulation of Temperature Field of TIG Welding Using FDM ”, ASME PVP 2009.
- “Non-Linear Creep-Buckling Analysis: An Approach Based On WRC-443 For Development Of Allowable Compressive Stresses In Coke Drums”, ASME PVP 2010.
- “An Approach Based On Code Case 2605 For Fatigue Evaluation Of Vanadium Modified Materials Reactor”, ASME PVP 2010.
- “Design Of Skirt To Cone Joint In Coke Drum: A Parametric Approach Based On Fatigue Analysis” ASME PVP 2011



World's Largest Coke Drum



Aug-2011

630 MT
9.8 m ID

15-May-12

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25 / 28



Track Record



Year: 2004

Coke Drum: ABB Process – 8.5 m
ID, 310 MT Each, 04 Nos



08/07/2009 Year: 2009

Coke Drum: FW Process – 9.8 m
ID, 520 MT Each, 04 Nos



Track Record



Coke Drum: CB&I Process – 8.0 m ID, 240 MT Each, 04 Nos



Coke Drum: Petrobras Process – 8.9 m ID, 245 MT Each, 16 Nos,



Thank you
You Imagine.....We Create

