Thermal Mechanical Fatigue Risk Evaluation With Thermal Calibration

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Honeywell Overview

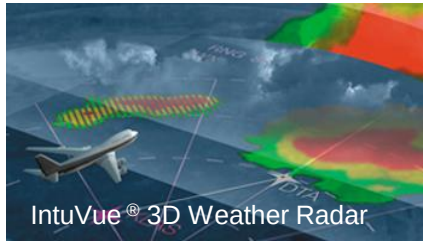
$38.6B in sales for 2015

53% of sales outside U.S.

- ~1,300 sites, ~70 countries
- More than 129,000 employees
- Morris Plains, NJ headquarters
- Fortune 100
- NYSE: HON

Aerospace

Sales ~$15.2B



Unmatched Scope Of Offerings

- Mechanical, Cockpit, & Software Offerings From Nose To Tail
- Apps, Services, Maintenance, Subscriptions
- End-To-End Connectivity Solutions From Hardware To Airtime
- Turbochargers For Fuel Efficiency

Automation & Control Solutions

Sales ~$14.1B

Connecting Homes, Buildings, & Workers

- Security And Fire, Addition Of Elster
- Connecting Homes With Lyric
- Open Software Connecting “Internet Of Things” In Buildings
- Wireless, Voice, Mobility, Data Analytic Solutions For Workers
- Targeted NPI Growing In HGRs

Performance Materials and Technologies

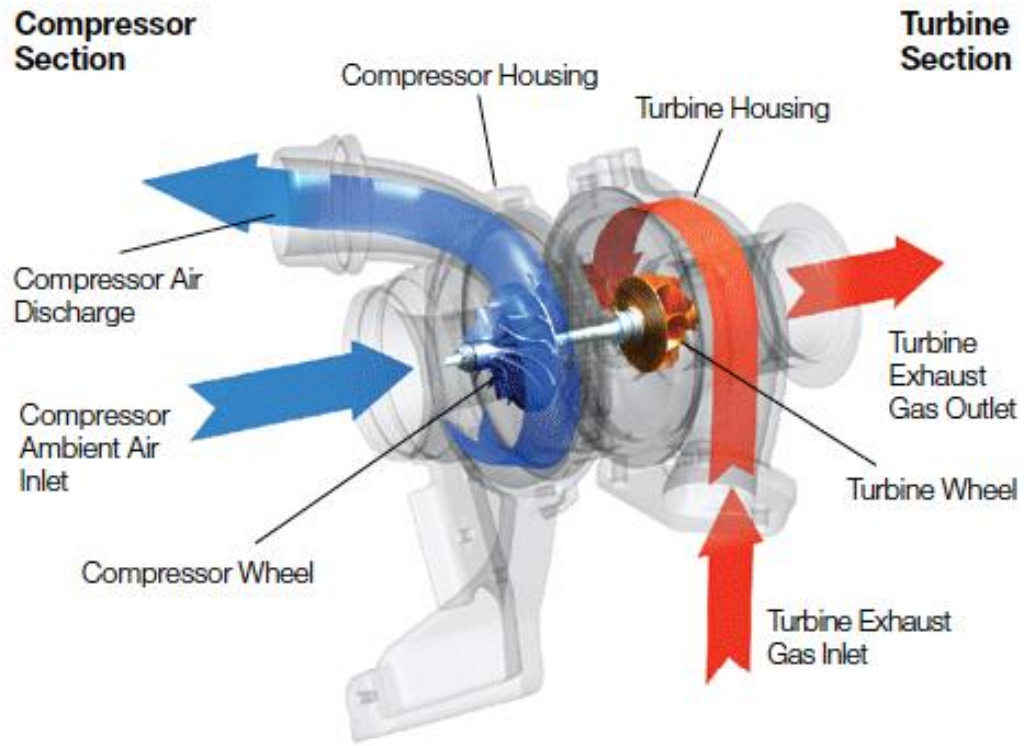
Sales ~$9.2B

Winning Technology

- Refining & Petrochemical Catalysts
- Gas Processing Modular Offerings
- Solstice® LGWP Materials
- SmartLine Transmitters
- Asset Optimization Software

How Turbocharging Works …

Turbo Dynamics



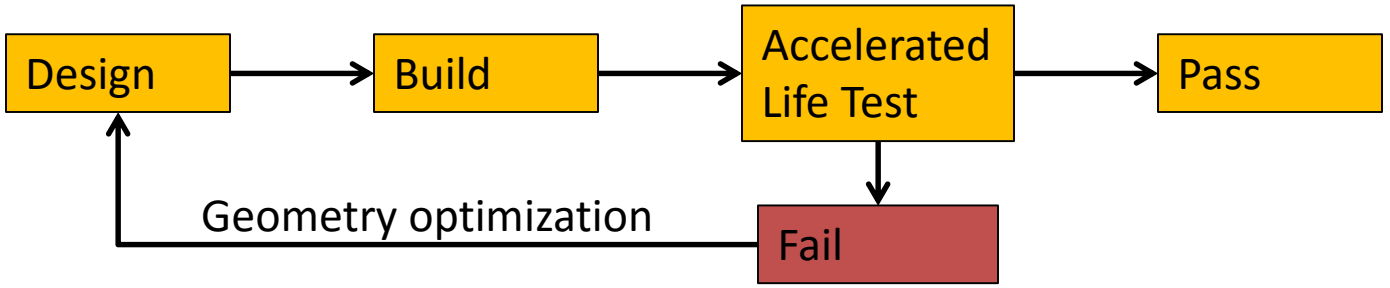
- Spinning at 250,000 rmp
- Exhaust gas temperature up to +1000° C for gasoline engines

Durability Process

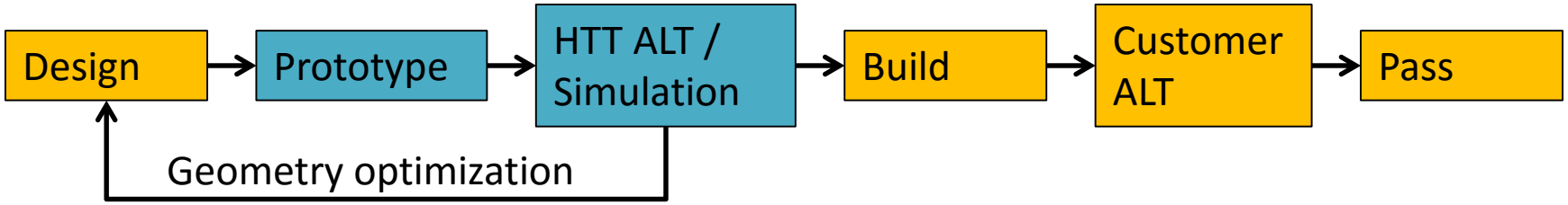
In product development, durability is driven by:

- Product Quality – the need for the product to be perceived as high quality
- Warranty: elimination of warranty or repair costs due to product failures
- Safety: the need to assure that a product meets or exceeds safety standards

Traditional test-based durability design process



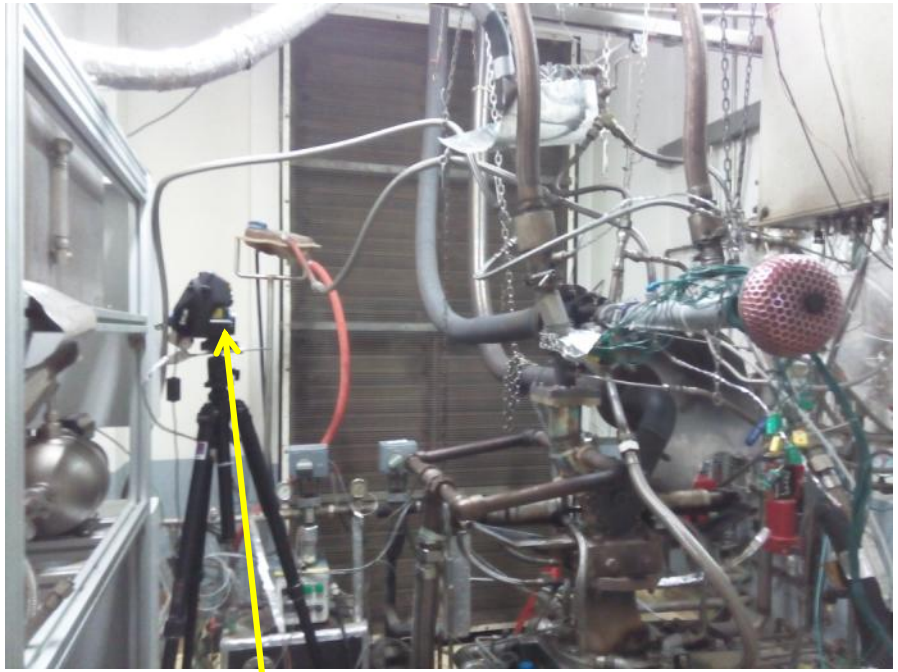
HTT ALT and simulation (ANSYS CFX +ANSYS Mechanical) based durability design process



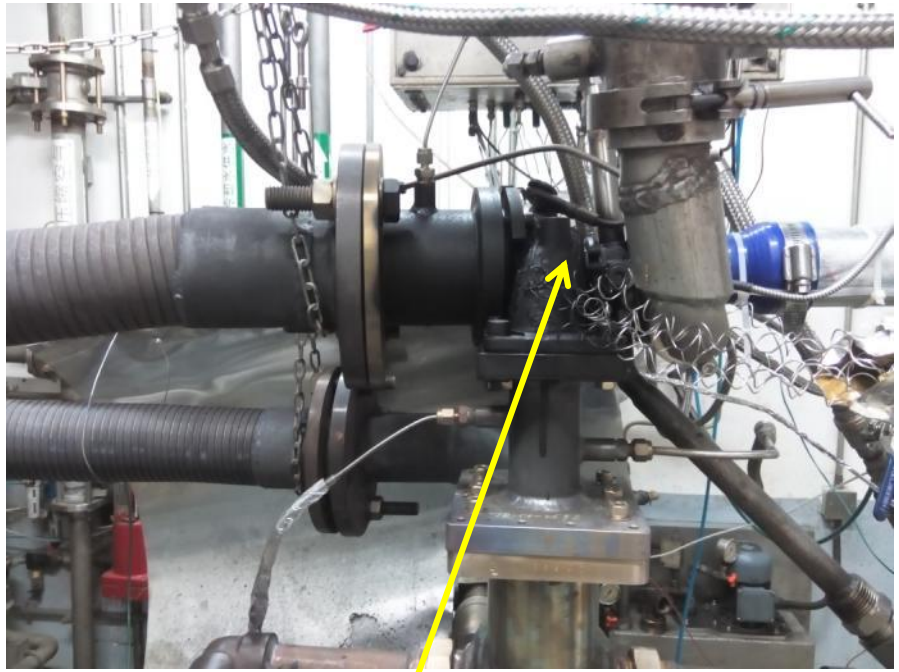
Keep in Mind: GIGO (Garbage-In, Garbage-Out)

Layout of Gas-Stand Test

- Calibrate Thermo-camera On Gas Stand Test

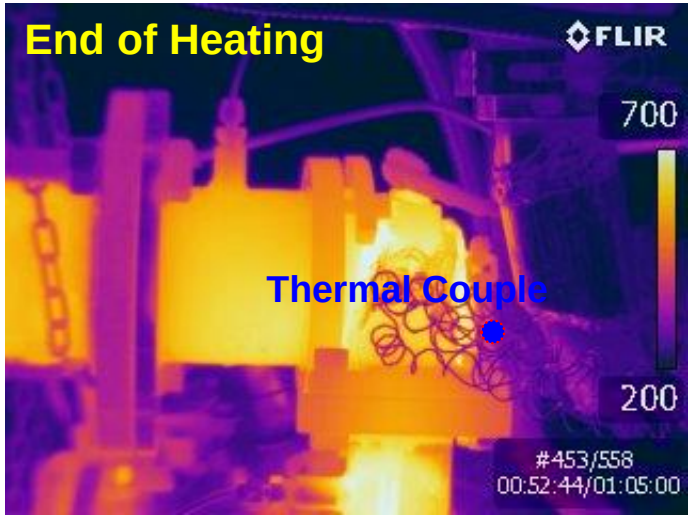


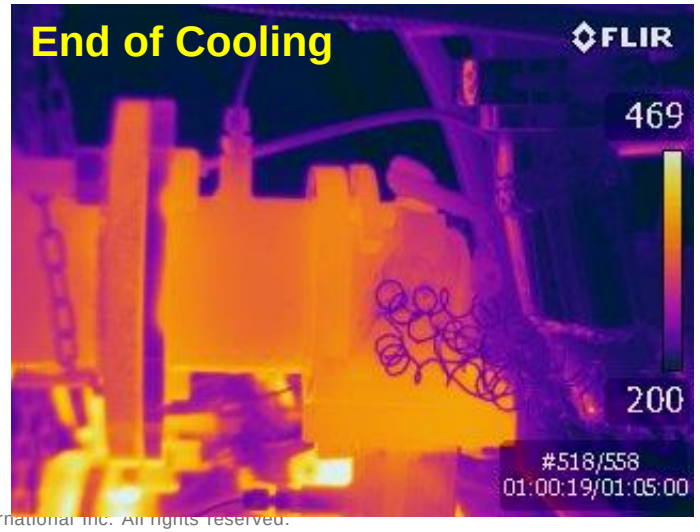
Thermo Camera

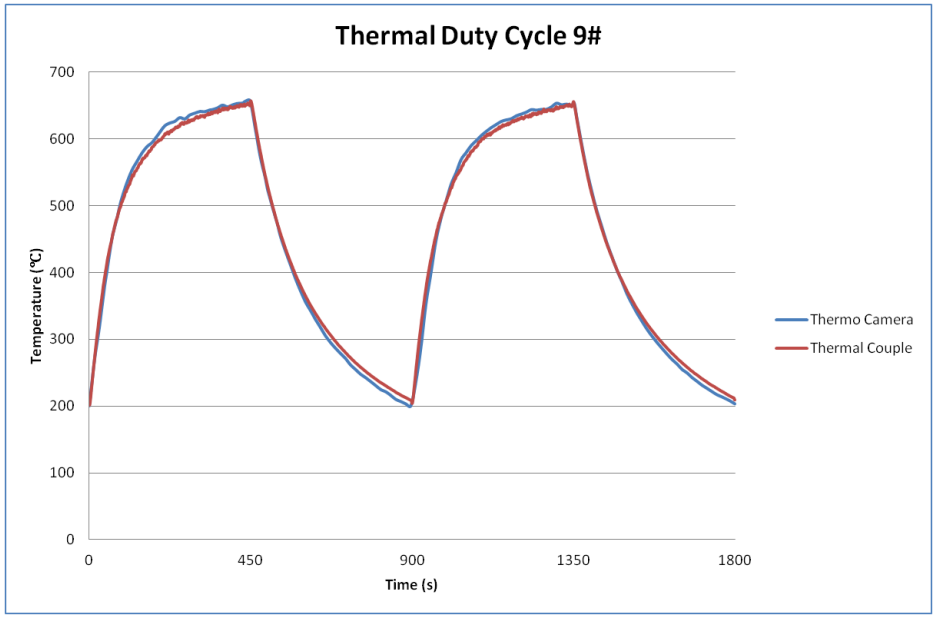


Thermal Couple

Comparison With Thermo-coupler



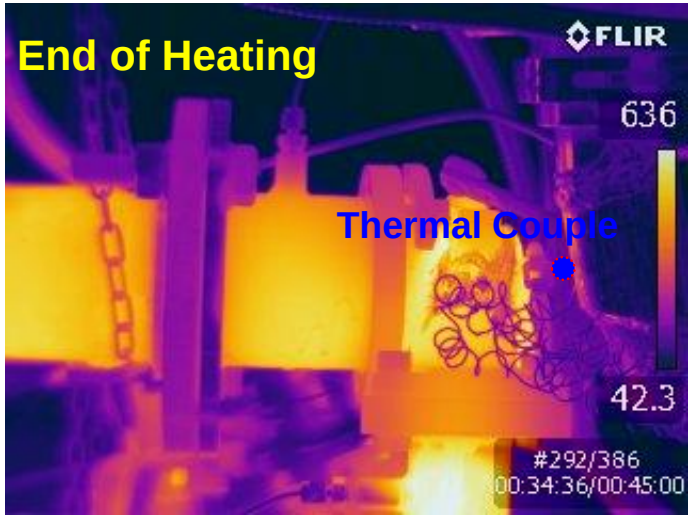


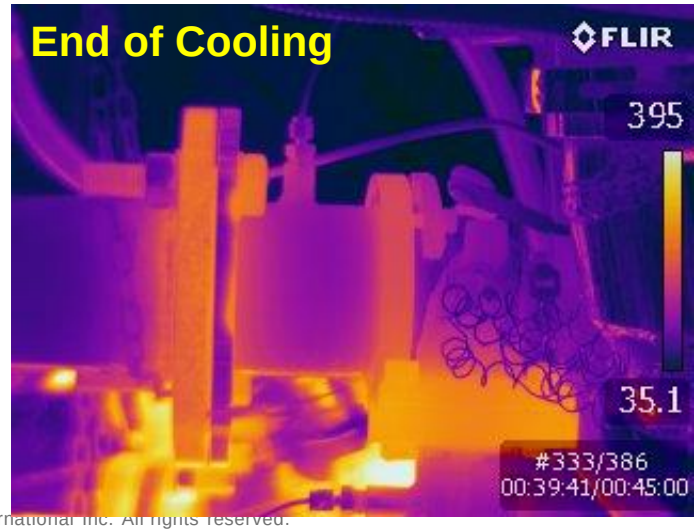


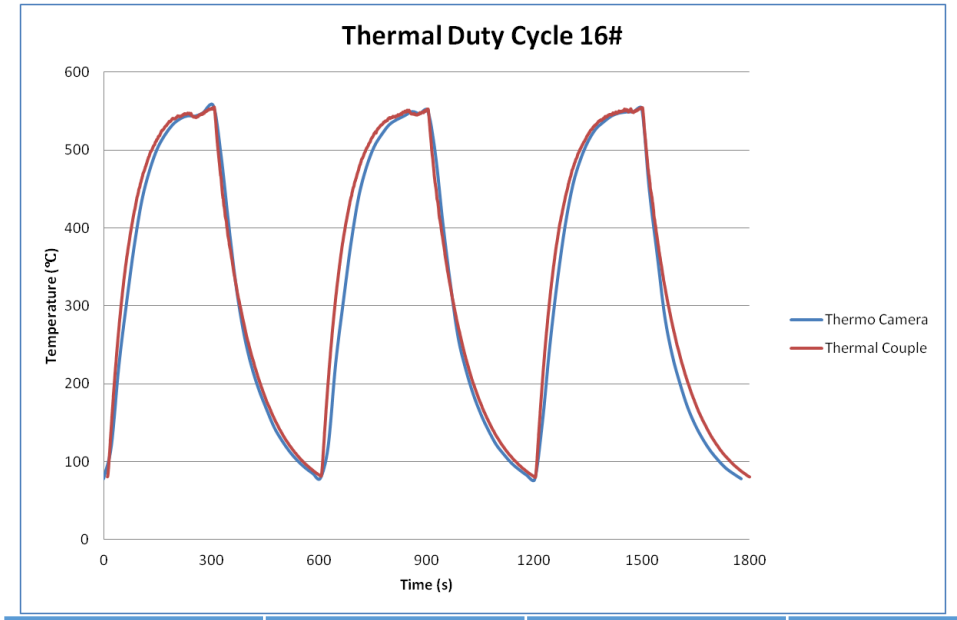
Time	Thermo Camera	Thermal Couple	Difference
0s	<200℃	201.6℃	>-1.6℃
450s	656.9℃	656.8℃	0.1℃
900s	<200℃	204.2℃	>-4.2℃
1350s	653.7℃	655.4℃	-1.7℃
1800s	203℃	209.4℃	-6.4℃

Reliable Temperature Test Data

Comparison With Thermo-coupler





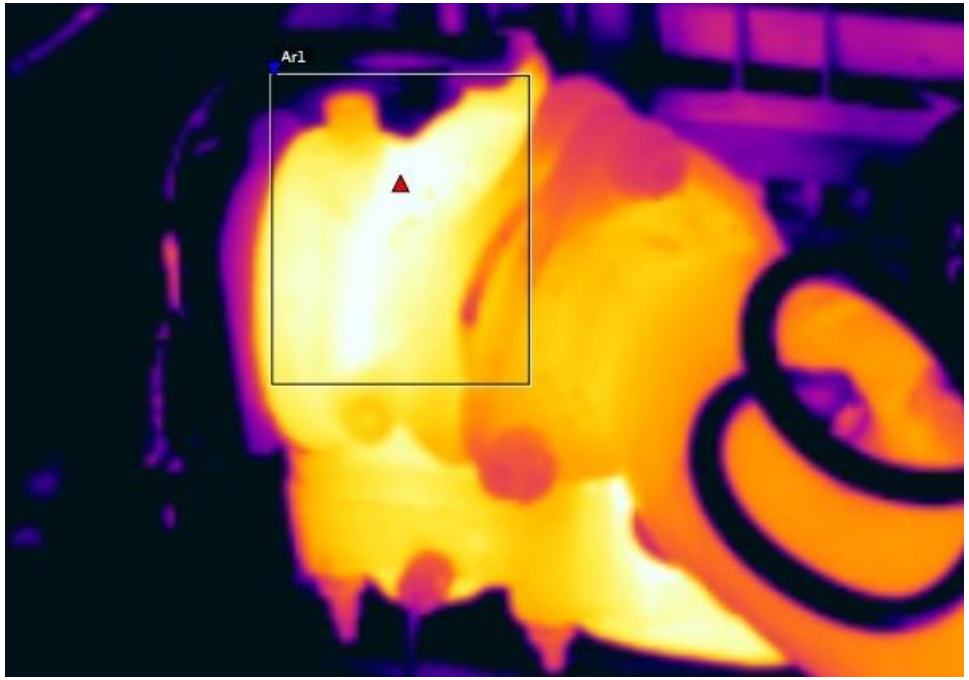


Time	Thermo Camera	Thermal Couple	Difference
0s	77.8℃	80.9℃	-3.1℃
300s	556.9℃	554.7℃	2.2℃
600s	78.5℃	81.7℃	-3.2℃
900s	550.9℃	552.2℃	1.3℃
1200s	76.9℃	80.2℃	-3.3℃
1500s	553.5℃	553.9℃	-0.4℃
1800s	77.8℃	80.9℃	-3.1℃

Reliable Temperature Test Data

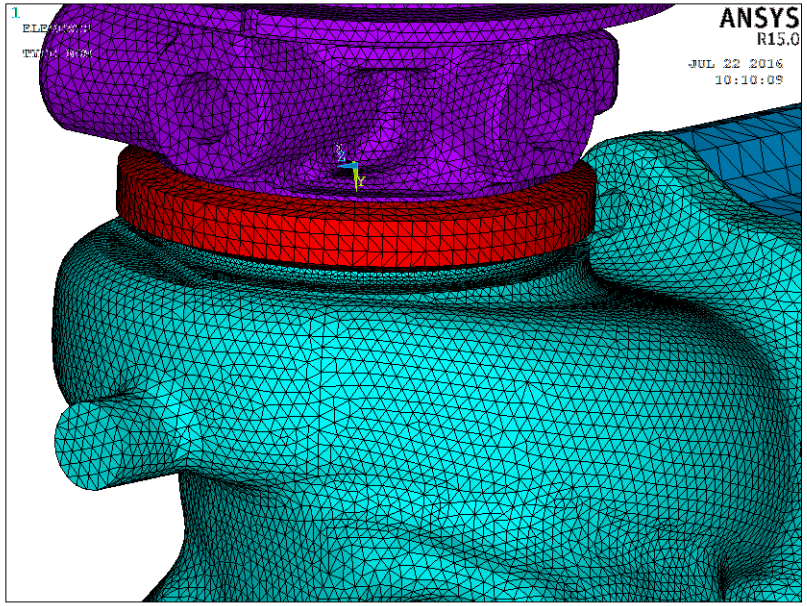
Layout of On-Engine Test

- Monitor and record the metal temperature in the duty cycle



Duty Cycle, Test Condition, etc.

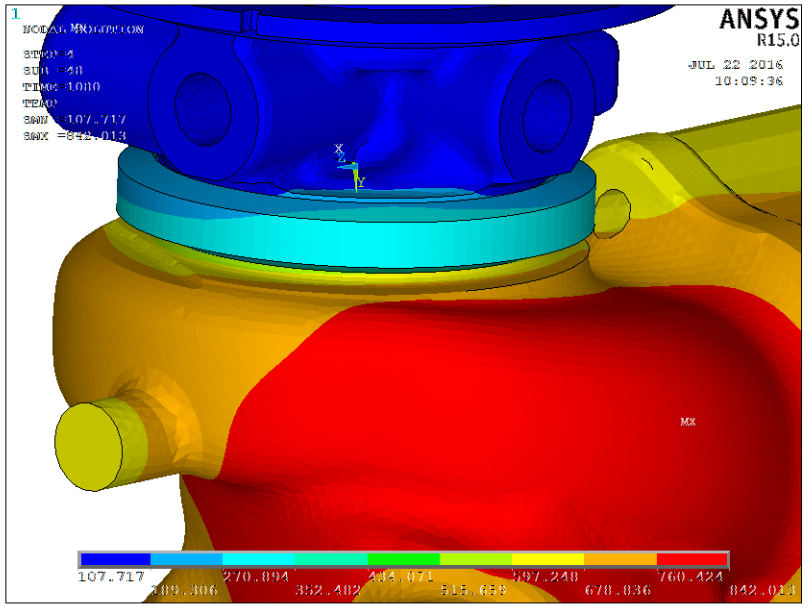
FE Model



Total Element Number: 534 K

Total Node Number: 810 K

Thermal Distribution @ End of heating



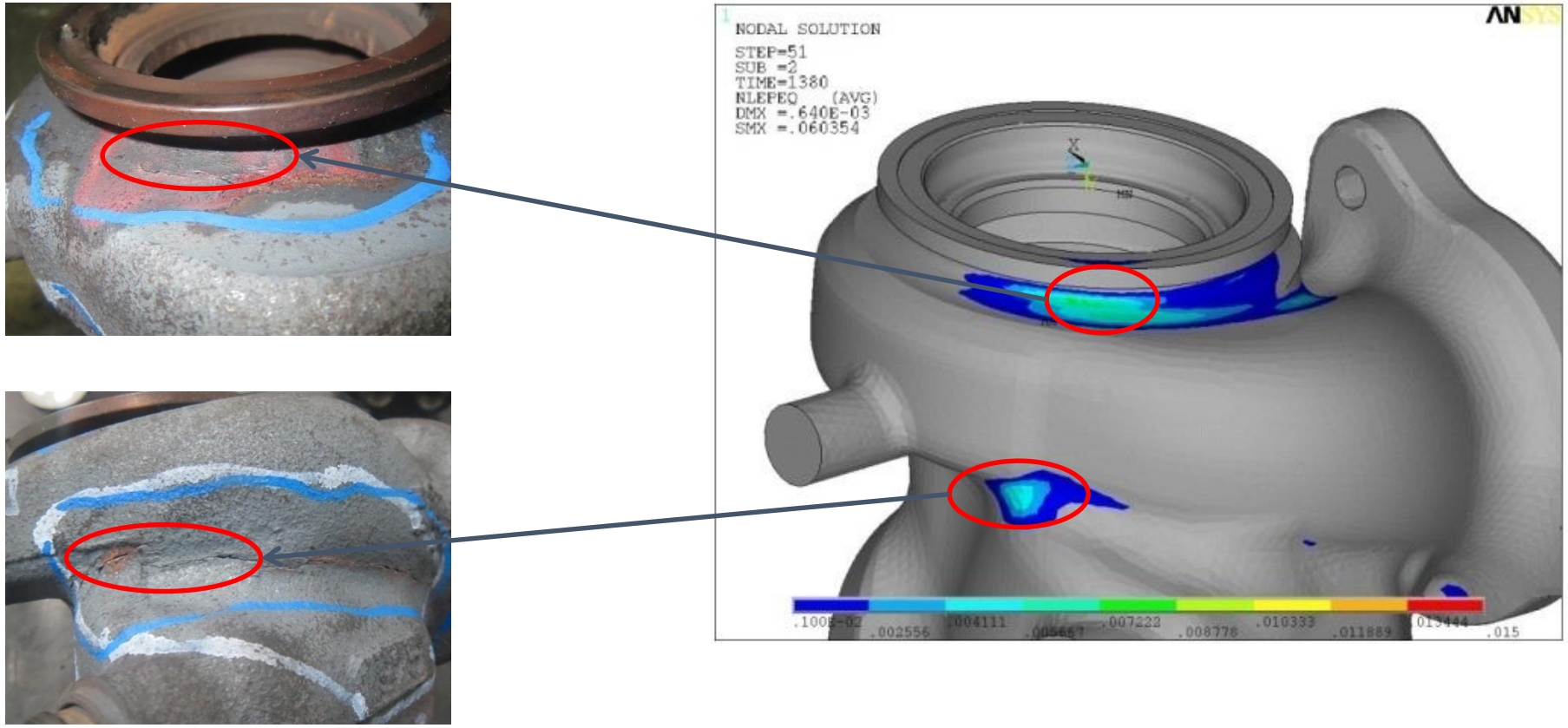
Thermal calibration includes two aspects.

1. Temperature distribution
2. Temperature evolution

	Test @ end of heating	FEA @end of heating	Difference	Ratio
SP1	808.73℃	812.40℃	-3.67℃	-0.45%
SP2	789.08℃	801.62℃	-12.54℃	-1.59%
SP3	691.46℃	716.79℃	-25.33℃	-3.66%
SP4	759.90℃	723.34℃	36.56℃	4.81%
SP5	683.13℃	679.55℃	3.58℃	0.52%

TMF Crack Risk Evaluation

- Higher fidelity FE models with reliable inputs are generating better TMF risk evaluation results.



Q & A

感谢聆听