



*We support your success.*

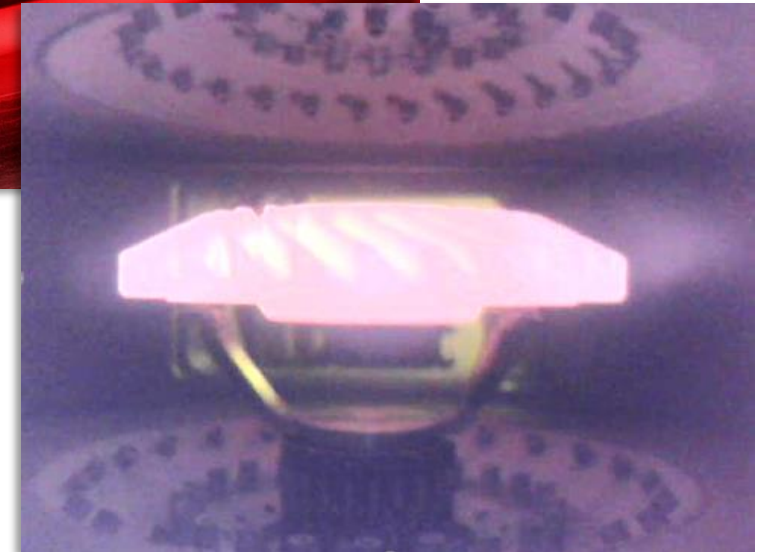
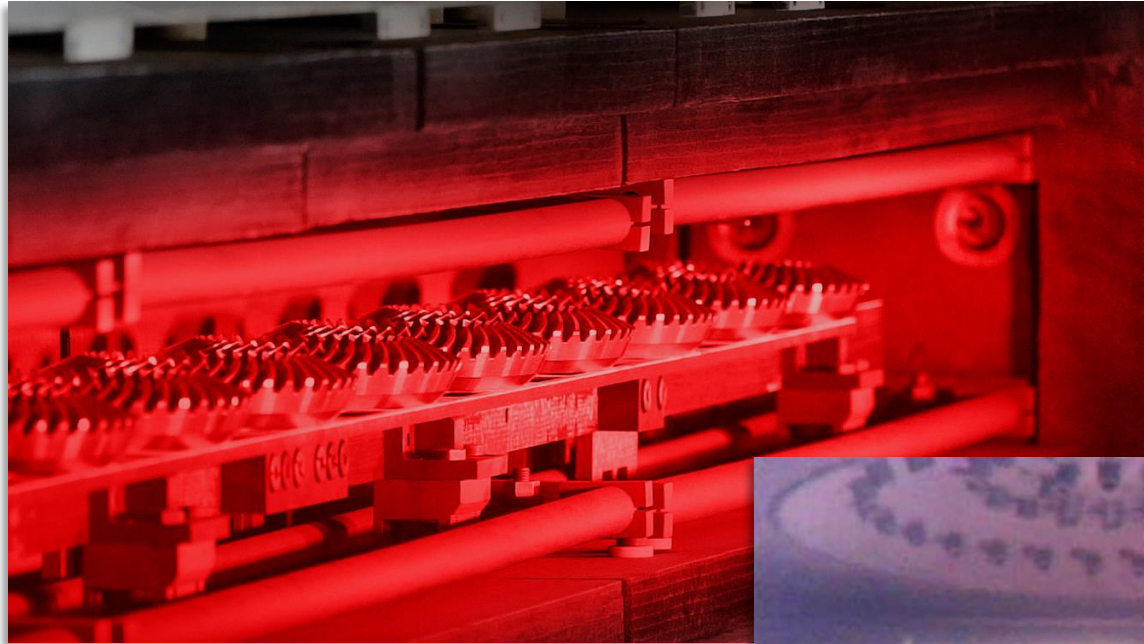
***UniCase Master with 4D Quench***

Quenching in the 4th Dimension

Controlling Heat Treat Distortion

Tom Hart – Product Manager – Vacuum Furnaces

# Up to 8,000,000 distortion free gears per year



SECO/VACUUM Technologies, a SECO/WARWICK Group Company is a **global** supplier of industrial equipment and modern technologies for metal heat processing.

Owing to the company's innovativeness and adaptation of a **lean industrial process philosophy**, our products provide customers with a **competitive edge** in production processing.



Vacuum  
Furnaces



Thermal  
Furnaces



Melting  
Furnaces



CAB

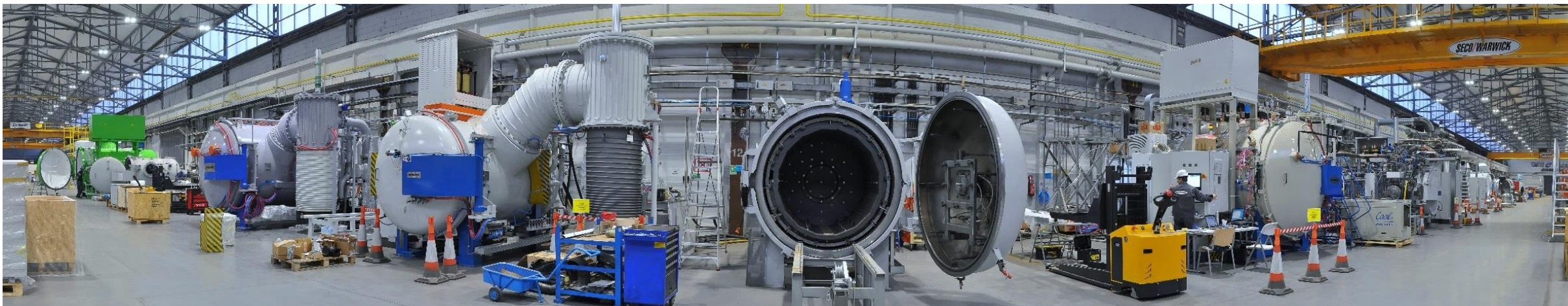


Aluminum  
Process



## **SECO/VACUUM** - USA Headquarters Pennsylvania

## **SECO/WARWICK** - Global Headquarters Poland



In operation for over **100 years**  
Located in **Meadville, PA**

**SECO/VACUUM**

*We support your success.*



**600+** employees



Established In **1991** (Elterma S.A. 1950 ),  
Located in **Świebodzin**, Poland

# **HARDENING PROCESS IN HEAT TREATMENT**



# TRADITIONAL SOLUTIONS - BATCH ATMOSPHERE / SALT BATH / PRESS QUENCH





# MODERN VACUUM SOLUTIONS – FOR CASE HARDENING (LPC + HPGQ/OIL)

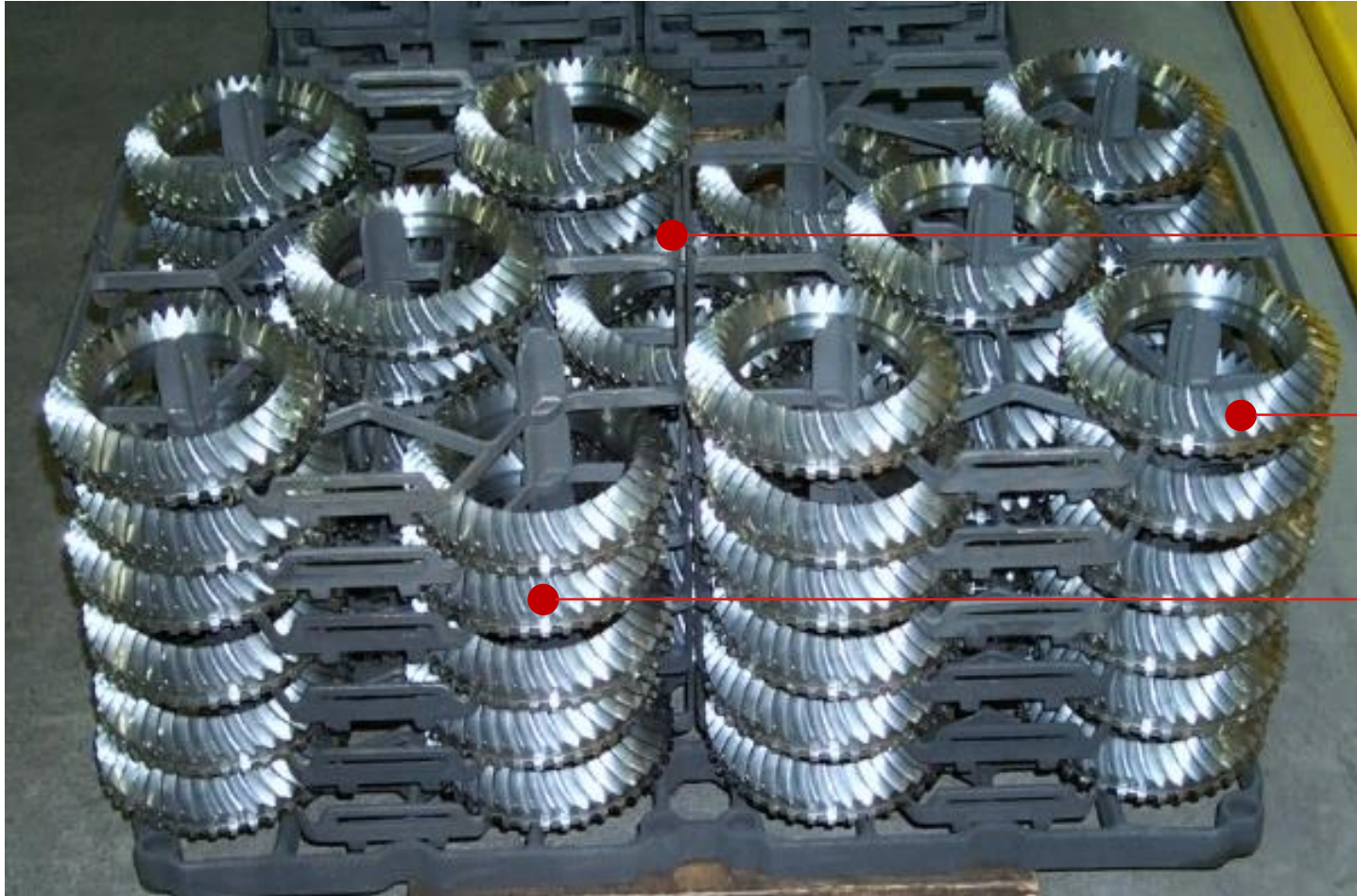


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# COMMON PARTS HANDLING - A BATCH SOLUTION



$t(1), T(1), C(1), Q(1)$

$t(2), T(2), C(2), Q(2)$

$t(3), T(3), C(3), Q(3)$

$t(1) \neq t(2) \neq t(3)$   
 $T(1) \neq T(2) \neq T(3)$   
 $C(1) \neq C(2) \neq C(3)$   
 $Q(1) \neq Q(2) \neq Q(3)$   
 **$ECD(1) \neq ECD(2) \neq ECD(3)$**

Results = function of [time (t), temperature (T), atmosphere (C), quenching (Q)]

**$ECD \rightarrow 0.024 - 0.043'' [0.6 - 1.1 \text{ mm}]$**   
**(Wide case depth variation / tolerances)**



# DISTORTION – FROM ONE DIRECTIONAL COOLING

Directional cooling  $\neq$  even gas stream

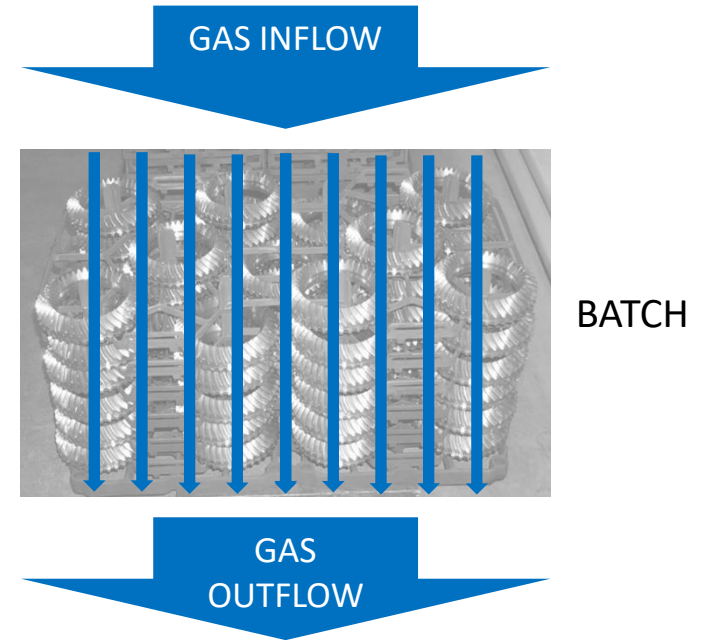
Directional cooling does not ensure even gas flow  
in the entire working space

Uniform gas stream  $\neq$  uniform cooling

*Even gas flow does not guarantee uniform cooling of part*

Uniform cooling  $\neq$  lower distortion

*Uniform cooling does not mean lower distortion*

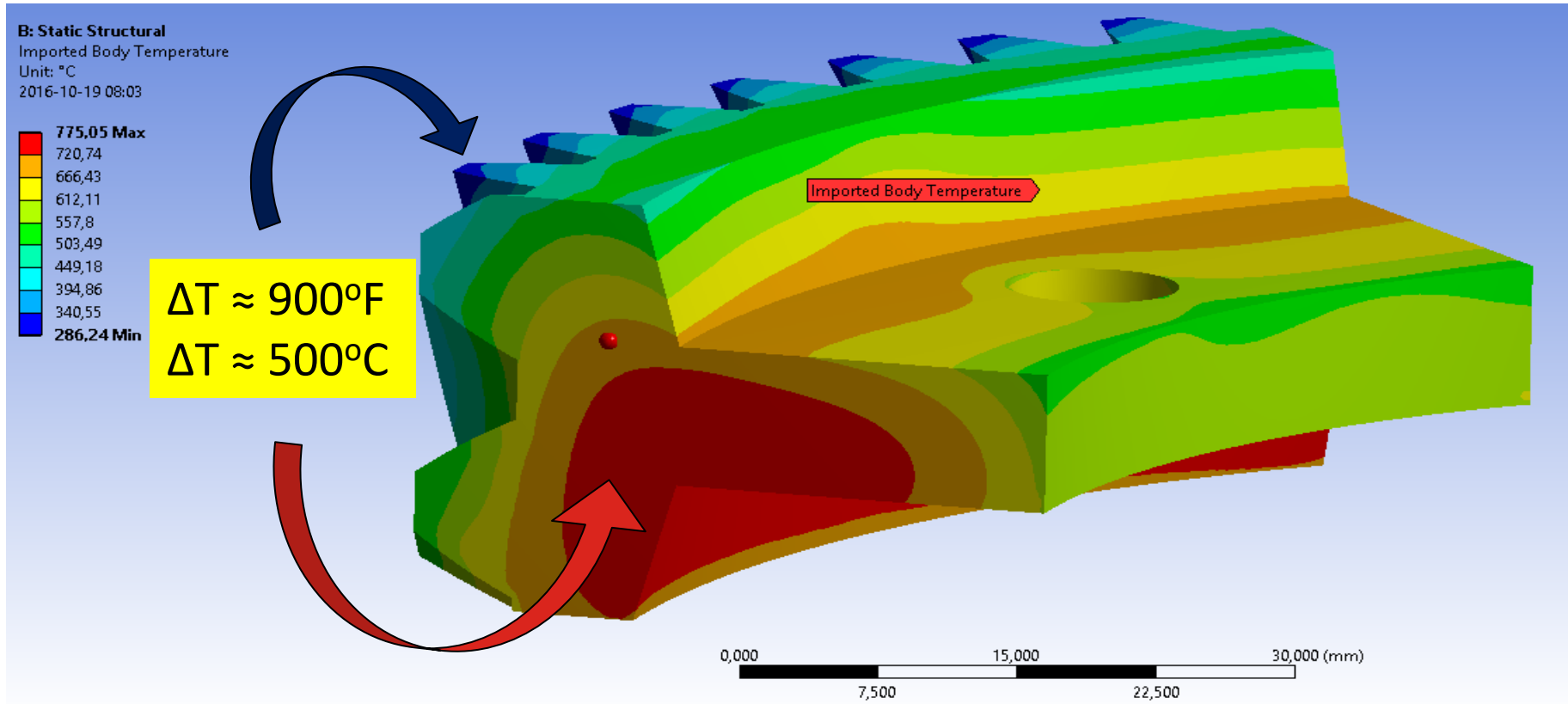


PART ONLY RECIEVES COOLING FROM ONE SIDE

# DISTORTION – UNI-DIRECTIONAL COOLING

NITROGEN PRESSURE = 20 BAR @ 15 m/s

GAS FLOW = TOP TO BOTTOM



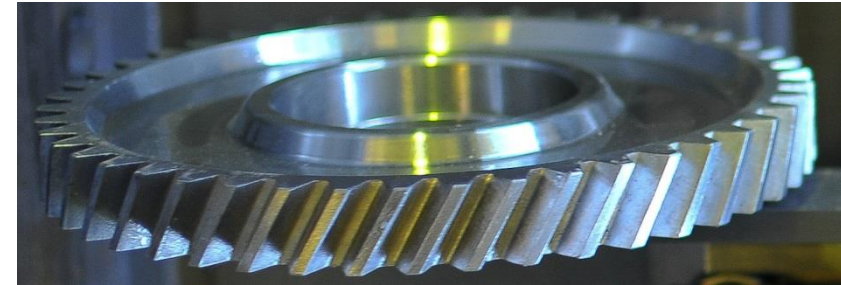
TEMPERATURE GRADIENT = DISTORTION



# IS THE BATCH HANDLING THE ONLY SYSTEM ?



## Single-piece flow



**Same process parameters = same results**

**UNICASE MASTER<sup>®</sup> WITH  
4D QUENCH<sup>®</sup>**



# ADVANCED HEAT TREATMENT solution for manufacturing



***The UniCase Master®***

***SECO/VACUUM***

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# LEAN MANUFACTURING

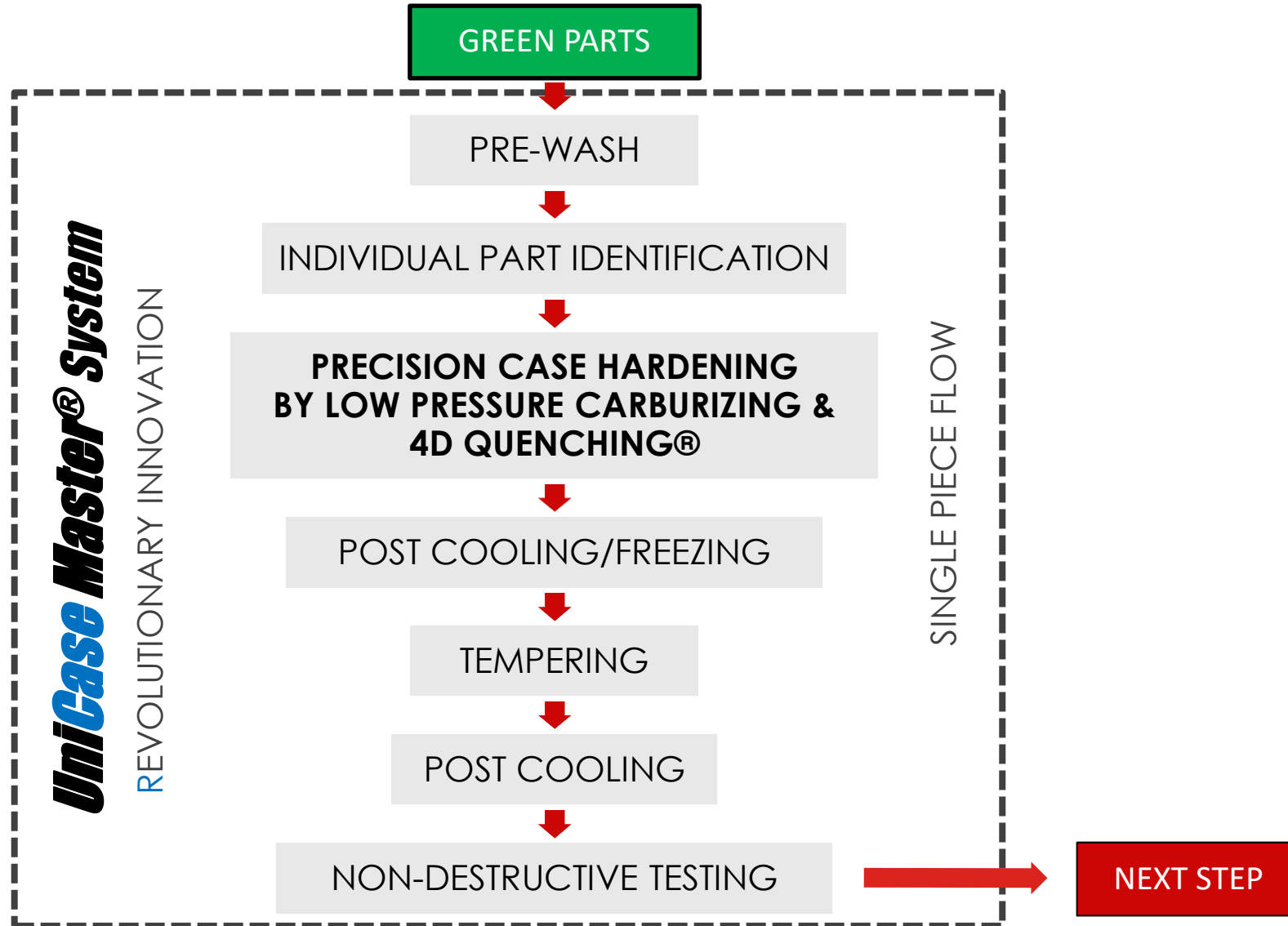
## *Precision Heat Treating for High-Volume Gear Manufacturers*



Heat treatment integration into continuous manufacturing production lines



# PROCESS FLOWCHART – 100% TRACEABILITY



# BENEFITS IN COMPARISON TO TRADITIONAL ATMOSPHERE TECHNOLOGY

A few of the many **UniCase Master®** benefits to industry include:

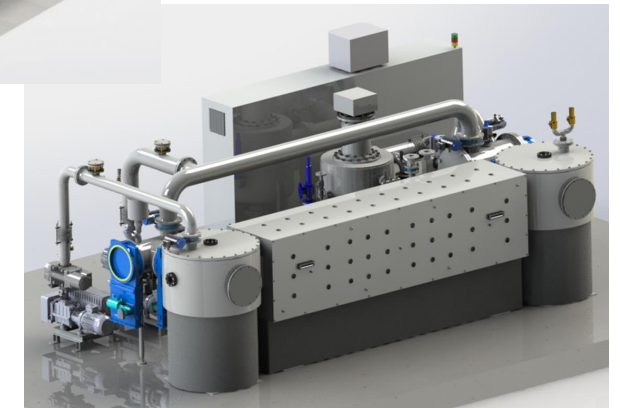
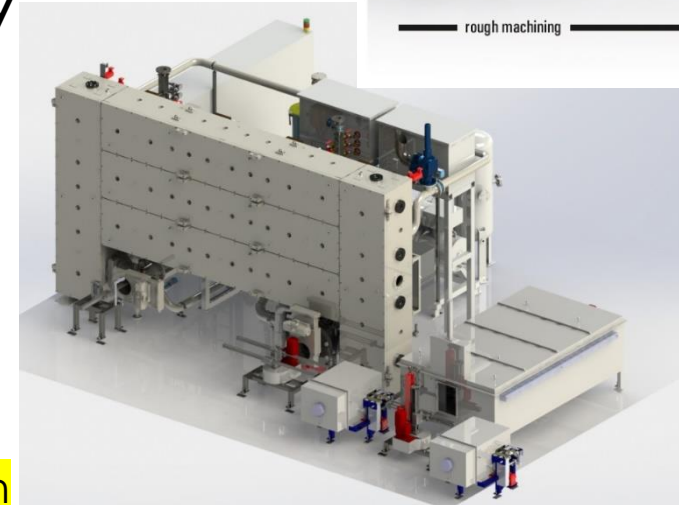
## Automated In-line manufacturing

/ Eliminates batch material handling costs & time

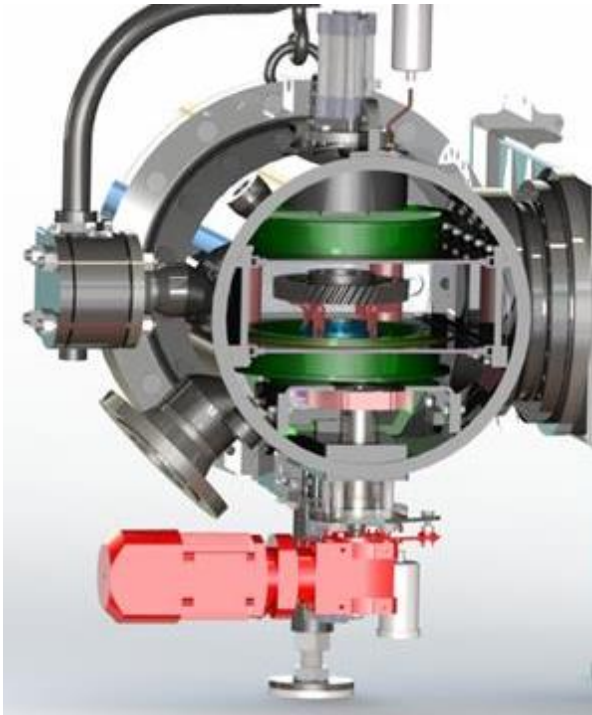
## Enhanced process precision, quality & repeatability

- / Improved distortion control
- / High productivity, fast throughput
- / Superior surface quality
- / No intergranular oxidation (IGO)
- / Reduced utility consumption
- / No quenching oil and post-washing
- / Safety, no open flame, no risk of fire or explosion
- / Clean, environmentally friendly process

## System flexibility & adaptability

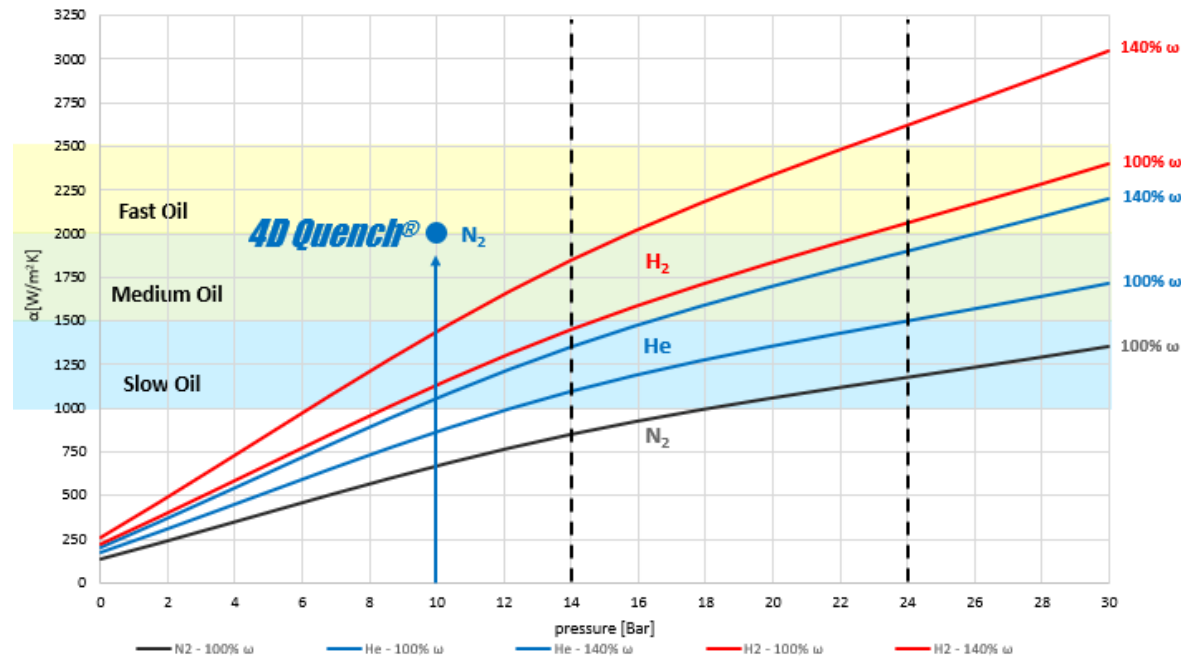


**4D QUENCH®** = **3D** cooling gas is delivered by nozzles from all sides  
+ **1D** as the quenched part rotates



## Powerful & Efficient Nitrogen Cooling

HPGQ vs. Oil - Quenching Speed



Powerful cooling

**10 bar nitrogen as fast as oil quenching**

Heat transfer coefficient = 2,000 W/m²K

**SECO/VACUUM**

*We support your success.*

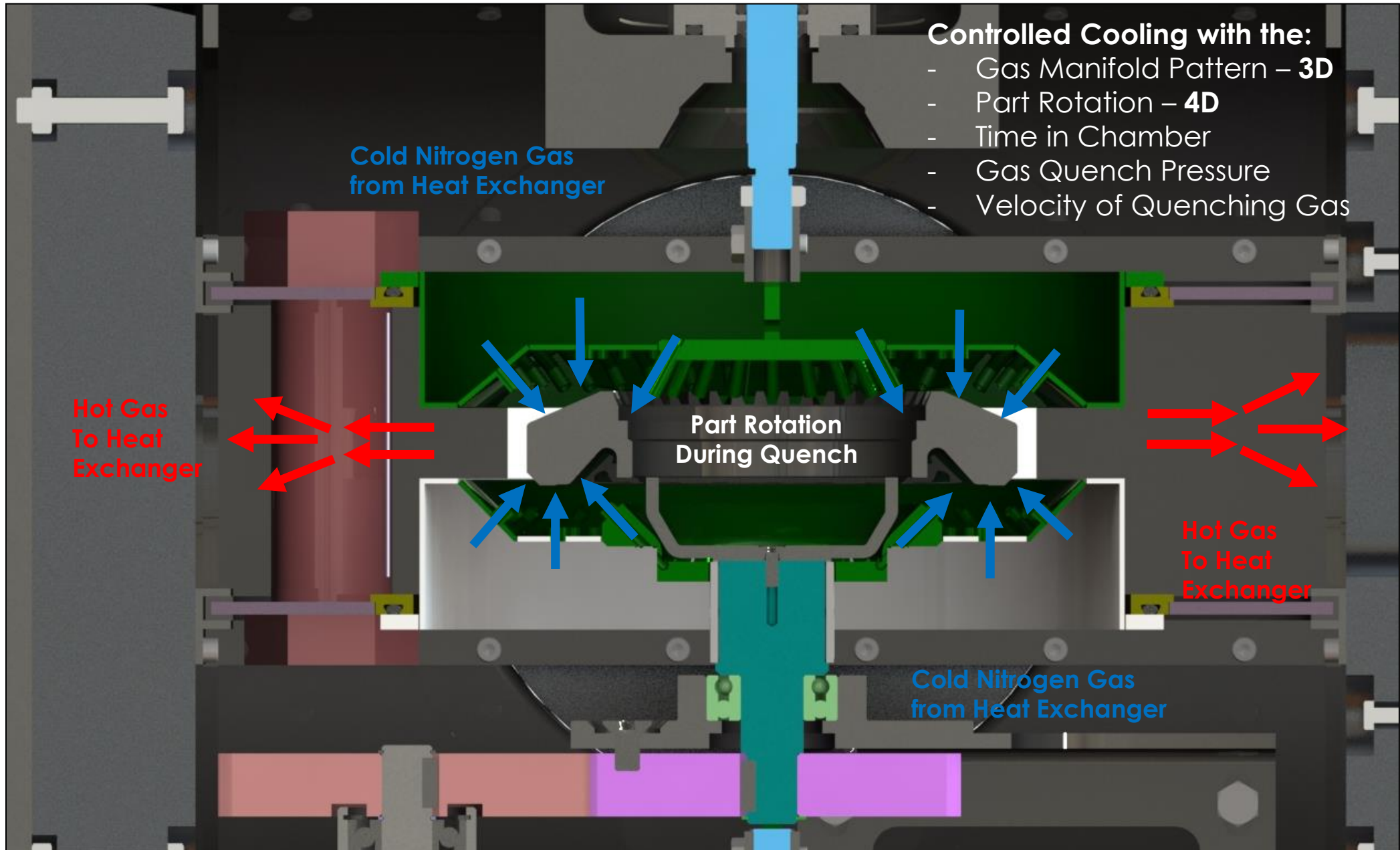
~~Oil~~

~~He~~





# 4D Quench<sup>®</sup> - How it works



**4D Quenching is a quenching process that is completely controllable.**

**All other quenching techniques are uncontrolled.**

**Controlled Quenching = Controlled Distortion**

**UniCase Master®** - Revolutionary In-line Case Hardening for Automotive, Transmission & Bearings



High Pressure Gas Quenching eliminates oil, washer and washing che

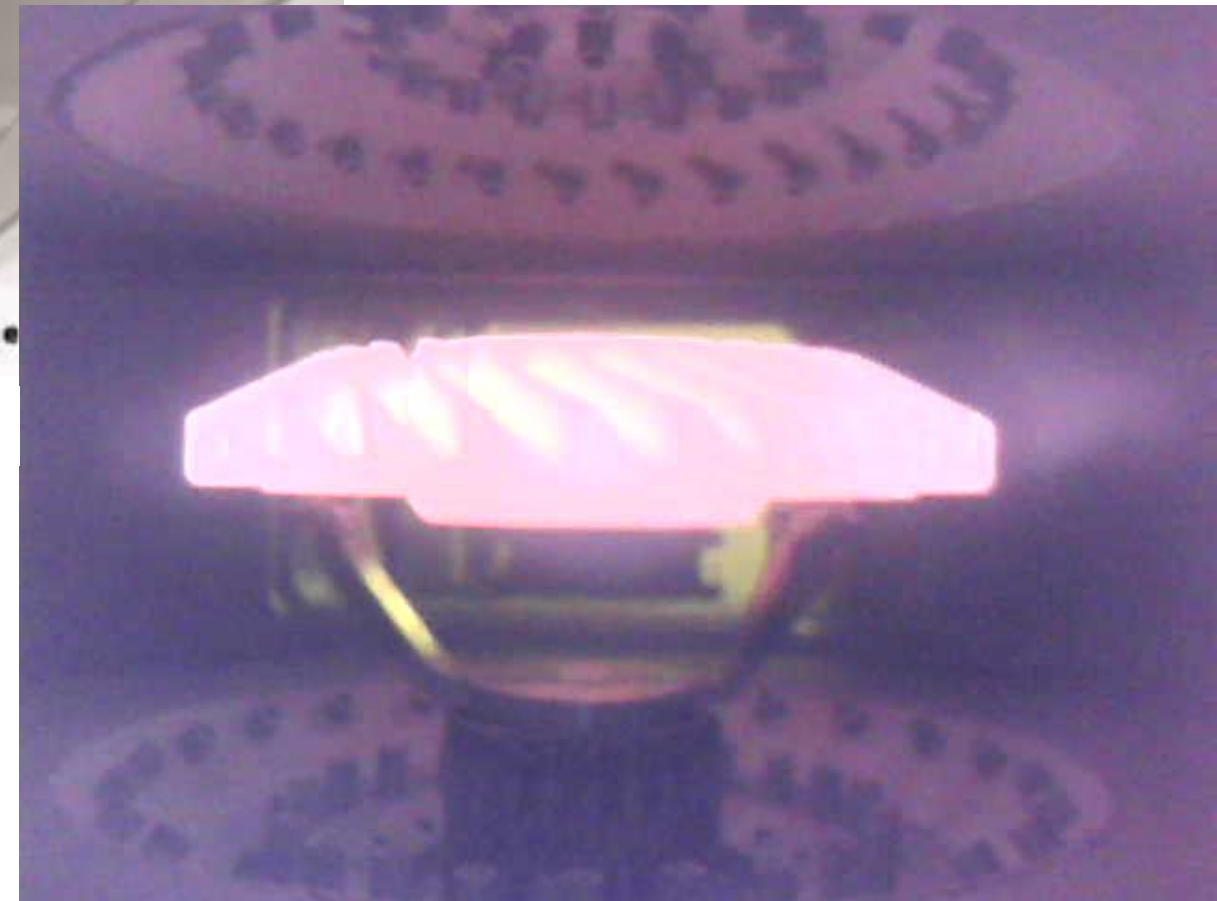
## 4D Quench®

0:00 sec	1500 F
2:00 sec	1400 F
4:00 sec	1300 F
6:00 sec	1200 F
8:00 sec	1100 F
10:00 sec	1000 F
12:00 sec	900 F

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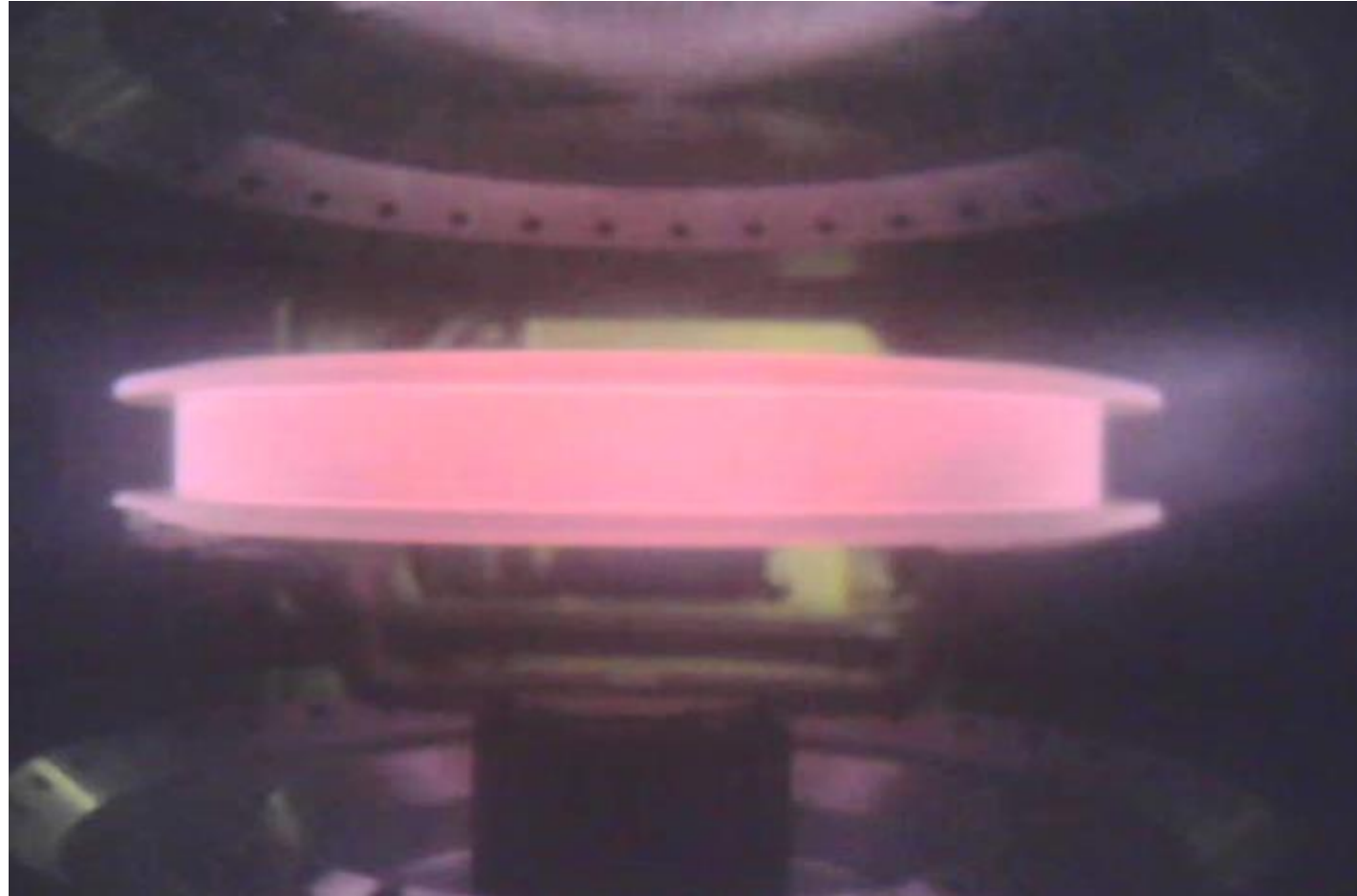
## 4D Quenching Bevel Gear - Live Video





# 4D Quench® - Coupling Sleeve

	Part Temp
0:00 sec	1500 F
1:00 sec	1400 F
2:00 sec	1300 F
3:00 sec	1200 F
4:00 sec	1100 F
5:00 sec	1000 F
6:00 sec	900 F

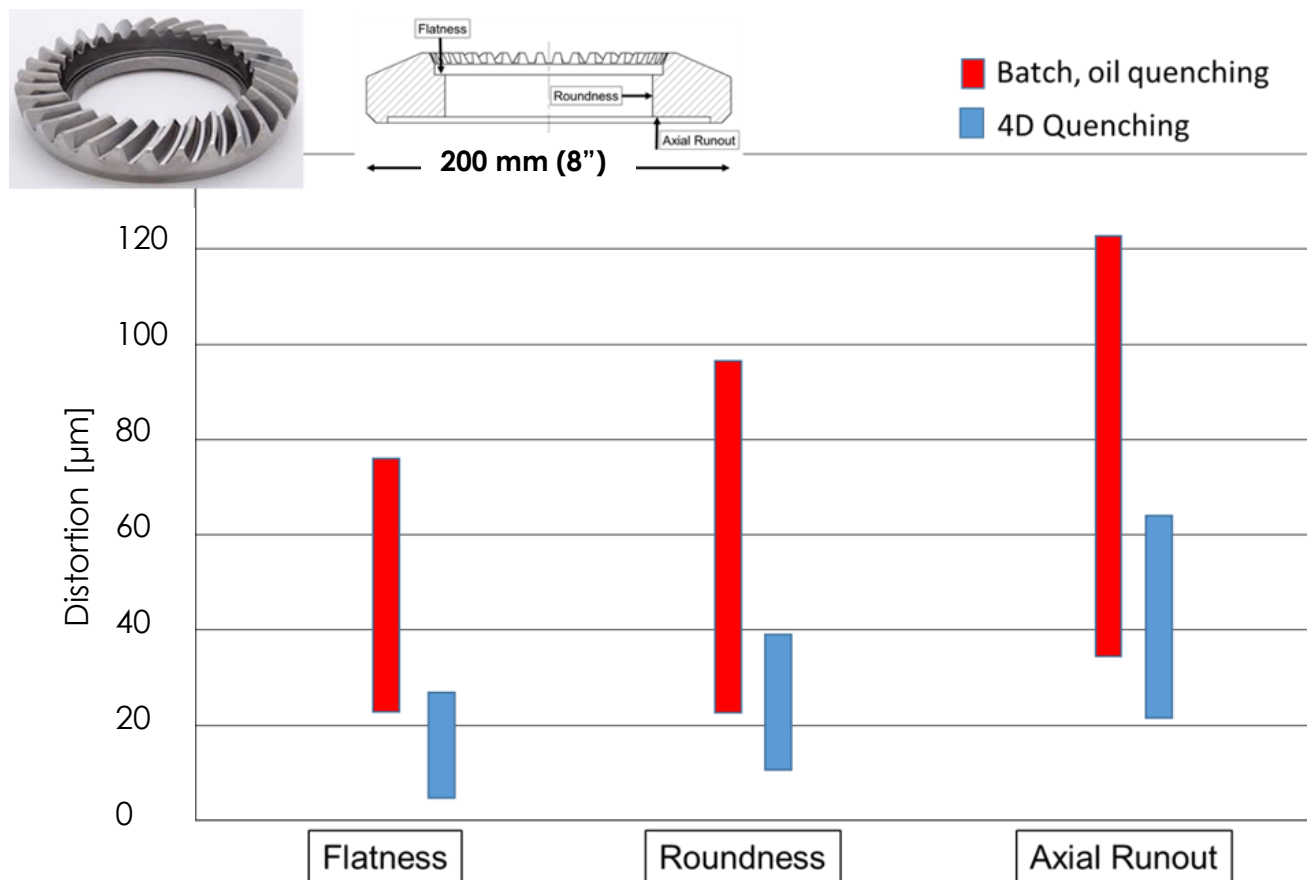


# DISTORTION

**UniCase Master®**

/ 2-4 times less distortion (size change and variation)  
quenching

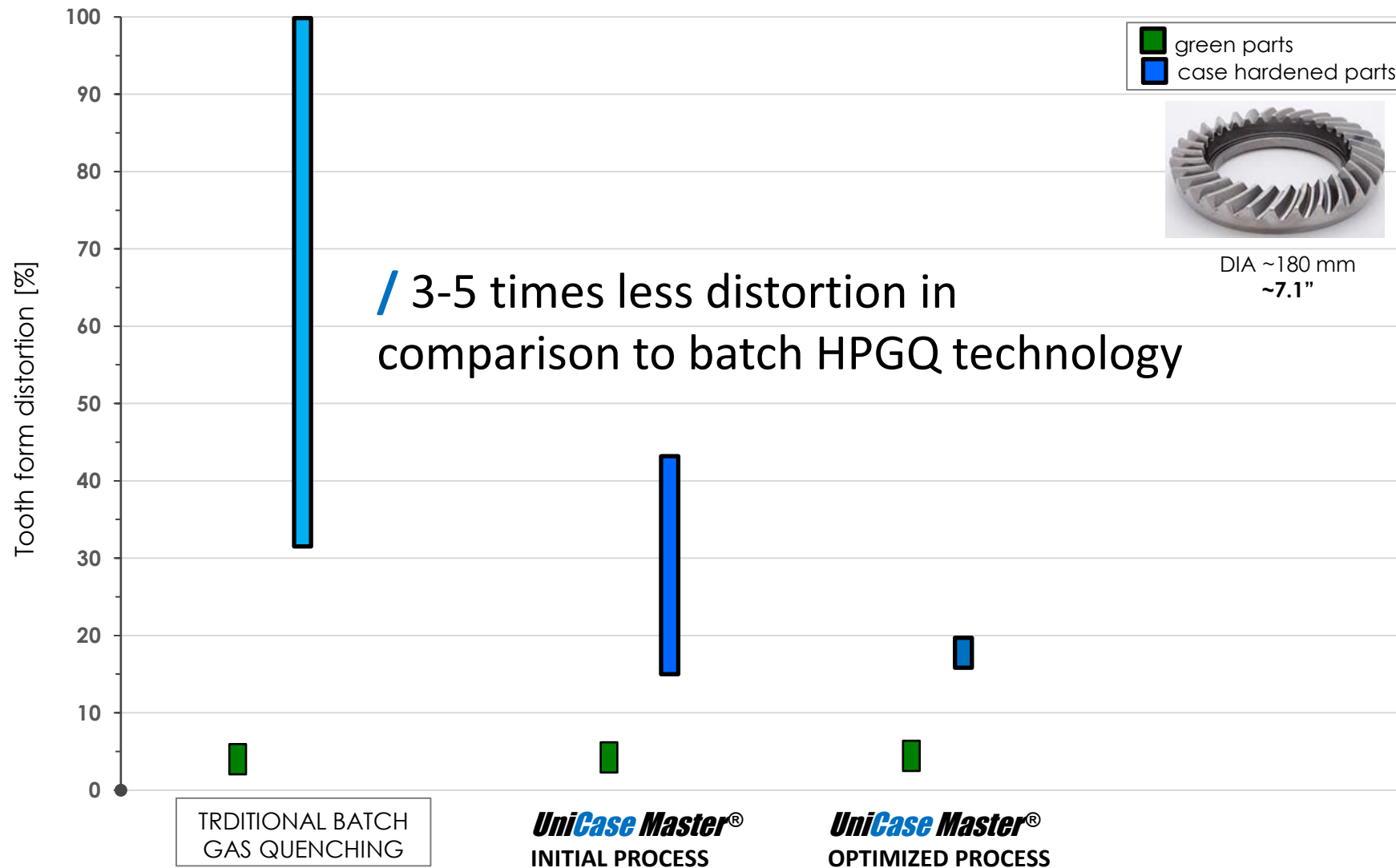
compared to vacuum batch oil



# DISTORTION

## 3D ANALYSIS OF RING GEAR TOOTH FORM

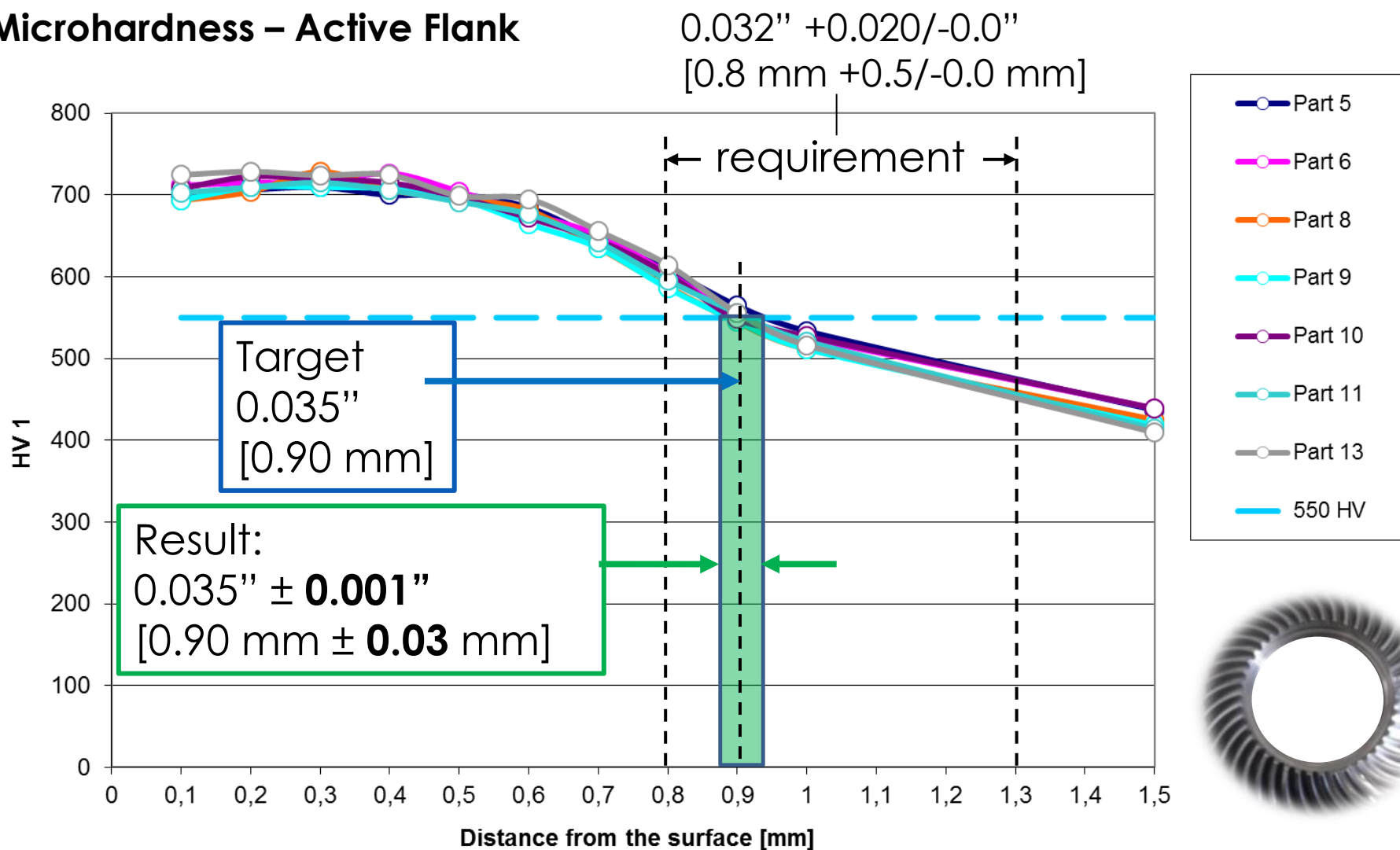
**UniCase Master®**





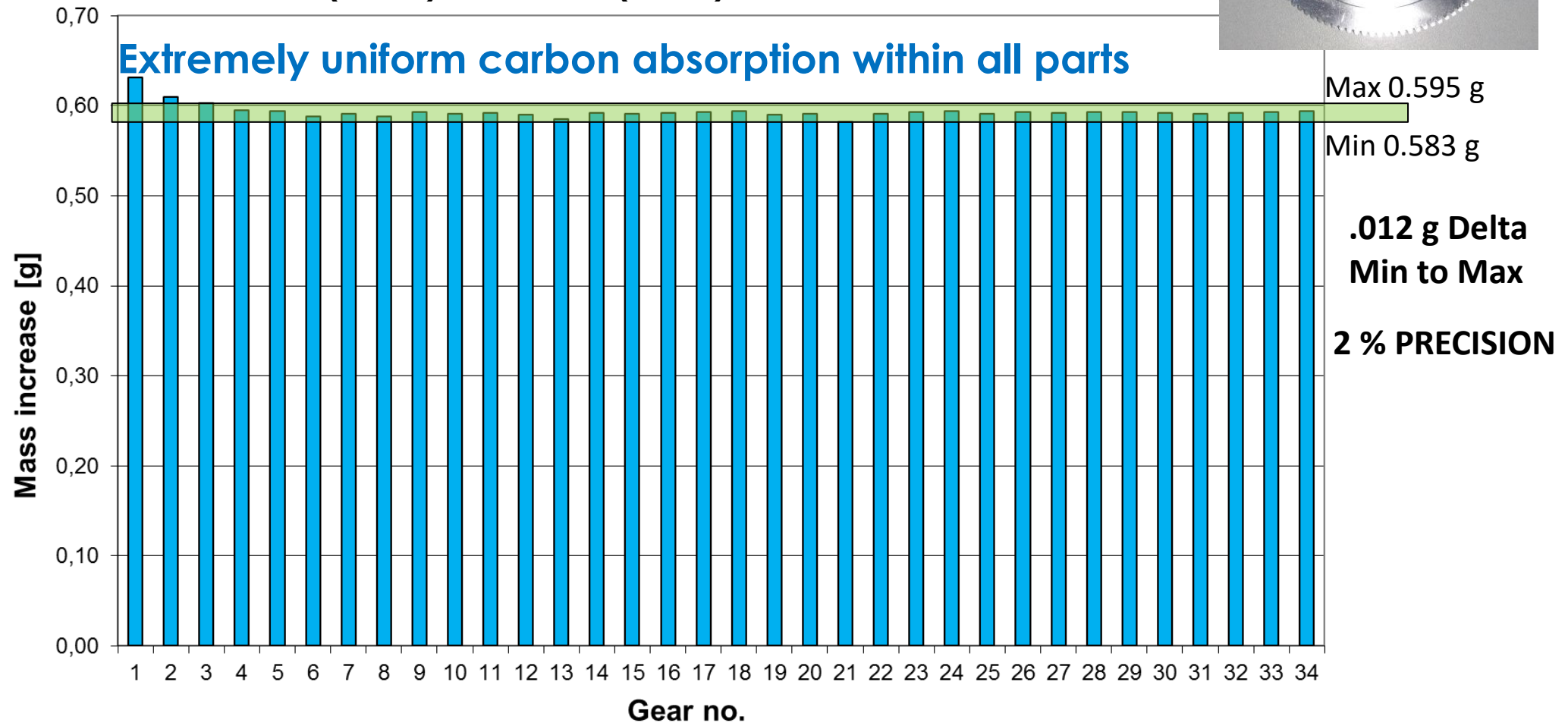
# CARBURIZING PRECISION

## Microhardness – Active Flank

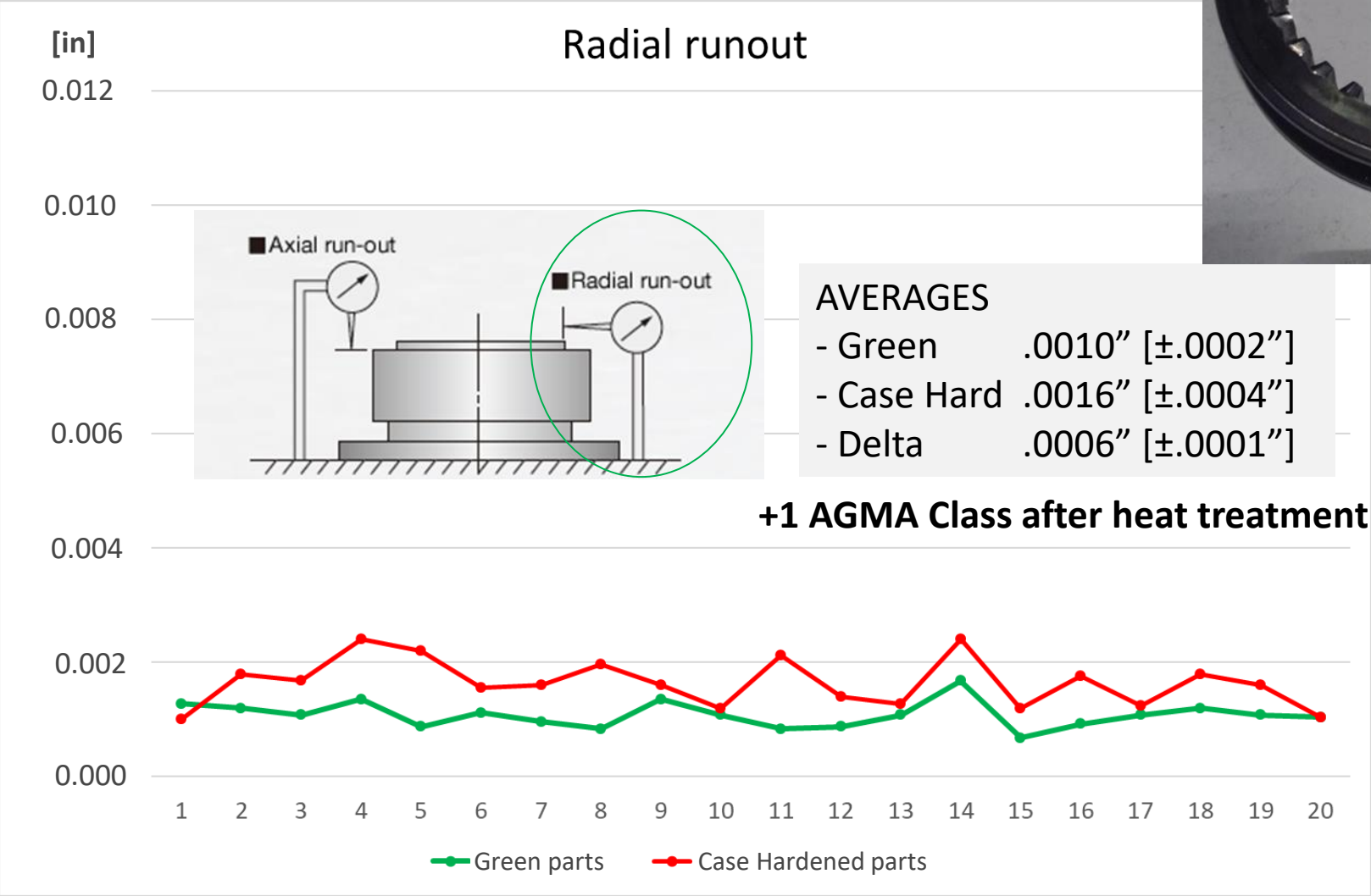


# CARBURIZING UNIFORMITY

Mass increase by carbon absorption in gears  
1050°C (1925°F) ECD 0.6 mm (0.024")



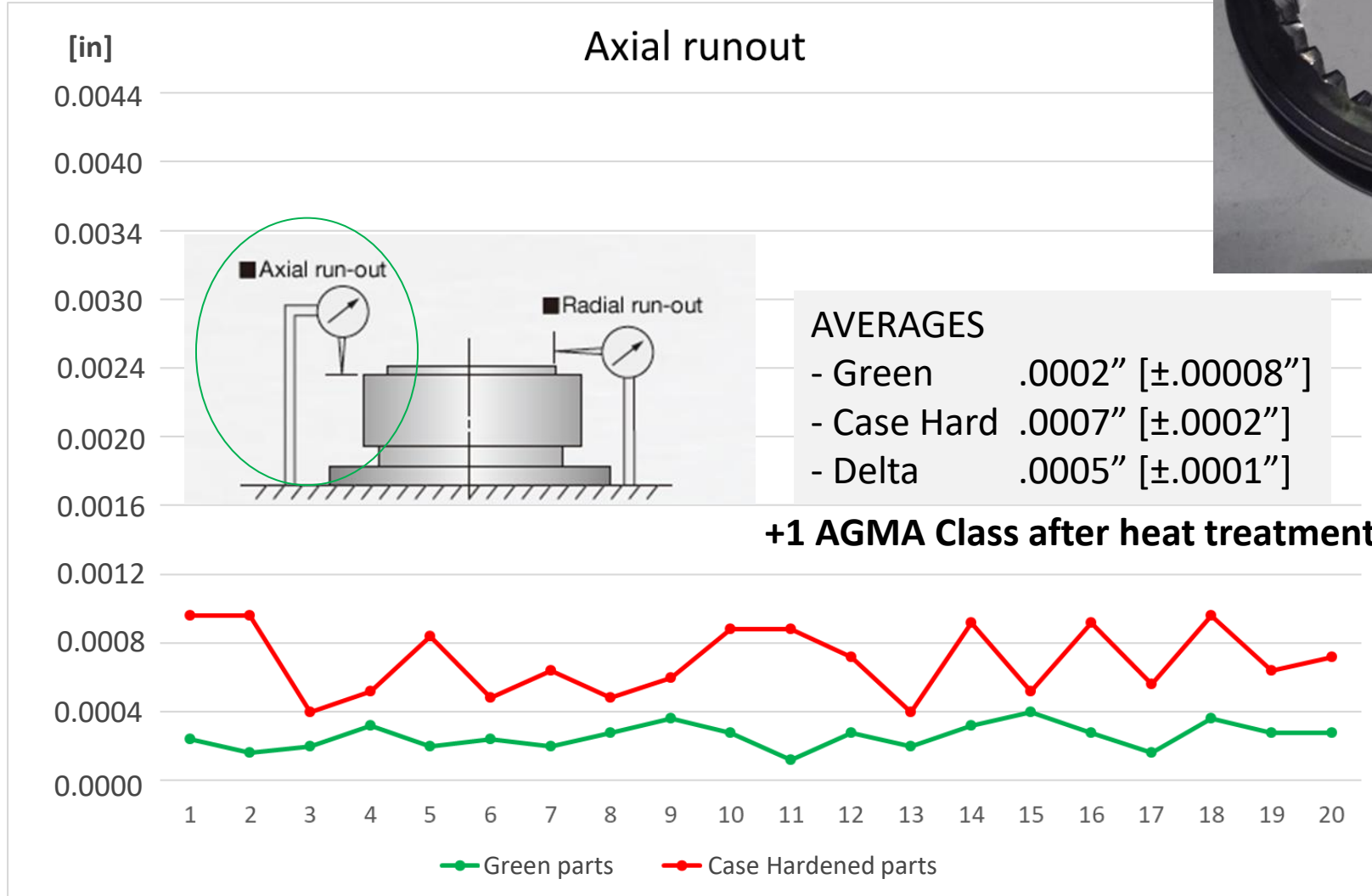
# DISTORTION TEST – COUPLING SLEEVE



Steel: 20NiCrMo  
Diameter: 150 mm



# DISTORTION TEST – COUPLING SLEEVE

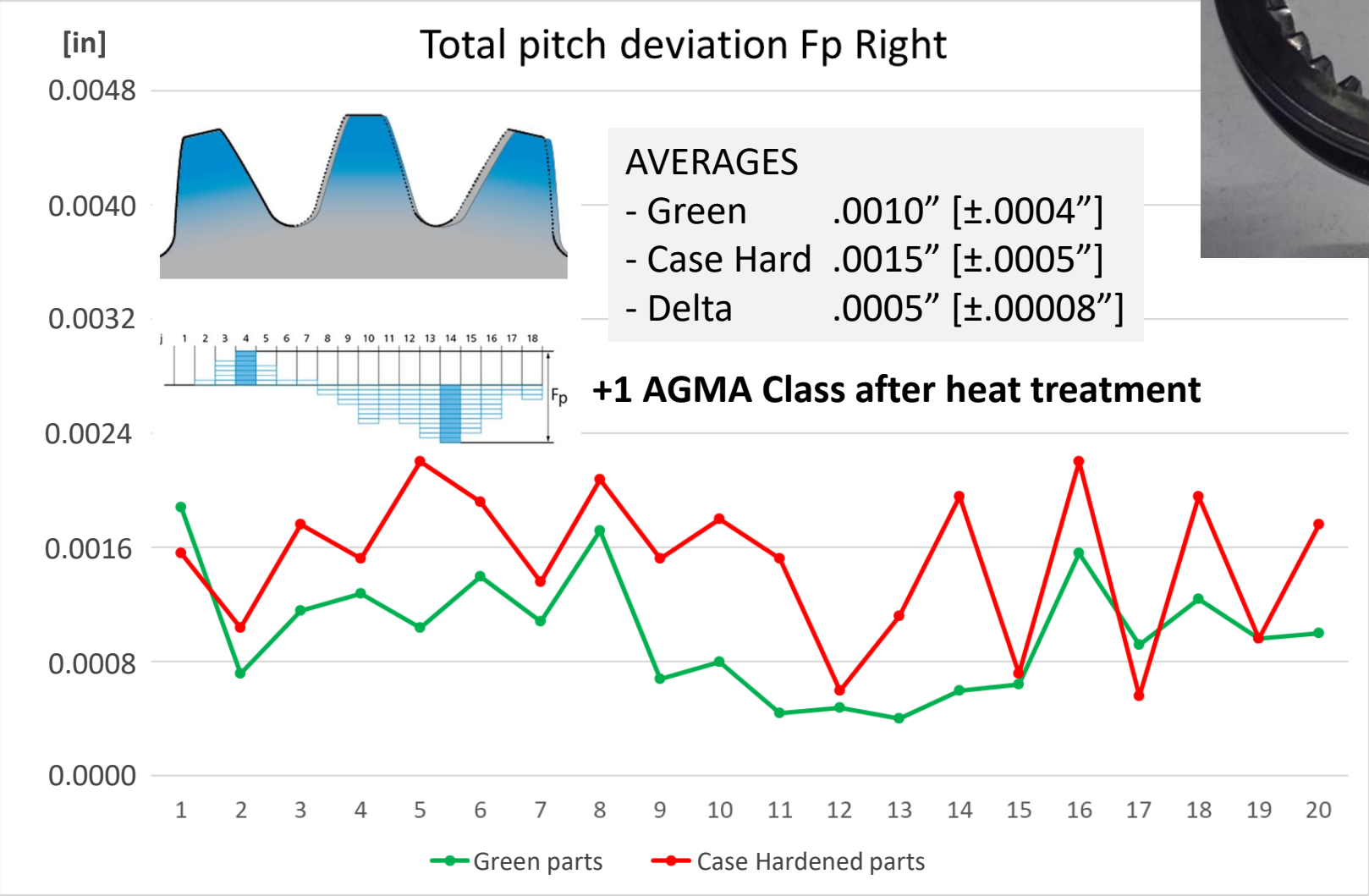


Steel: 20NiCrMo  
Diameter: 150 mm

# DISTORTION TEST – COUPLING SLEEVE



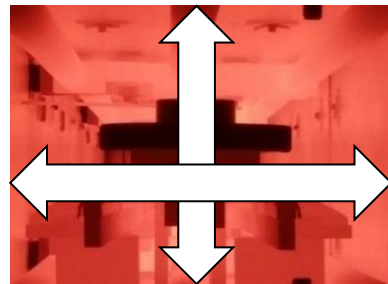
Steel: 20NiCrMo  
Diameter:150 mm



**UNICASE MASTER<sup>®</sup> WITH  
4D QUENCH<sup>®</sup> - EQUIPMENT CONFIGURATION**

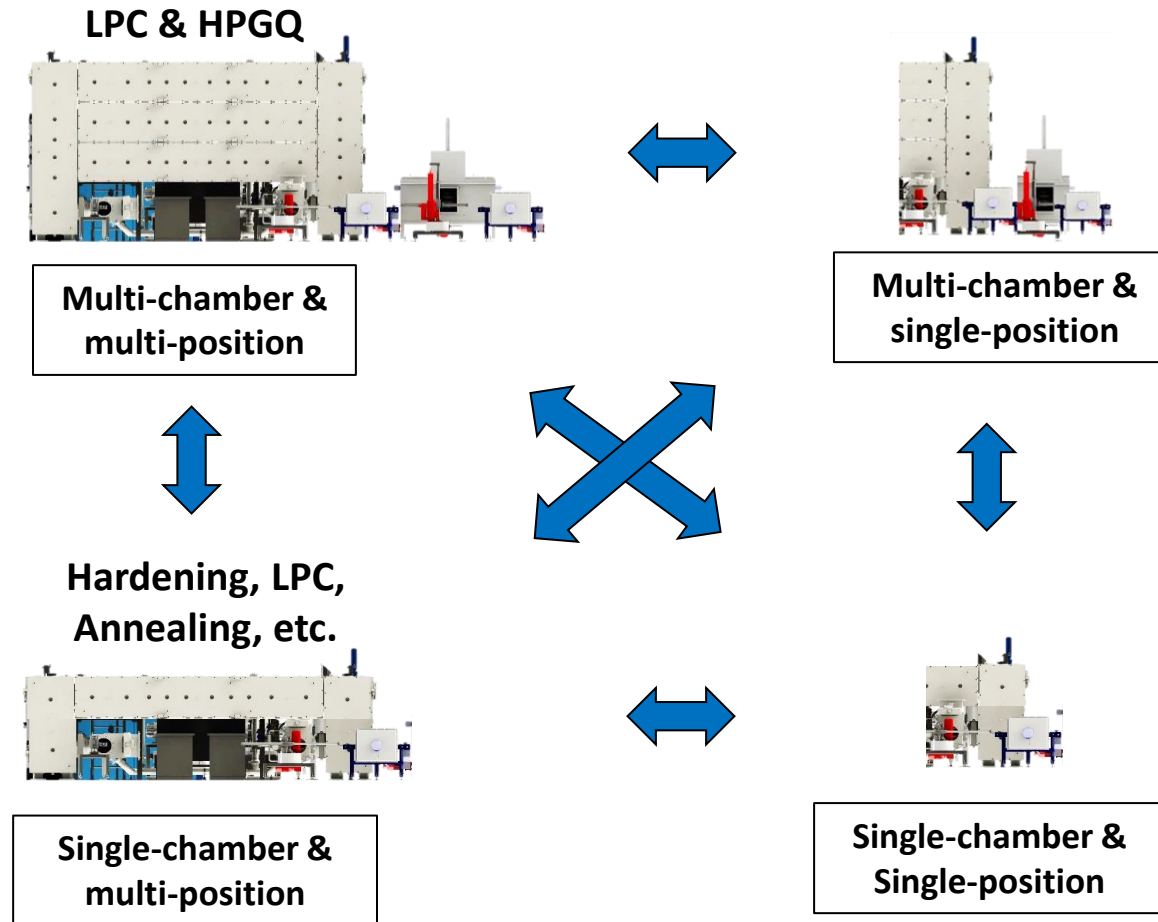


# **UniCase Master®** — FLEXIBLE AND ADAPTABLE

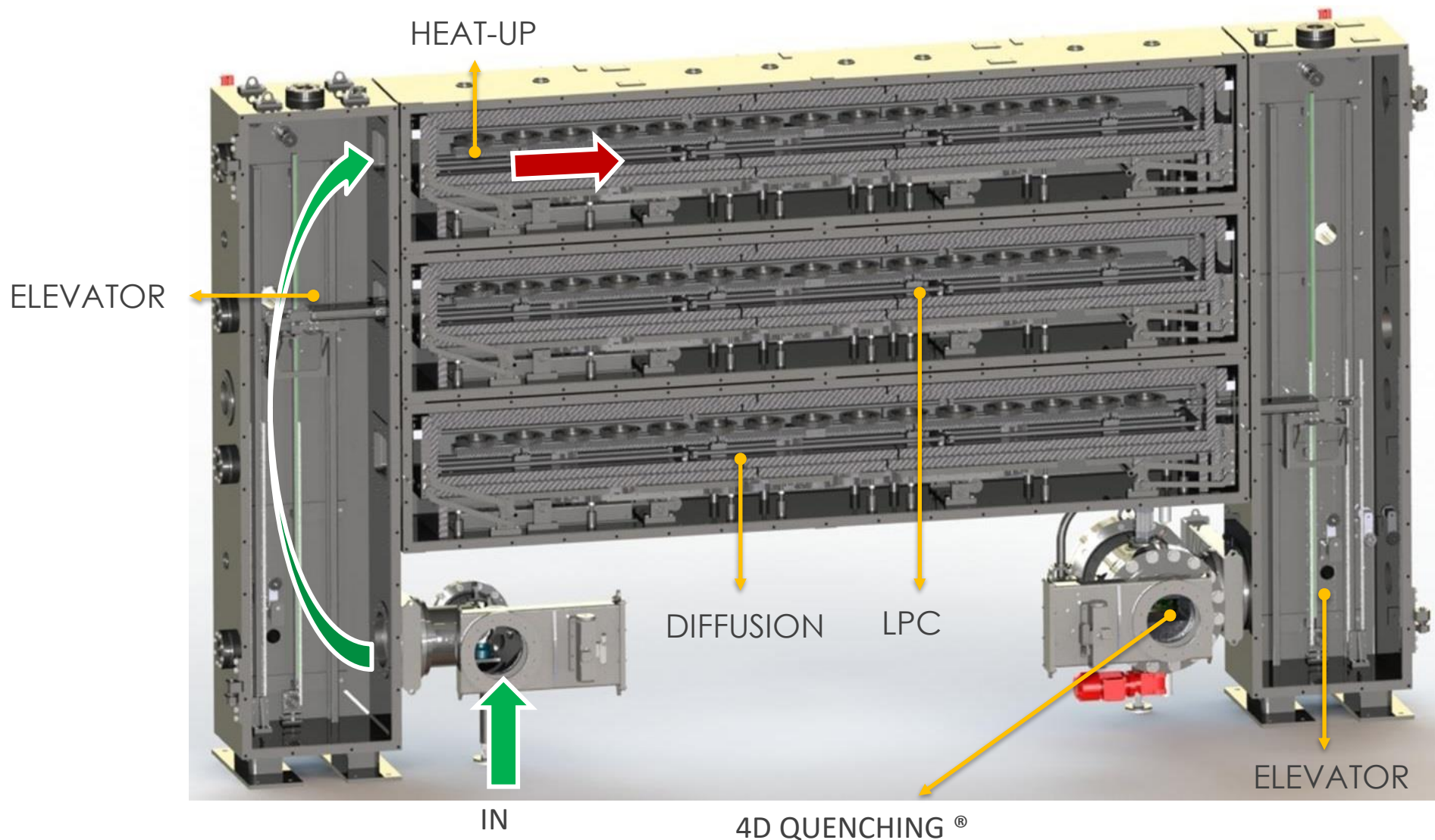


Re-sizing

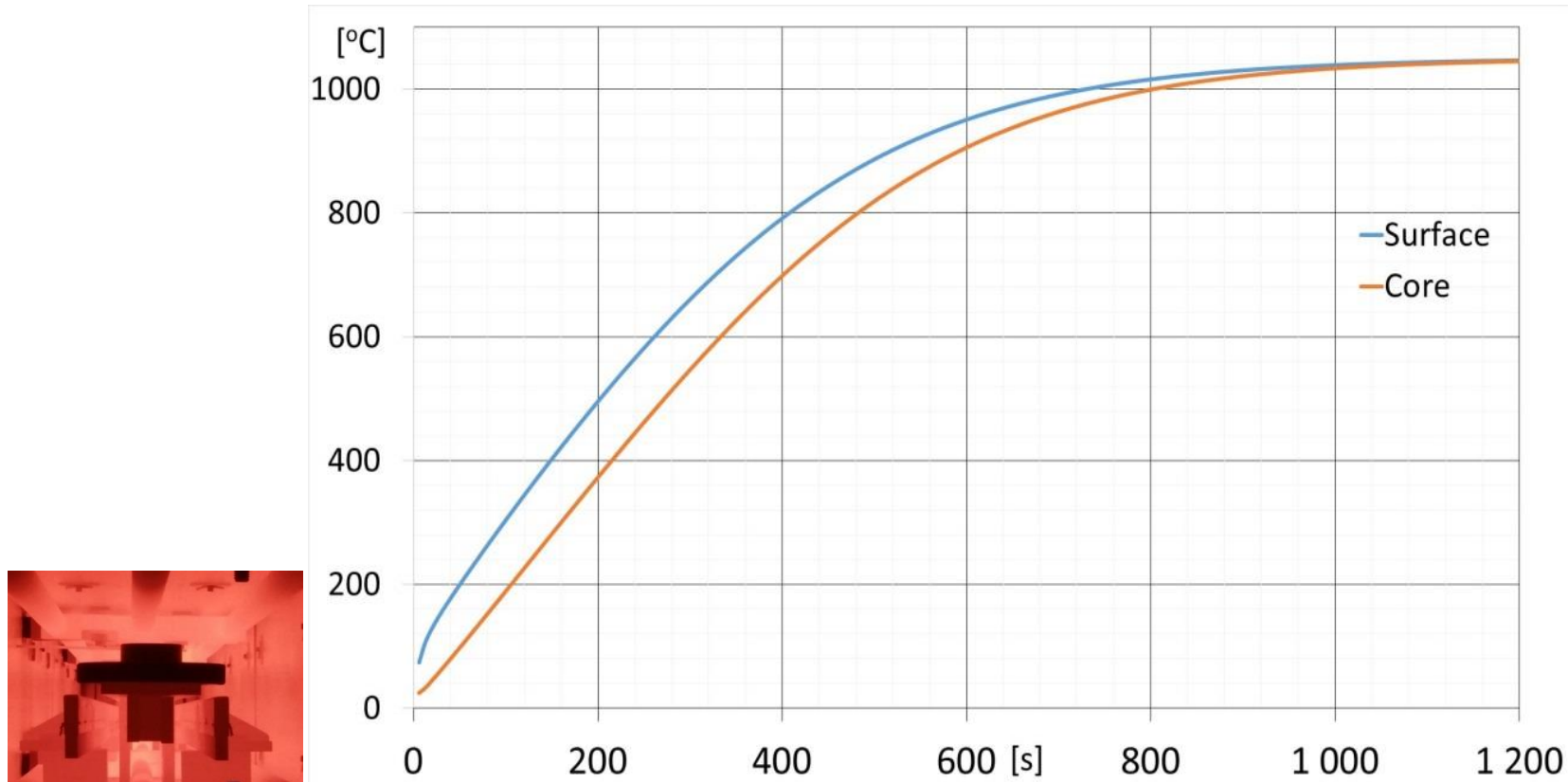
Technology, process, throughput



# **UniCase Master®** – SINGLE-PIECE FLOW – HEAT-UP



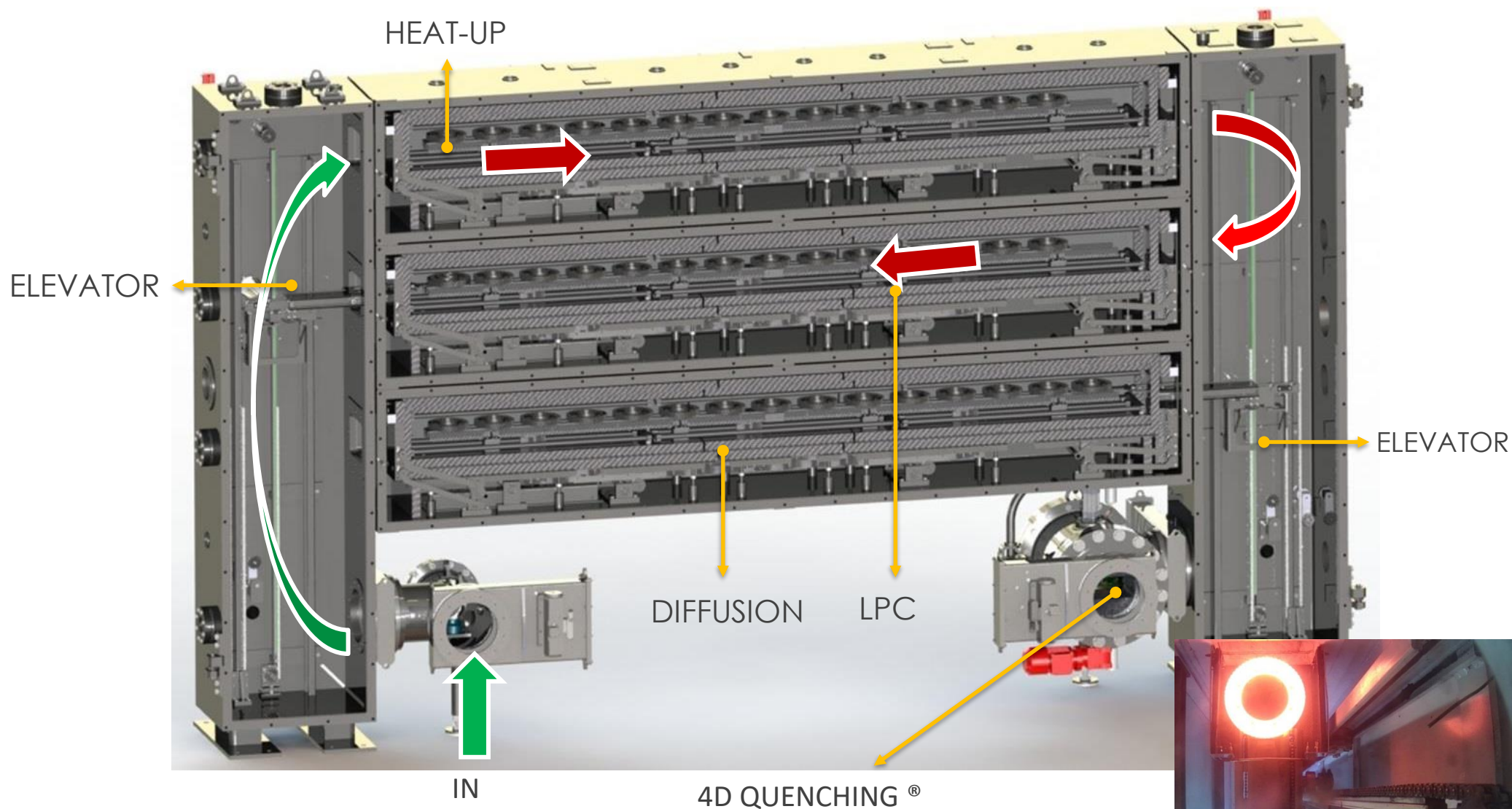
# HEAT-UP IN HEAT-UP CHAMBER (1)



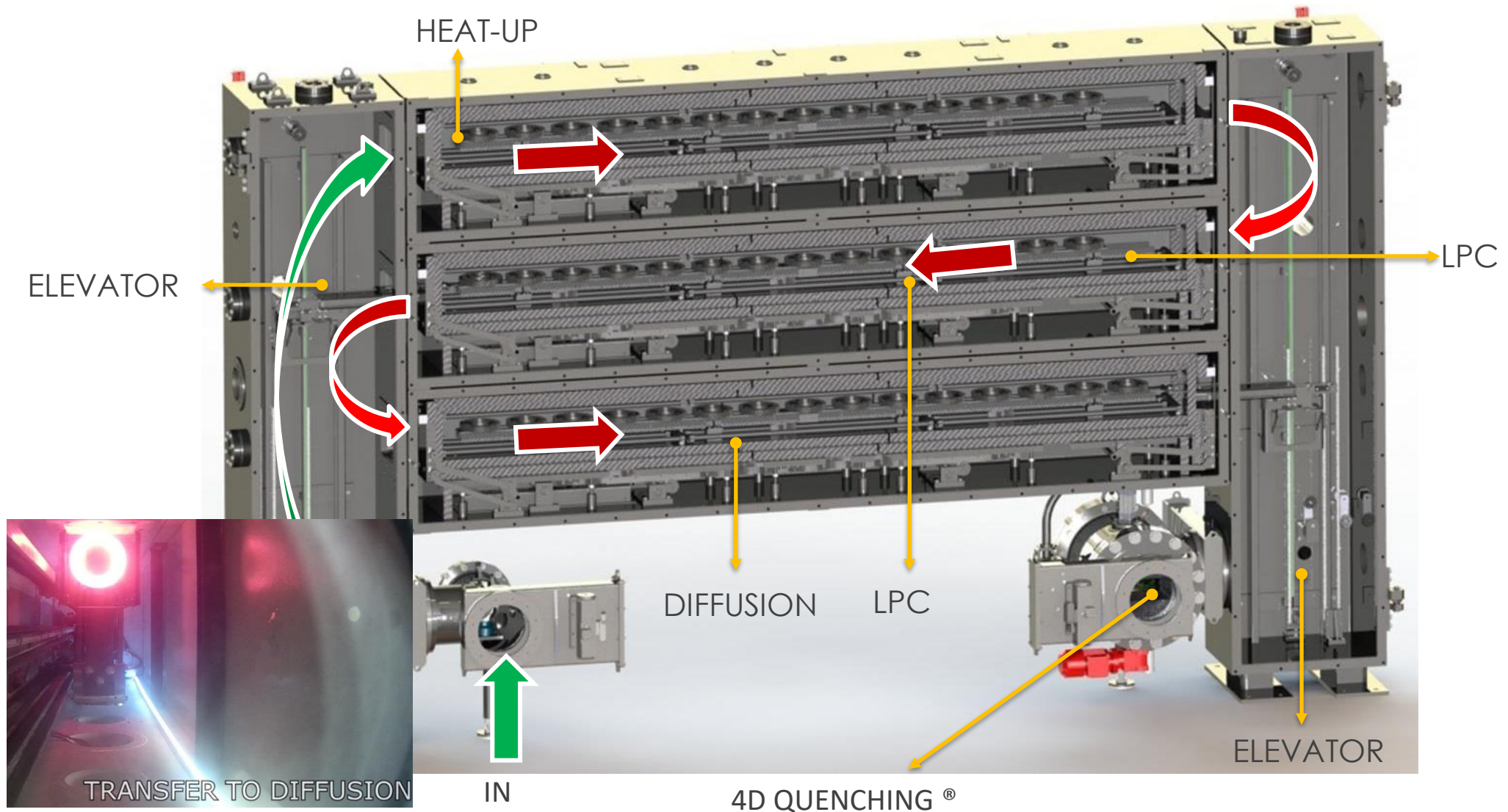
Heating curve by radiation, CFD simulation for a single gear,  
dia. 190 mm / 7.5" , 3,0 kg / 6.6 lbs,  $\epsilon = 0,35$



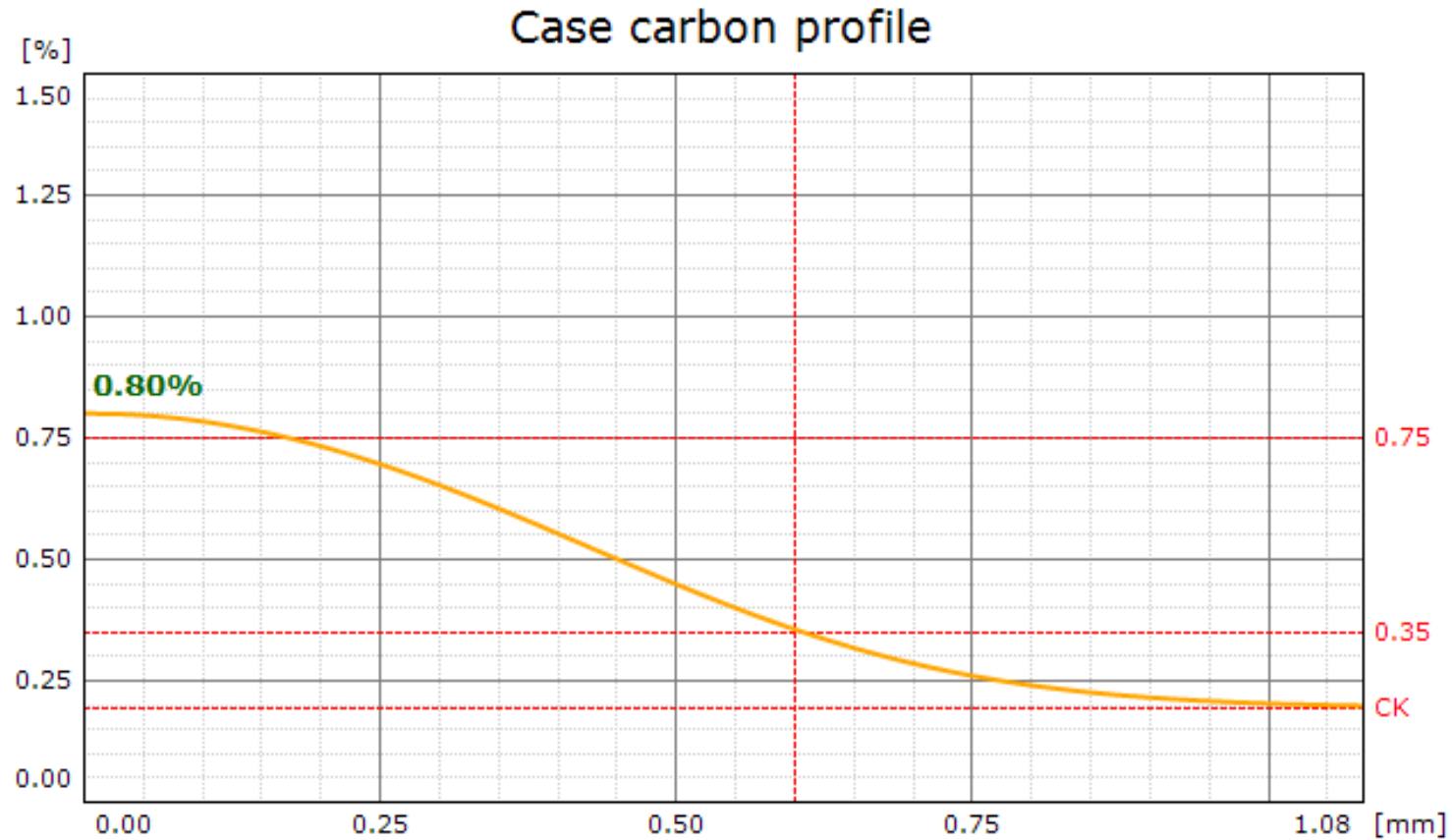
# **UniCase Master®** – SINGLE-PIECE FLOW – LPC



# **UniCase Master®** – SINGLE-PIECE FLOW – DIFFUSION



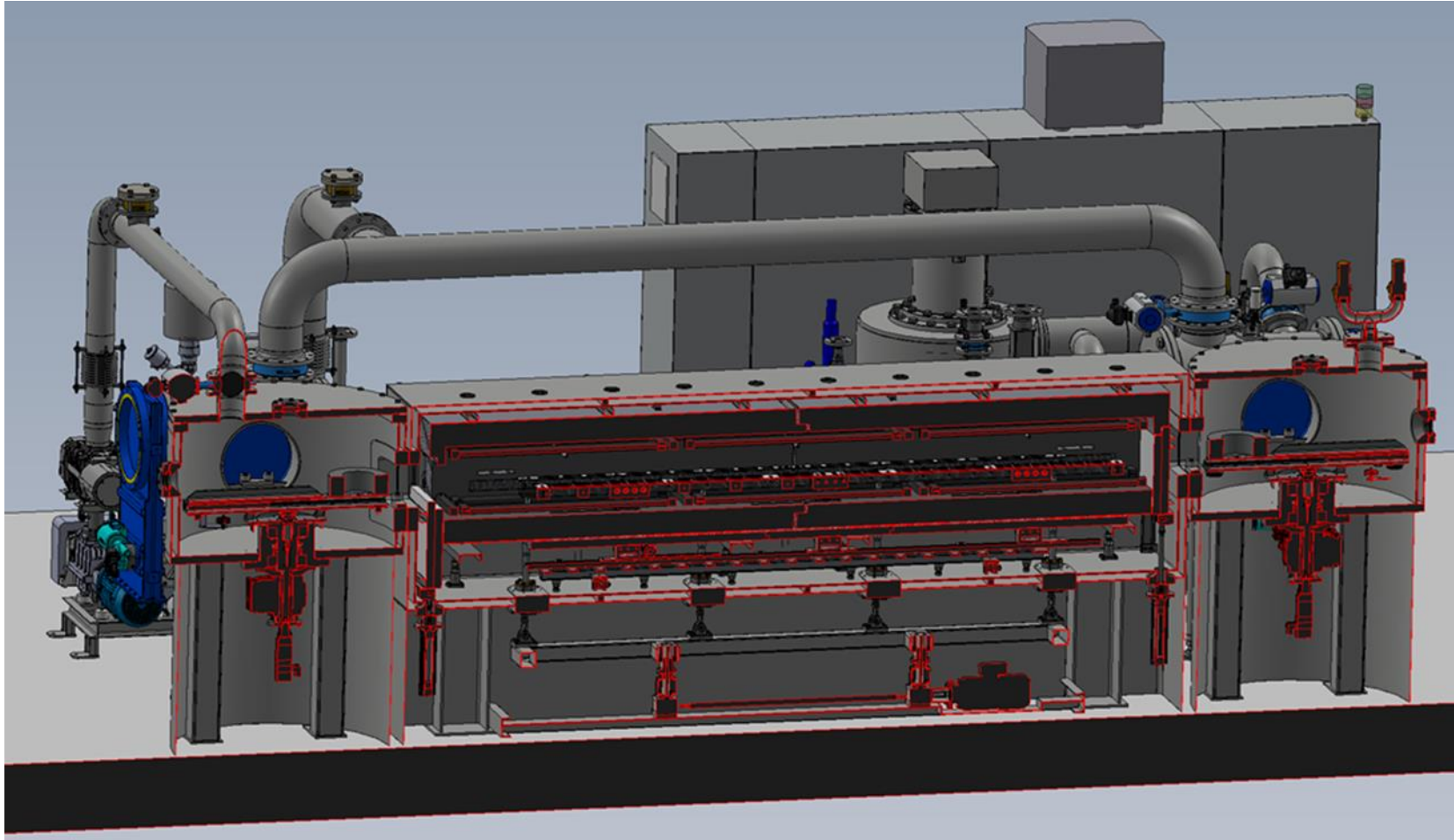
# FINAL CARBON PROFILE AFTER DIFFUSION



30 min total process time (LPC and diffusion at 1040°C / 1900°F)

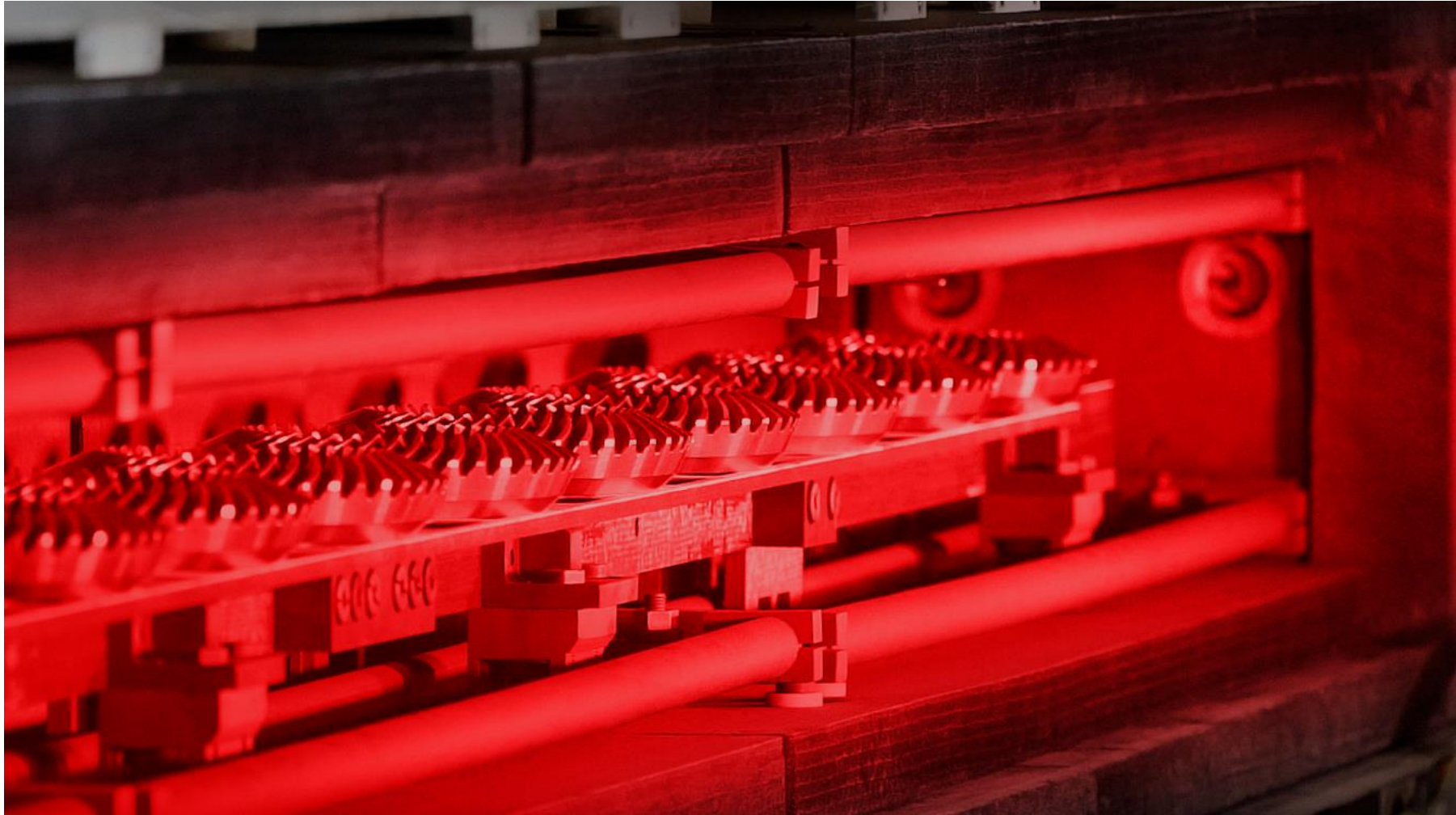


# *UniCase Master*– 4D QUENCH®



**Vacuum Austenitizing & High-Pressure Gas Quenching**

# ***UniCase Master***– 4D QUENCH®

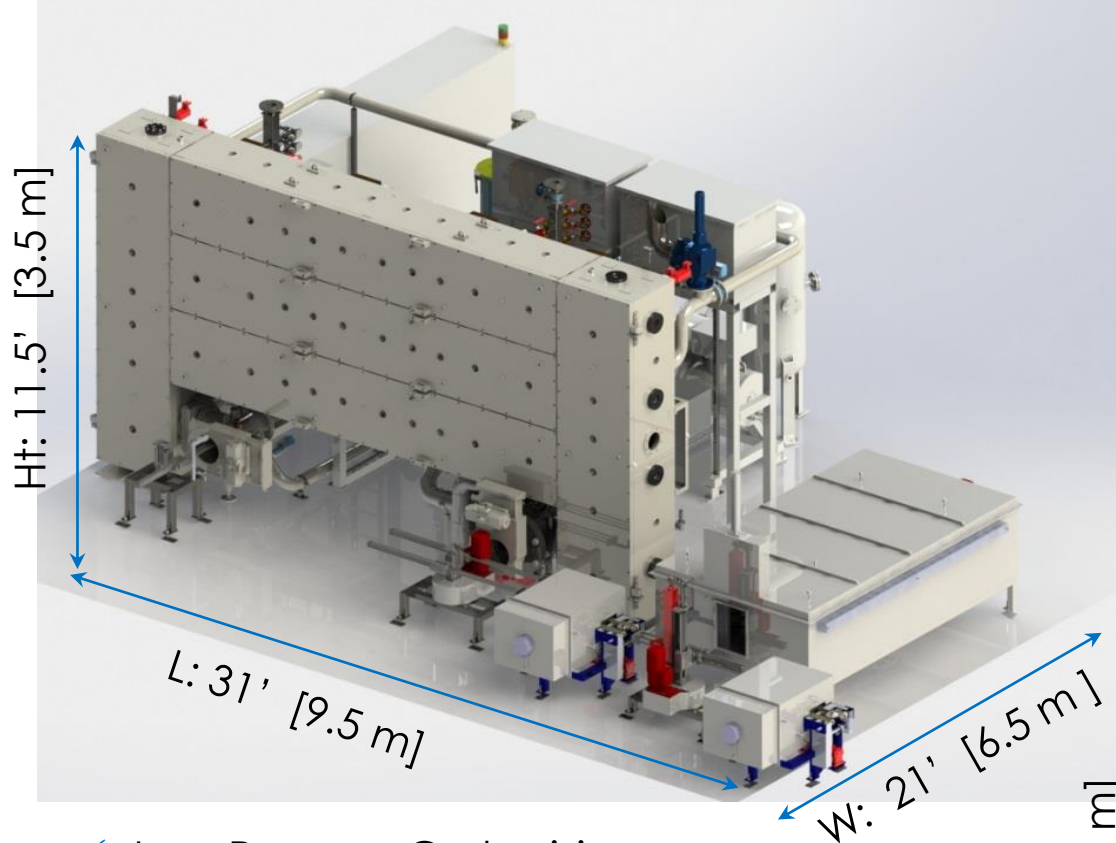


**Vacuum Austenitizing & High-Pressure Gas Quenching**

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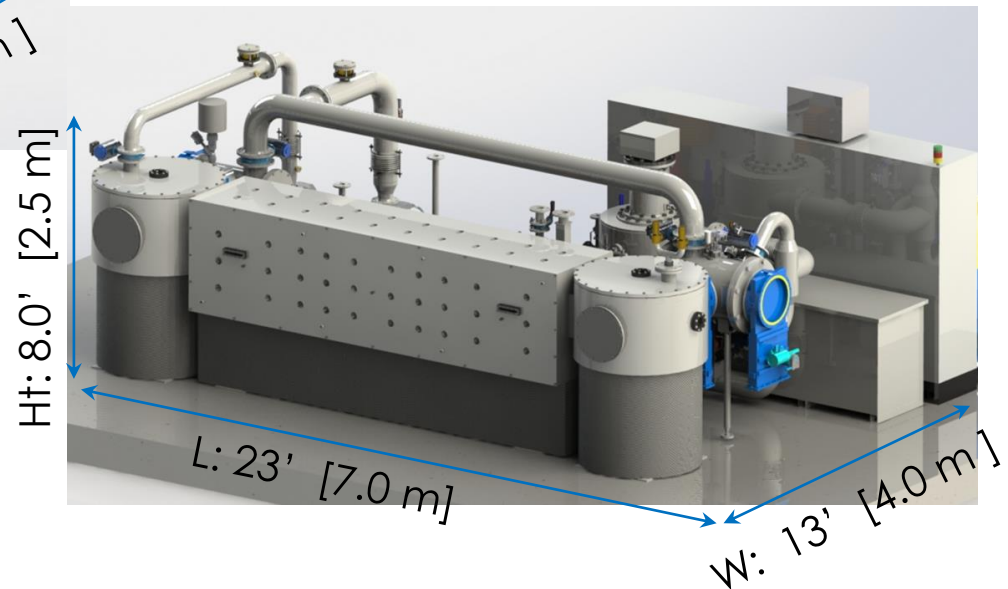
# UniCase Master® – INSTALLATION OVERVIEW



- ✓ Low Pressure Carburizing
- ✓ Austenizing
- ✓ Hardening with 4D Quench®

**Compact &  
Efficient**

- ✓ Austenizing
- ✓ Hardening with 4D Quench®



# UniCase Master® – SIZE CONFIGURATIONS

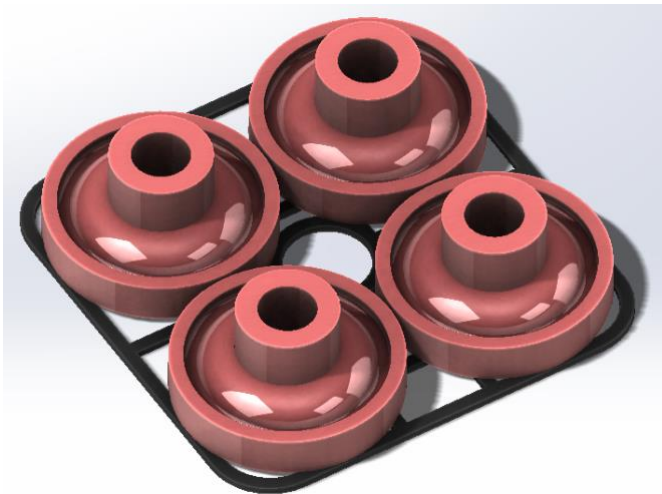
UCM Model #	O.D.	Height	Mass	# of Pos	Tact Time	Pcs. p/yr.	Temp.	Uniformity	Quench Pressure
200/50-1	8.0" 200mm	2.0" 50mm	11 lb. 5 kg	15	40 sec	750 K	2300 F 1260 C	+/- 10°F +/- 6°C	10 Bar N <sub>2</sub>
300/100-1	12.0" 300mm	4.0" 100mm	22 lb. 10 kg	10	60 sec	500 K			
500/150-1	20.0" 500mm	6.0" 150mm	22 lb. 10 kg	6	90 sec	300 K			
200/50-3	8.0" 200mm	2.0" 50mm	11 lb. 5 kg	15	30 sec	500 K			
400/100-3	16.0" 400mm	4.0" 100mm	22 lb. 10 kg	15	60 sec	500 K			

(-1) = Single Level

(-3) = Triple Level



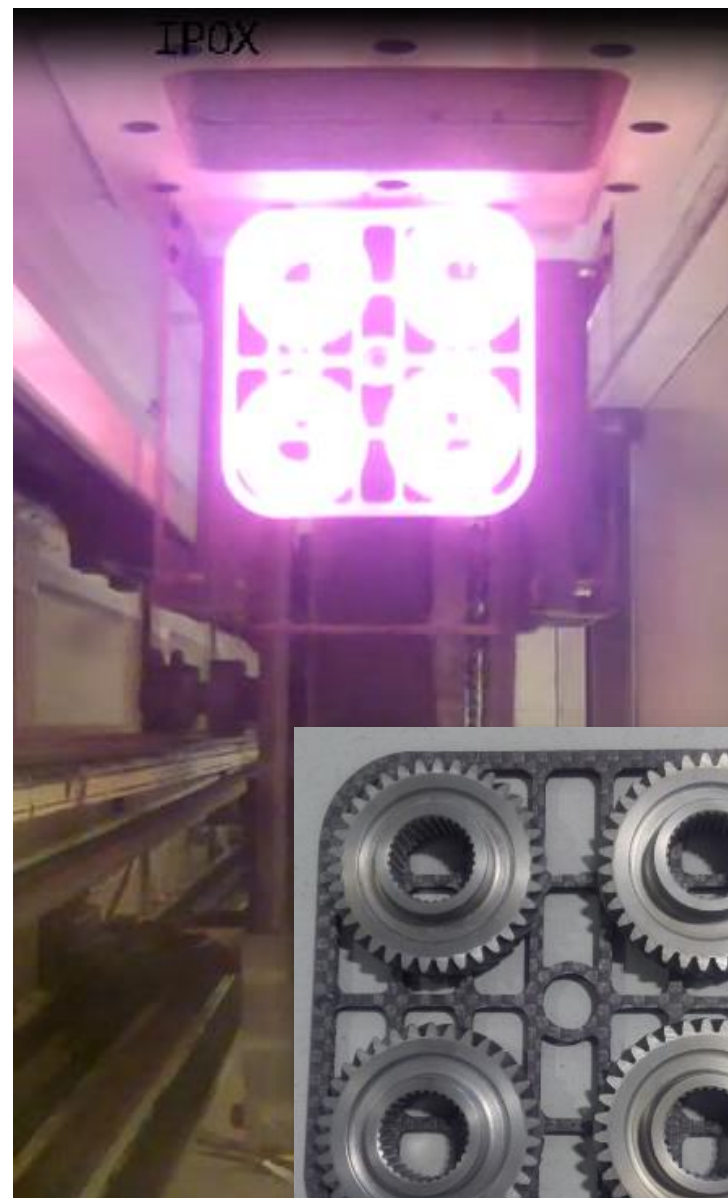
# THROUGHPUT INCREASE



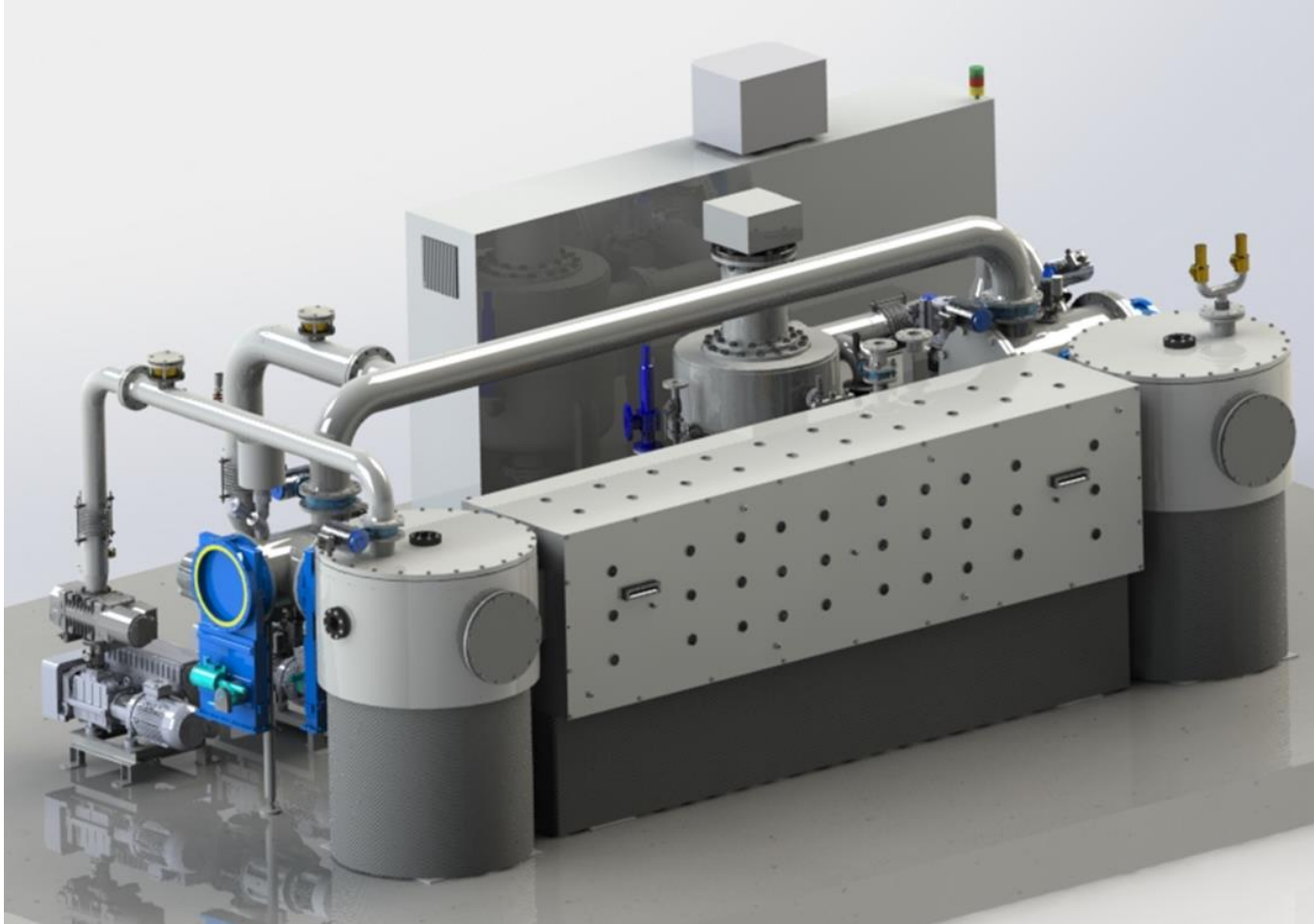
**x4**  
2 mln pcs/y



**x16**  
8 mln pcs/y

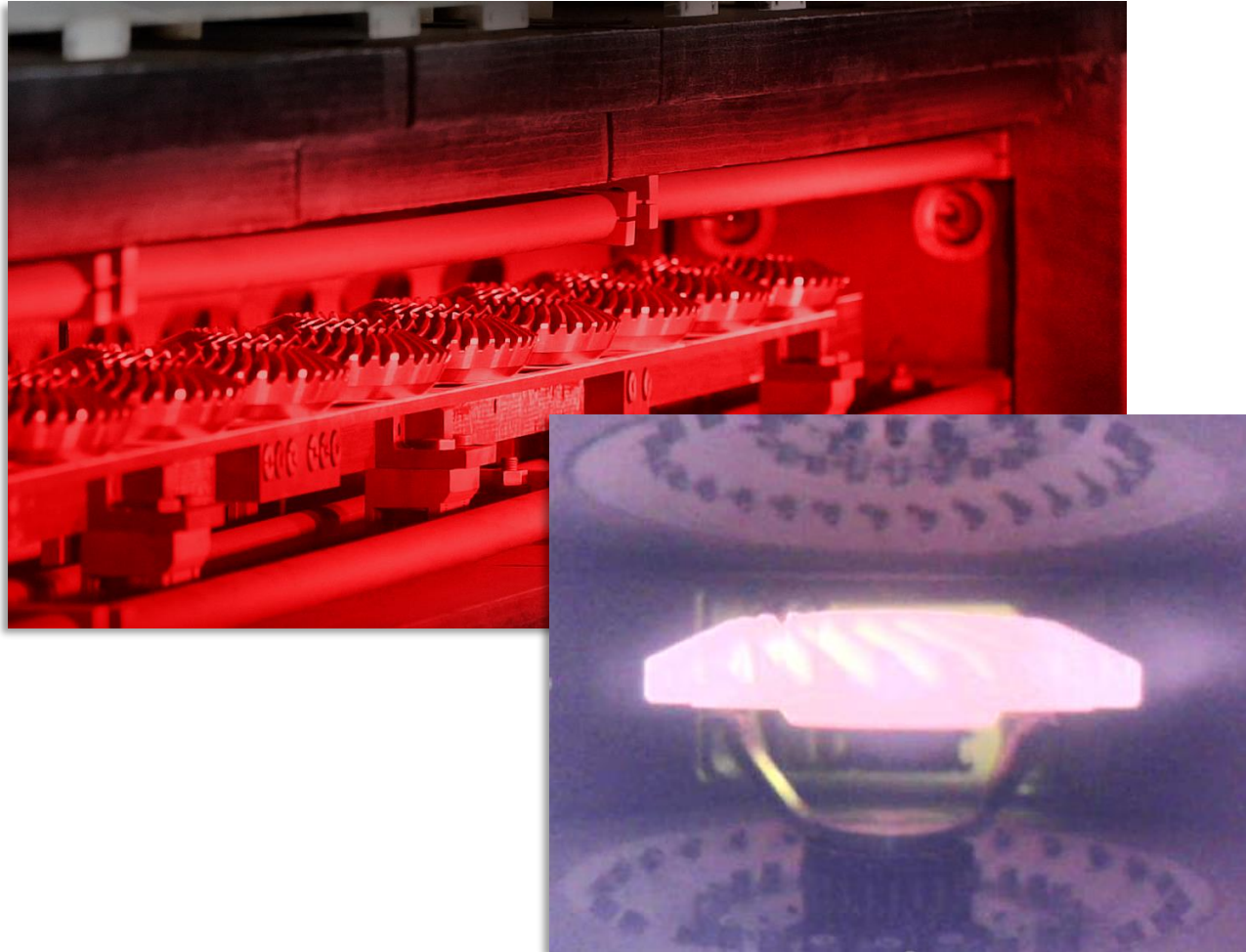


# 4D Quench® vs. Press Quench



- ✓ Distortion control, reduction and prediction
- ✓ Absolute precision and repeatability of results
- ✓ Improved safety and no fire risk
- ✓ Total process automation & integration
- ✓ Full single part traceability and reporting
- ✓ Flexible, on-demand operation
- ✓ No human involvement and impact
- ✓ Compact footprint
- ✓ Elimination of press tooling
- ✓ Eliminates the need for furnace fixtures
- ✓ No decarburization or oxidation
- ✓ Clean part surface (vacuum)
- ✓ Nitrogen quench (neither oil nor helium is needed)
- ✓ Elimination of copper masking or stop off paints
- ✓ Elimination of high-temperature radiation
- ✓ Elimination of oil and oil vapor contamination
- ✓ Elimination of washers and cleaning chemicals
- ✓ Safe and environmentally friendly process

## **UniCase Master**– 4D QUENCH®



- ✓ 4D Quench®
- ✓ Single-Piece Flow
- ✓ In-line Manufacturing
- ✓ High Accuracy and Quality
- ✓ Noiseless Drives
- ✓ eCar, eTruck, eTrans
- ✓ Industry 4.0

**Modern alternative to batch hardening and press quenching**





**Tom Hart**

Product Manager – Vacuum Furnaces

[tom.hart@secovacusa.com](mailto:tom.hart@secovacusa.com)

814-882-1606

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