«Düşük Basınçlı Sementasyonda Enerji Verimliliği»

«Energy Efficiency: Lpc vs Atm Carburizing Or Modultherm vs Sqf»

Gerald Hiller
(ALD Vacuum, Meta-Mak)

3.Oturum: Döküm Teknolojileri Demir&Çelik

3rd Session: Casting Technologies Iron&Steel

***Oturum Başkanı/Session Chairman**: Prof. Dr. Cahit Ensari (Yalova Üniversitesi)*

Oturumlarda yer alan sunumlar 3 Ekim 2016 Pazartesi tarihinde akademi web sayfasına **(akademi.tudoksad.org.tr)** yüklenecektir.

Welcome to ALD Vacuum Technologies GmbH
Dedicated People for Demanding Jobs

Energy Efficiency: LPC vs. atm. carburizing or ModulTherm vs. SQF



Ankiros, Istanbul
29th – 01st September/October 2016 in İstanbul

Energy Efficiency: LPC vs. atm. carburizing or ModulTherm vs. SQF

Gerald, Hiller, ALD Vacuum Technologies GmbH, Hanau, Germany

1. Motivation
2. Introducing furnace systems
3. Batch for energy efficiency comparison
4. Required energy for the heat treatment process
5. Energy fluxes in the furnace chamber
6. LPC: Further potential for energy saving
7. Optimized fixturing for load charging
8. Enhancing energy efficiency with accelerated processes
9. Energy efficiency thru flexibility
10. Further advantages of LPC
11. Summary

1. Motivation

Approximately 30 billion Euros ($39bil) per year of energy costs for operation of industrial furnaces in Germany

More than 40% of the total energy used in the German industry is consumed by thermo-processing plants[1]

(in 2005: 270 TWh = energy-consumption of 14 million households)

European climate and energy policy until 2030:

- **increase of energy efficiency by 25%**
- **reduction of greenhouse gas emissions by 40% compared to 1990**
- **renewable energy share of at least 27%**

Energy efficiency = CO_2 convert to 1kWh electricity → 460 g CO_2 [2]

[1] source: Beneke et al: VDMA-Leitfaden „Energieeffizienz von Thermoprozessanlagen“; VDMA Thermoprozesstechnik, 2011

2 http://www.sunearthtools.com/tools/CO2-emissions-calculator.php

1. Motivation

Hurriyet: Climate action plan, Paris December 2015

[…] Turkey’s dependence on coal is increasing. The “Coal Report” prepared by Sabanci University’s Istanbul Policy Center has shown that with coal occupying a significant place in our energy policies, a climate policy toward the decreasing of greenhouse gasses has become impossible.

Both in Turkey and in the world, civil societies are more focused on the issue than governments.

http://www.hurriyetdailynews.com/the-paris-conference-and-turkey-.aspx?pageID=449&nID=91901&NewsCatID=402

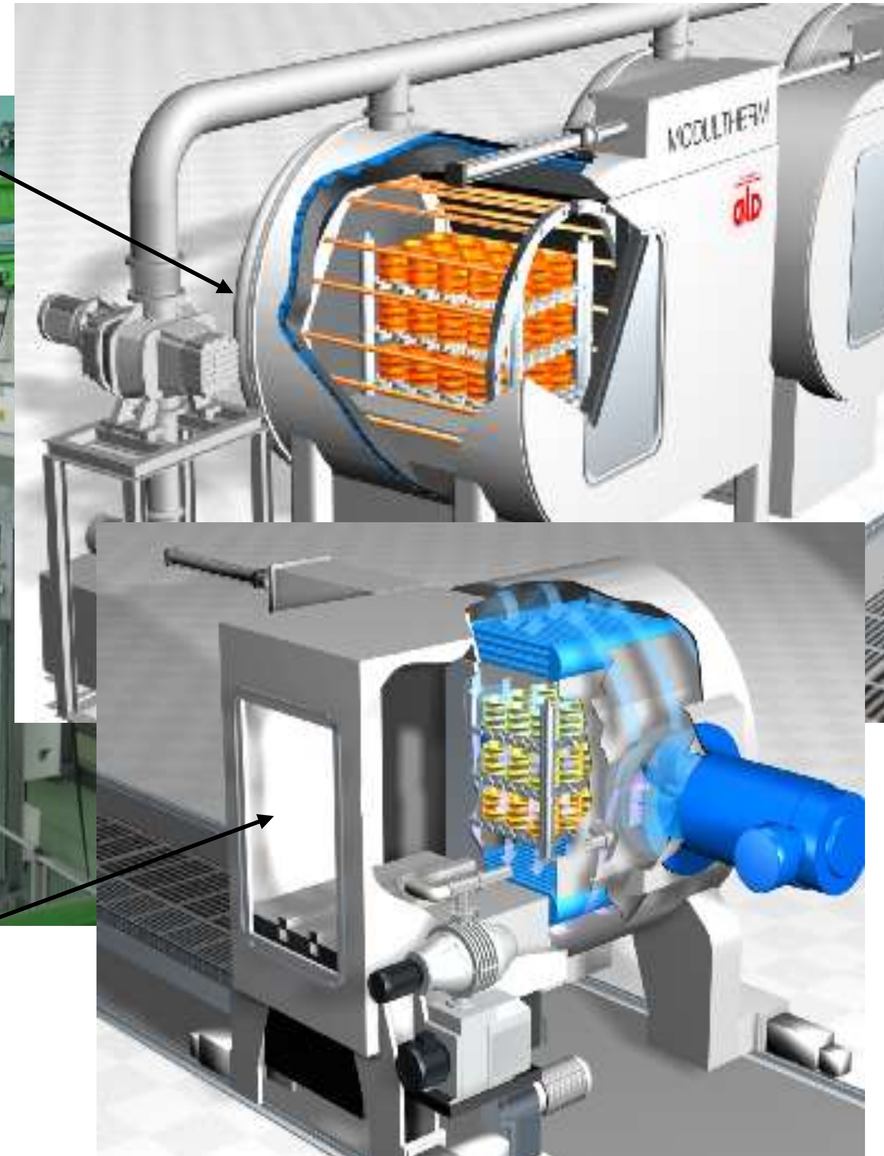
Energy efficiency = CO_2 convert to 1kWh electricity → 459 g CO_2*

* http://www.sunearthtools.com/tools/CO2-emissions-calculator.php

2. Introducing the furnace systems

Furnace system ModulTherm LPC

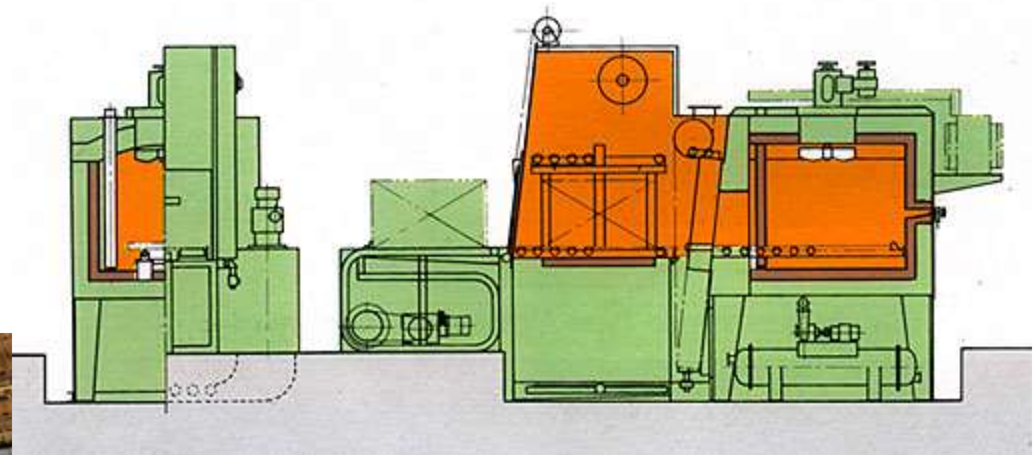
Treatment chambers (for vacuum carburizing)



Mobile Quenching Cell (for gas-quenching),

Shuttle-module on tracks

Furnace system Seal Quench atm. carb.



3. Batch for energy efficiency comparison

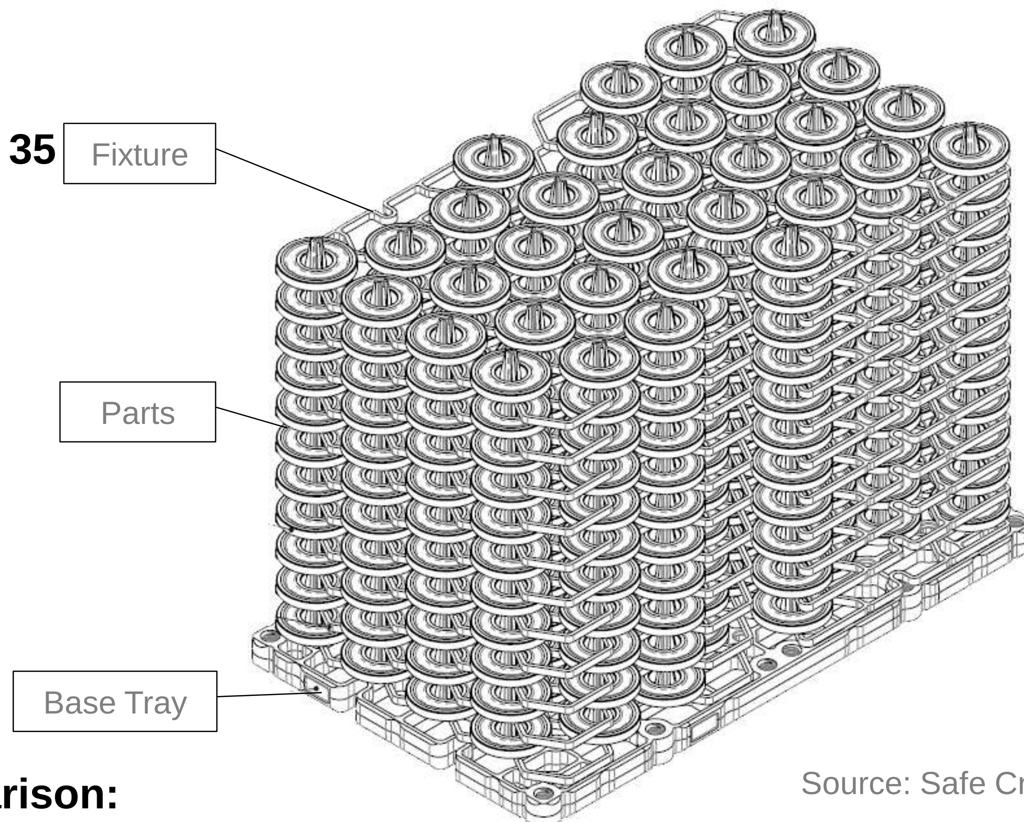
Example for process comparison

Heat treatment Specification

- **Automobile 2nd gear OD 120 ID 35 H 37**
- **Material: 20MnCr5**
- **CHD = 0,5 + 0,5 mm 550HV**
- **Core Hardness > 300 HV10**

Production Specification

- **Annual production volume:**
  500.000 2nd gears



Source: Safe Cronite

Assumption for comparison:

- **Batch get pre heat up to 400 °C**
- **Only carburizing process**
- **Quenching or any post treatments are not part of consideration**
- **Standard furnaces**

Batch in ModulTherm (LPC)

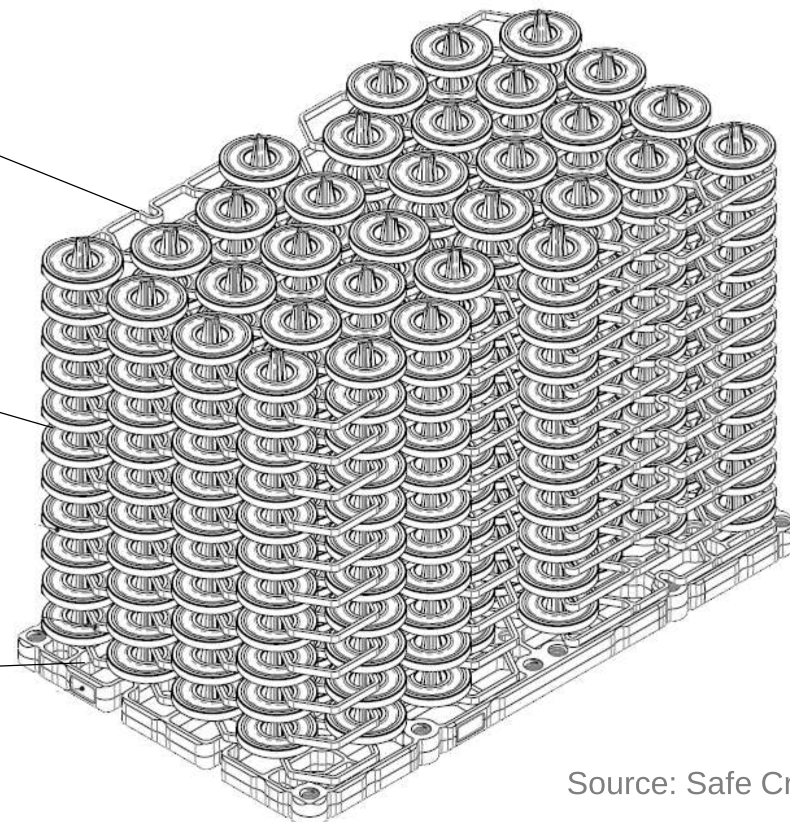
- **Material: 20MnCr5**
- **CHD = 0,85 mm 550HV**

Furnace / Load configuration

- **600 x 750 x 1000 mm [w x h x l]**
- **Load weight = max 1000 kg**
- **Number of gears per batch = 352 pcs**
- **Gross weight = 655 kg**
- **Net weight = 517 kg**
- **Fixture weight = 138 kg**
- **Ratio Gross/Net weight = 1,27**

- **Recipe time at 970 °C = 167 min**

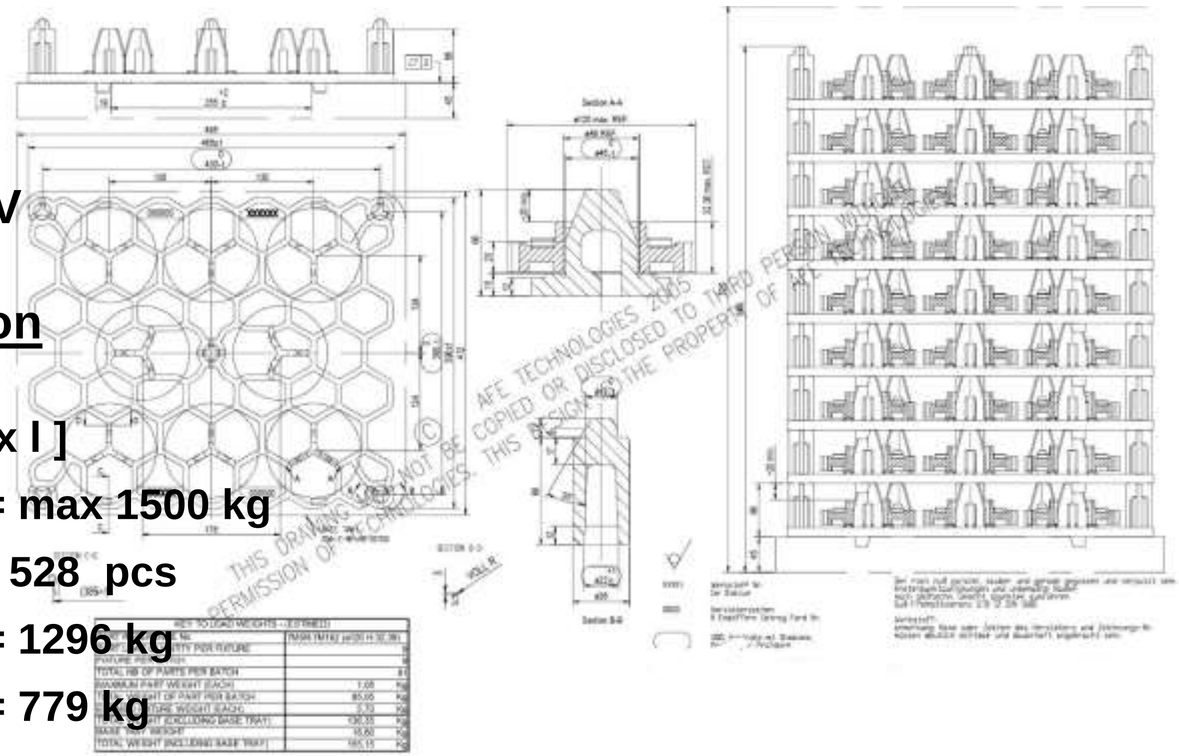
- **Fixture material: Mancellium or HR23 (48Ni-28Cr-05W)**
- **Expected life time: = 24 Month**



Source: Safe Cronite

Batch in SQF (atmosphere)

- **Material: 20MnCr5**
- **CHD = 0,5 + 0,5 mm 550HV**



Furnace / Load configuration

- **910 x 910 x 1220 mm [w x h x l]**
- **Load weight = max 1500 kg**
- **Number of gears per batch = 528 pcs**
- **Gross weight = 1296 kg**
- **Net weight = 779 kg**
- **Fixture weight = 519 kg**
- **Ratio Gross/Net weight = 1,66**
- **Recipe time at 930 °C = 540 min**

- Fixture material: Mancellium or HR4 (52Ni-18Cr)
- Expected life time: 18 Month

Source: Safe Cronite

4. Required energy for the heat treatment

Energy calculation SQF

Q = heat quantity [kwh]
c_p = spec. heat capacity of steel 0.6 $[\frac{kJ}{kg} * °C]$
ΔT = temperature difference [°C]

Fixture/Gears

$Q = c_p \times m \times \Delta T$

$Q = 0.6\,\frac{kJ}{kg} * °C \times 1{,}296\ \text{kg} \times 910\ °\text{C}$ = 707,616 kJ / 3,600 = **197 kwh**

Idle lost calculation

Q_A = Idle lost [kwh]
t = time in [h]
Q_V = standby power [kJ]

$Q_A = t \times Q_V$

Q_A = 540 min/60 h * 210,000 kJ = 1,890,000 kJ / 3,600 = **525 kwh**

Total energy consumption load/SQF = 197 + 525 = 722 kwh

Energy calculation ModulTherm

Fixture/Gears

$Q = 0{,}6\ \frac{kJ}{kg} * °C \times 655\ kg \times 950\ °C =$ **373.350 kJ / 3600 = 104 kwh**

LPC idle lost			
	t [min]	Qv [kW]	QA [kWh]
Convection heating	60	38	38
Vacuum heating	20	27	9
LPC	52	34	29
Final diffusion	35	27	16
	167		92

Total energy consumption load/MT = 104 + 92 = 196 kwh

Energy comparison of one load

	MT	SQF
Gross weight kg	655	1298
Q_{sum} kWh	195	722
Energy kWh/kg	0,2982	0,5567
	-46%	

Production comparison

	MT	SQF
Load Volume	0,45 m³	1,01 m³
Load mass gr/net [ratio]	655/517 Kg [1,27]	1298/779 Kg [1,67]
Annual production	500.000 2nd gears	
Gear / batch	352	528
Batch / a	1420	947
Complete Carb. time h	3954	8523
Number Furnaces*	0,59	1,27
*6702 h/a	Factor 2,15	

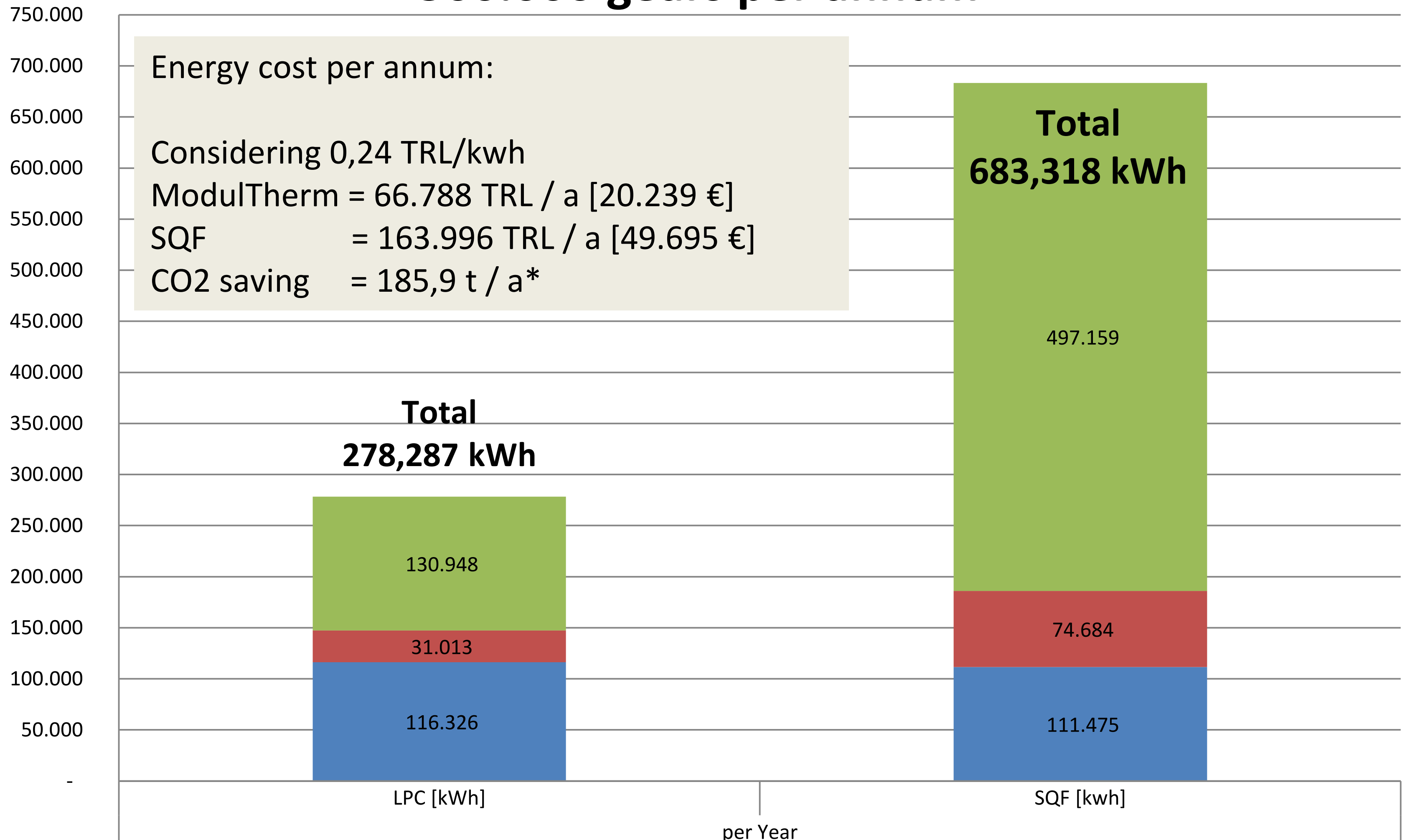
Complete Project Volume of a 6 speed Dual Clutch gear box:

8 gears + 4 shafts = 12 Treatment Chambers in ModulTherm or 26 SQF

Energy consumption [kWh]
500.000 gears per annum

Energy cost per annum:

Considering 0,24 TRL/kwh
ModulTherm = 66.788 TRL / a [20.239 €]
SQF = 163.996 TRL / a [49.695 €]
CO_2 saving = 185,9 t / a*



	LPC [kWh]	SQF [kwh]
Idle lost	130.948	497.159
Fixture	31.013	74.684
Gears	116.326	111.475

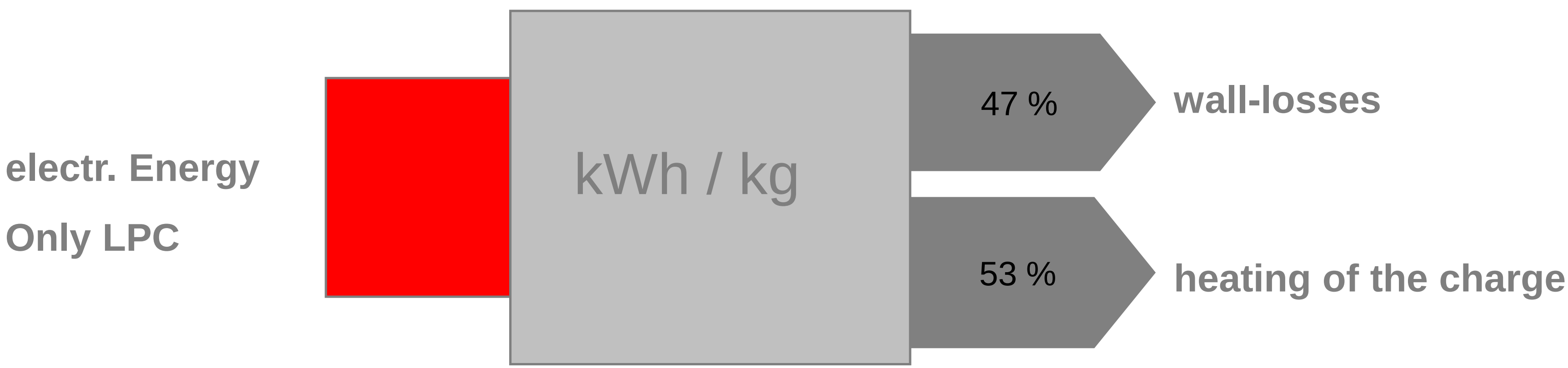
0,459 kgCO_2/kWh*
http://www.sunearthtools.com/tools/CO2-emissions-calculator.php

5. Energy fluxes in the furnace chamber

Energy fluxes ModulTherm (LPC)

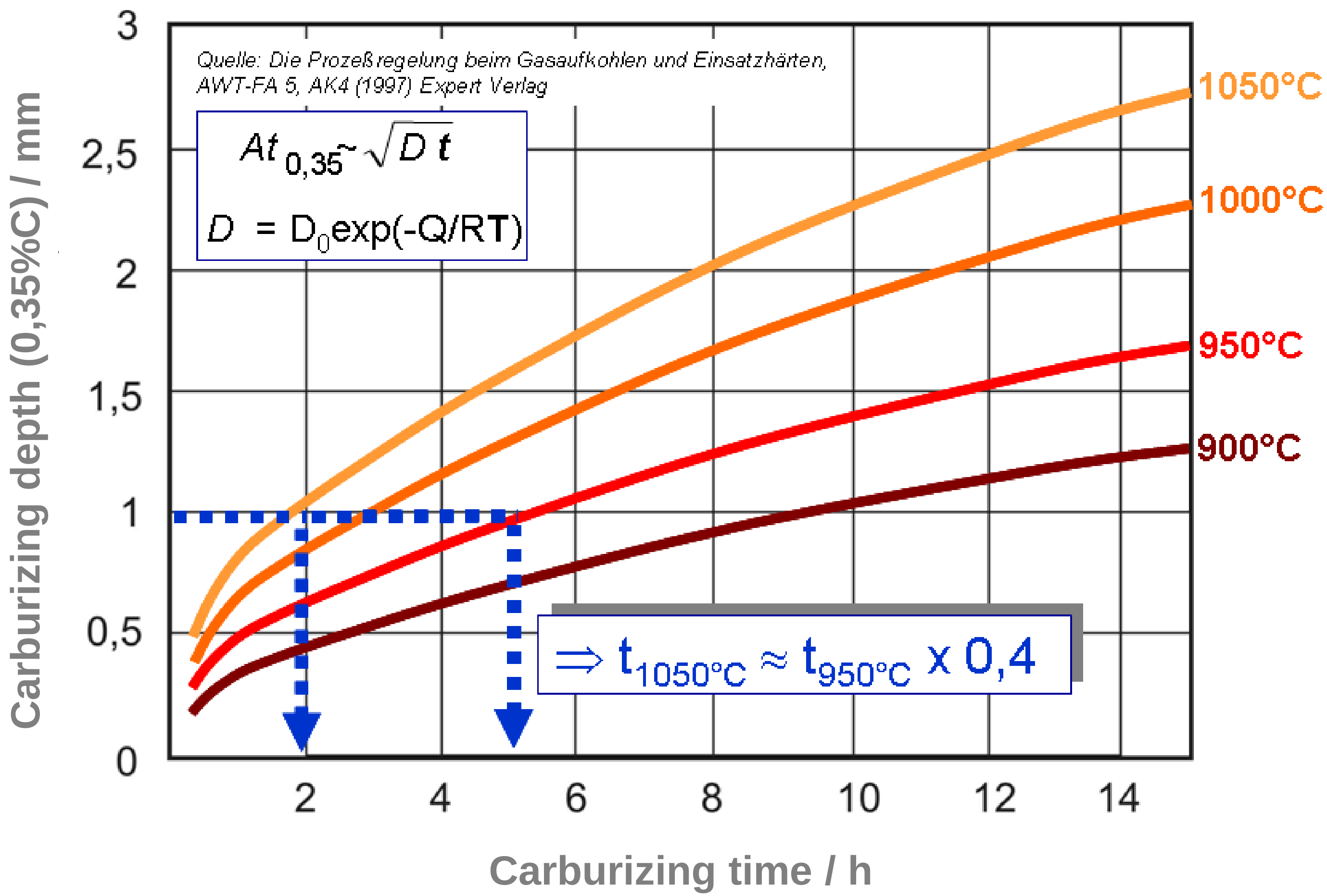
Vacuum heat treatment systems:
indirect resistance heating with graphite heating elements
(heat-transfer by radiation and convection)

Sankey-Diagram (LPC at 970° C; carb.-depth= 0,85 mm, recipe time 167 min



6. LPC: Further potential for energy saving

High temperature - case hardening carbon diffusion = f (T)



→ 60 % reduction of cycle-time for the process step „carb. & diffusion“

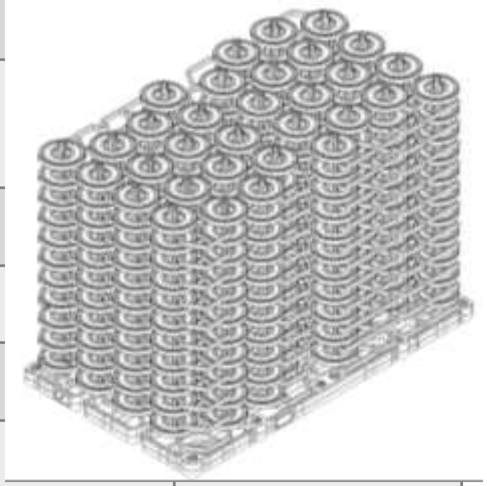
High temperature – LPC

Example 2nd Gear:

20 MnCr5

CDH = 0,85 mm

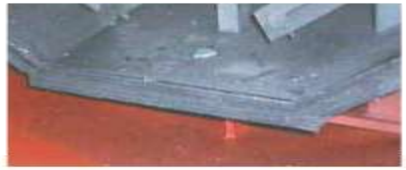
Low pressure carburizing, CD 0,85 mm; 20 MnCr5		
LPC Temperature	**970 °C**	**1050°C***
Heating (convective+vacuum)	80 min	90 min
Carburizing	52 min	6 min
Diffusion	35 min	33 min
Total recipe time	**167 min**	**129 min**
Saving	- 38 min (22%)	

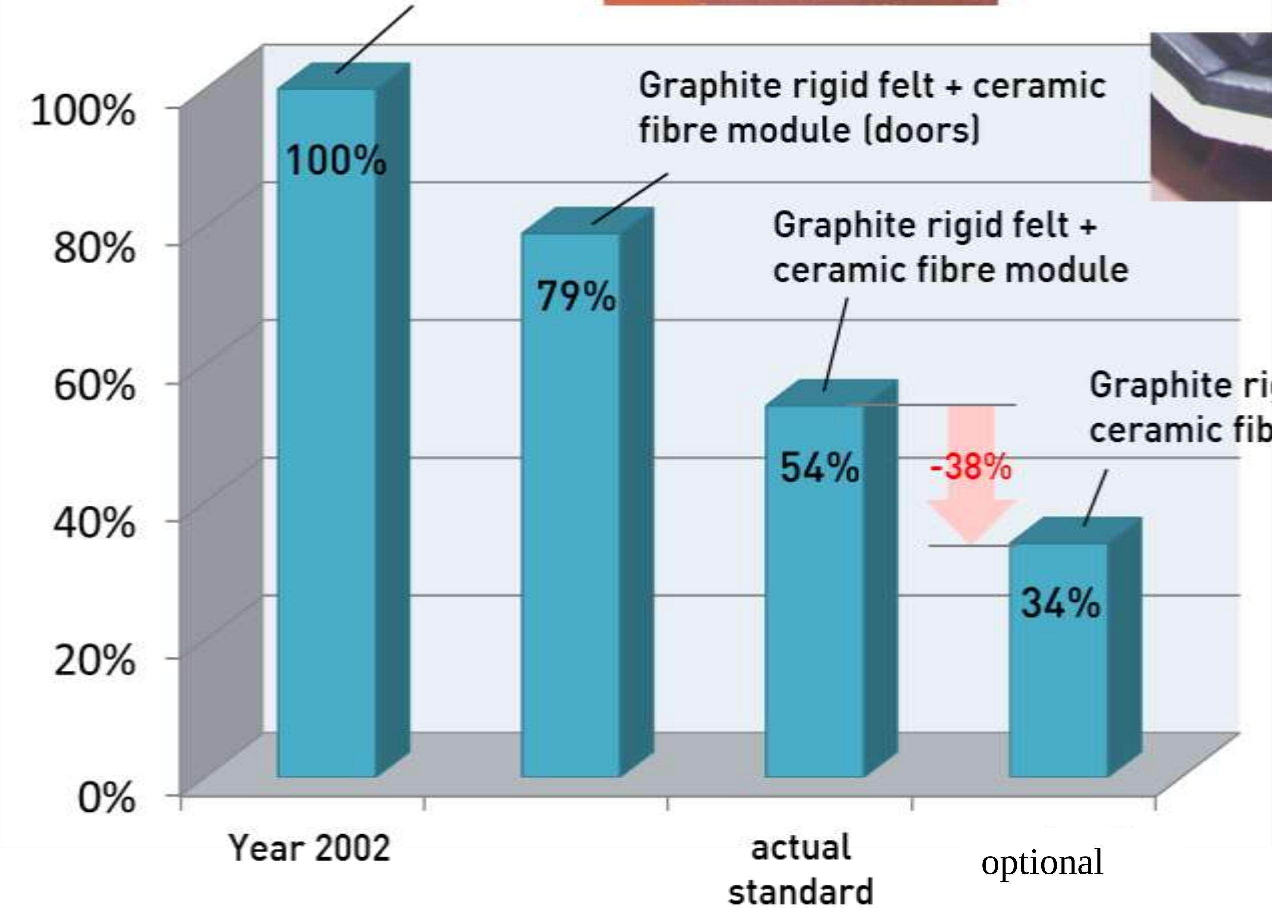


*Fine grain stable material required

7. Optimized thermal insulation

Idle power in a vaccum furnace at 950° C and 0,05 $mbar_{abs}$ Nitrogen





Increased energy efficiency with optimized insulation

	Standard	Optimized	Comment
Insulation	40mm Hardfelt-Graphite + 40mm Ceramic fibre	20mm Hardfelt-Graphite + 100mm Ceramic fibre	
Idle power per TC	30,8 kW	19,2 kW	950°C, Vacuum
Energy consumption per a and TC	206.360 kWh/a	128.640 kWh/a	6.700 h p.a.
Saved energy per a and TC	-	77.720 kWh/a	
Saved energy cost per a and TC	-	18.652 TRL/a [5.652 €]	Electricity cost 0,24 TRL/kWh [0,07 €/kWh]
Cost saving for complete MT line with 8 TC	-	149.216 TRL/a [45.218 €]	ModulTherm-System with 8 BK
Estimate CO_2-Reduction per ModulTherm-System	-	509,8 t CO2/a	0,46* kgCO2/kWh *

8. Optimized fixtures for load charging

Comparison CFC- / cast steel fixturing

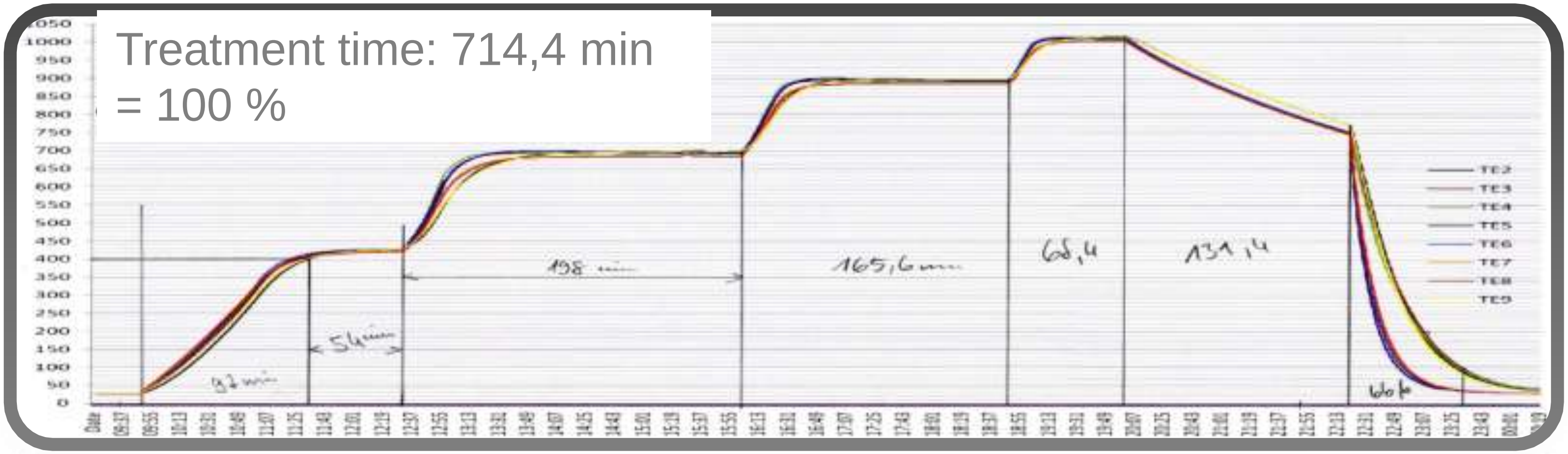
(Data for one fixture-tray)

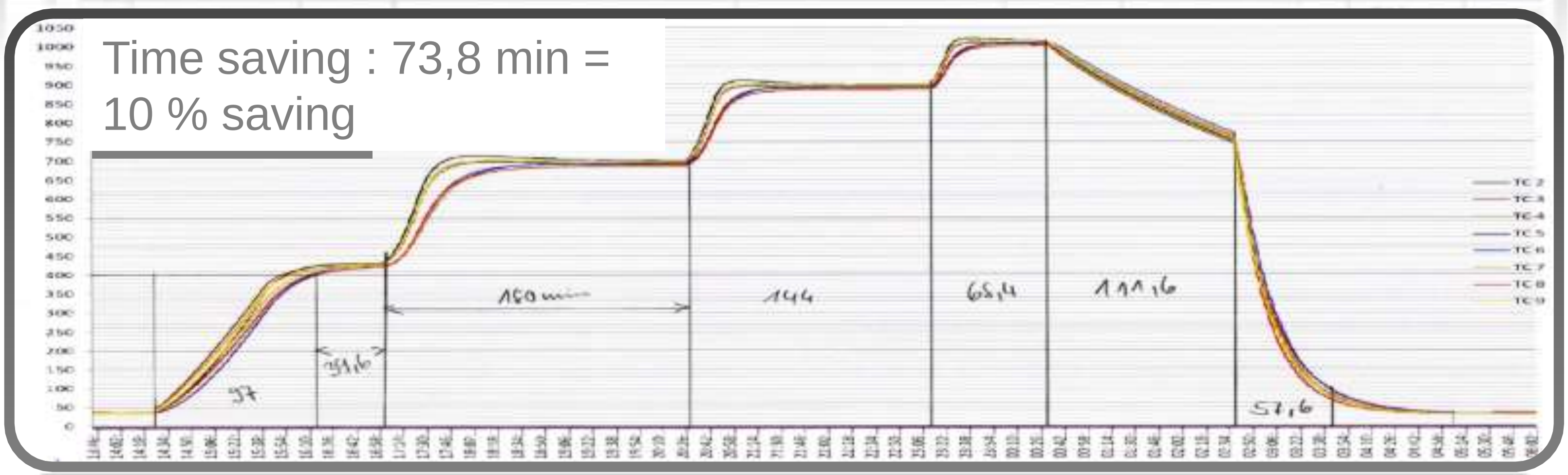
CFC (carbon reifnorced carbon)

Material	**CFC**	**Cast steel (1.4818)**
Weight of the tray	1 kg	12 kg
spec. heat capacity	1,8 kJ/kgK	0,7 kJ/kgK
Energy needed to heat up to 1000° C	**1.764 kJ (21%)**	**8.232 kJ (100%)**

Source: GTD Graphit Technologie GmbH

CFC fixture: reduced cycle time



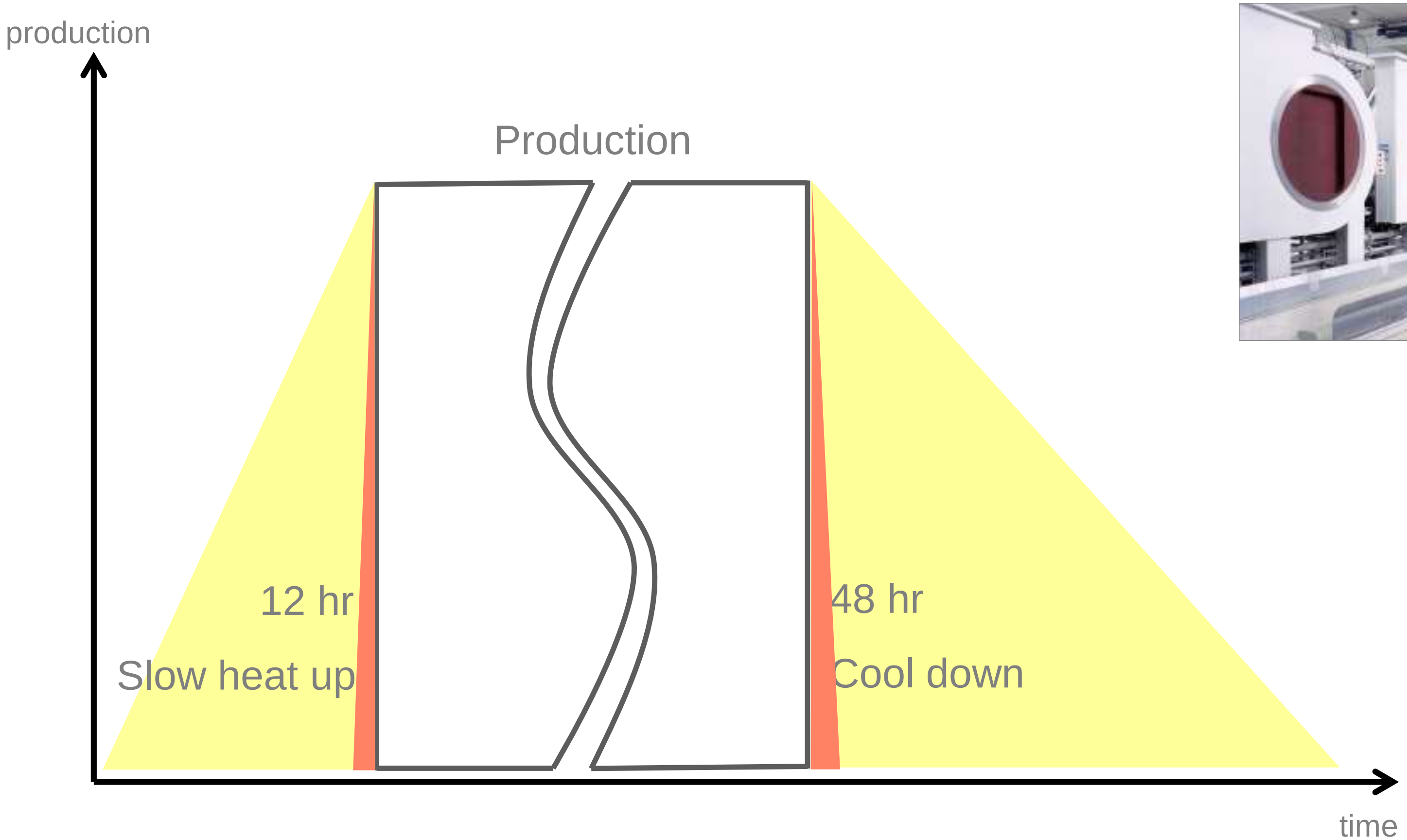


Source: Graphite Materials GmbH

9. Energy efficiency thru flexibility

Energy efficiency thru flexibility

Reaction on production demands



ModulTherm: Heat up 1 hr – cool down 8 hr*

* Energy not required, TC is off

Summary

- Enhancing energy efficiency is of great importance
- LPC/vacuum furnace is energy efficiency process/heat treatment equipment
- Optimized thermal insulation and optimized fixtures to improve energy efficiency
- When production is only partly needed, ModulTherm react fast on changes
- Highest production flexibility with a Vacuum furnace – short reaction time on demands of production
- Energy efficiency is enhanced significantly by accelerated processes such as “High temperature – LPC”

Further advantages of LPC

Advantages in Process

- No surface- and intergranular oxidation
- Different CHD, different process at same time
- High case depth, surface- and core hardness uniformity

Advantages in Manufacturing

- H/T is part of the manufacturing
- Low logistic effort
- Control of distortion
- Less machine/straightening operations
- Separate building not necessary
- Extendable according ramp up curve
- Flexible in production
- High grade of automation → documentation, manpower
- Post washing/blasting not required
- Low maintenance efforts
- Maintenance during production
- LPC reduce the manufacturing cost (TCO)

Advantages in Environmental

- No Co2 generated at the H/T
- Waste disposal of quenching oil is not required
- Energy management system for automated start and shutdown of the plant

Thank you