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UTILIZATION OF A LATENT HEAT STORAGE FOR WASTE HEAT RECOVERY FROM AN ALUMINUM DIE CASTING PROCESS

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CONTENT

- Aluminum foundry
- Waste heat utilization
- Latent thermal storage
- Preheating furnace
- Modelling
  - Charging
  - Discharging
- Simulation results
- Conclusion and outlook

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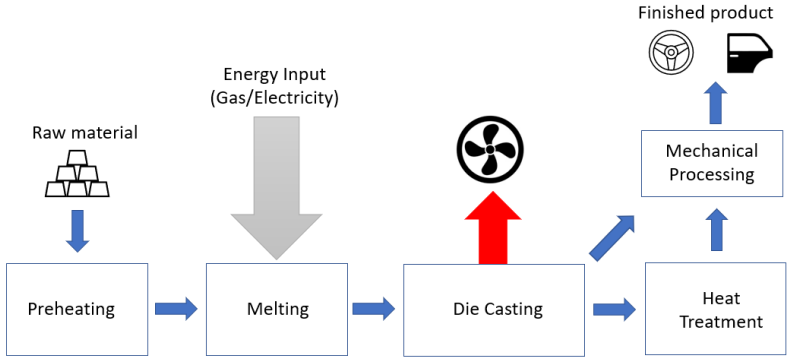
CONCEPT OF WASTE HEAT RECOVERY

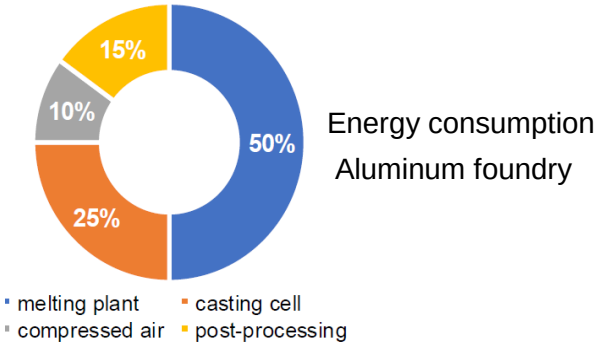
ALUMINUM FOUNDRY

- Most energy-intensive process is melting
- Focus on die-casting
- State of the art
  - Waste heat in die-casting re-cooled

Improvements:

- Reduction of heat losses
- Waste heat utilization – including PCM storage
- Optimized heat distribution system

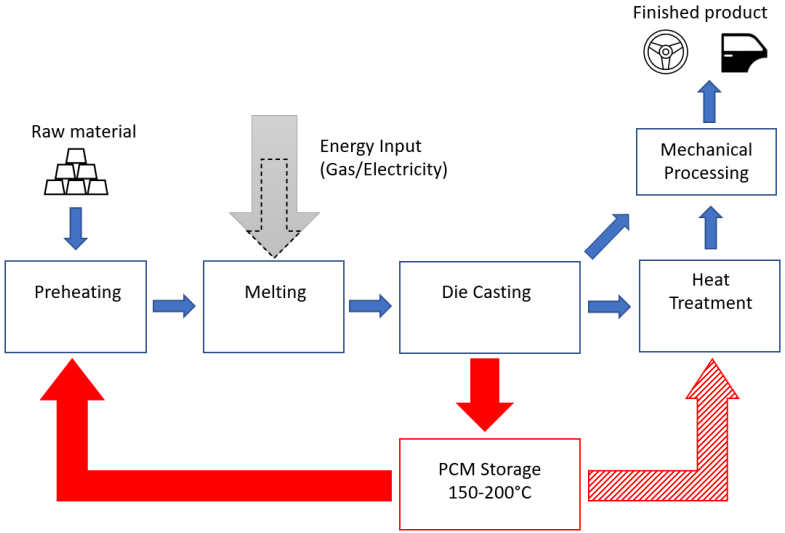




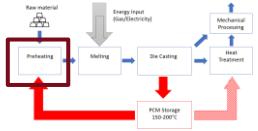
Energy consumption
Aluminum foundry

WASTE HEAT UTILIZATION FROM DIE CASTING

- Preheating is the only reasonable sink
- Heat treatment only as additional sink
- Missmatch waste heat supply and demand
  - In terms of time and quantity
  - Meaningful use of PCM storage



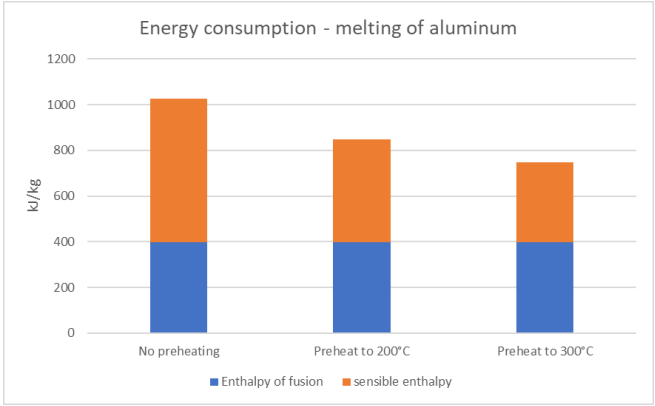
PREHEATING



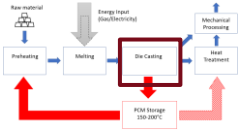
- Heating up ingots with waste heat before melting - increases efficiency
  - Directly with exhaust gas of melting furnace – Partly state of the art
  - With waste heat from die-casting – Not used in the industry so far

- Reduced energy consumption of melting furnace

- Preheating to 200° C → Potential reduction of energy consumption by roughly 17%



DIE CASTING



- Casting under high pressure
- Solidification and cooling of casting parts requires heat removal
  - Temperature control units
  - Cooling channels in casting tool

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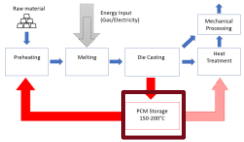
MODELLING

PCM STORAGE



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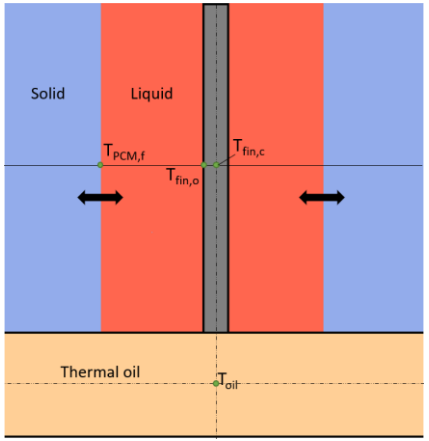
- Latent storages - Utilizes enthalpy of phase change
  - Higher storage densities
  - Isothermal phase change
- PCM – Organic salt
  - Phase Change Temperature approx. 165°C
- Fin-tube heat exchanger
- Heat transfer fluid – Thermal oil (MarlothermSH)

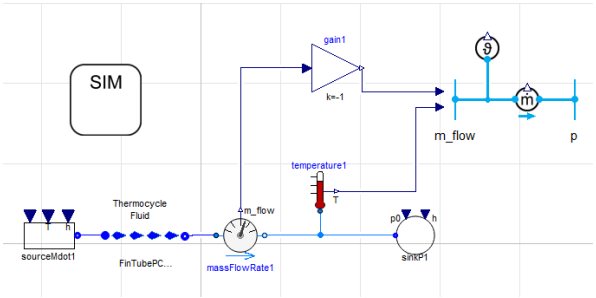
MODELLING PCM STORAGE

- Moving phase change boundary
- Nusselt correlation for heat transfer between tube and fluid
- Validated and more details in [1]



<u>Charging PCM with waste heat:</u>

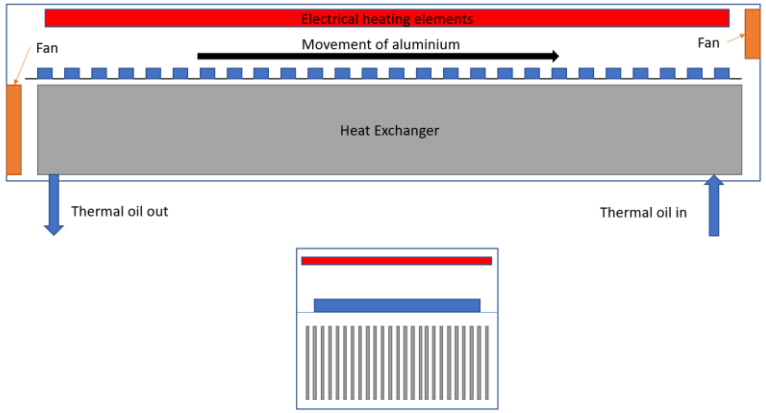
- SoA constant mass flow → Investigated
- WHR System developed within project “enviotcast”



Source [1]: Experimental characterization and simulation of a fin-tube latent heat storage using high density polyethylene as PCM, 2016, Applied Energy

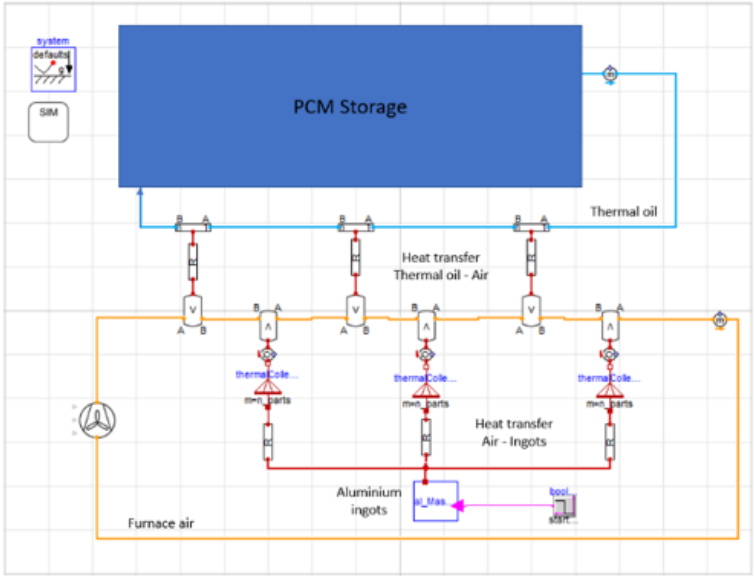
PREHEATING FURNACE

- Continuous furnace
- Air-thermal oil HX to heat up furnace air
- Ingots heated up with furnace air – ensure sufficient heat transfer
- Optionally electric heating elements (use surplus renewable electricity)



DYMOLA MODEL STORED HEAT UTILIZATION

- Utilization of stored heat for preheating
- PCM Model with closed thermal oil circuit
- Continuous heating of ingots – closed air circuit
- Heat transfers modeled with heat resistances



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SIMULATION OF FIRST USE CASE

DESCRIPTION AND SIMULATION OF USE CASE

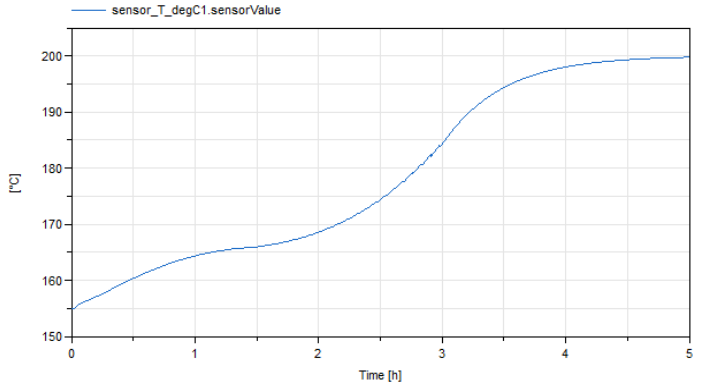
- Use case – Casting of current series production at LKR Ranshofen
  - Battery casing with given cooling channels

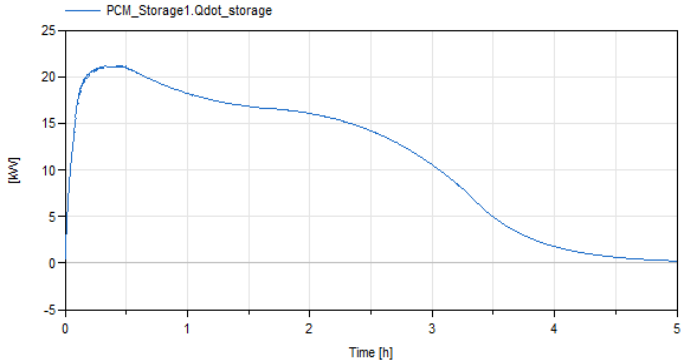
- Task:
  - Designed a furnace for this use case
  - Integrate PCM storage (EDCSproof)
  - With thermal oil as heat transfer medium

- With the investigated casting tool, temperatures up to 200 °C are achievable

RESULTS CHARGING

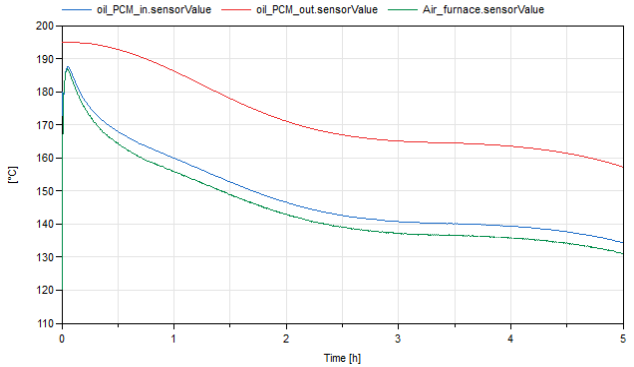
- Storage capacity approx. 55 kWh
- Full charging within 5 hours possible
- Start temperature 155°C
- Successfully charged storage up to 200°C

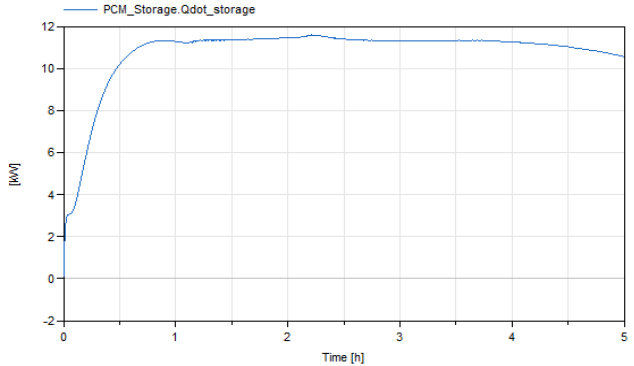




RESULTS – UTILIZATION OF STORED HEAT

- Discharging 55 kWh in 5 hours
- Storage successfully discharged to roughly 155°C
- Sufficient power to preheat ingots
- Outlet temperatures of the thermal oil sufficiently high to heat up furnace air



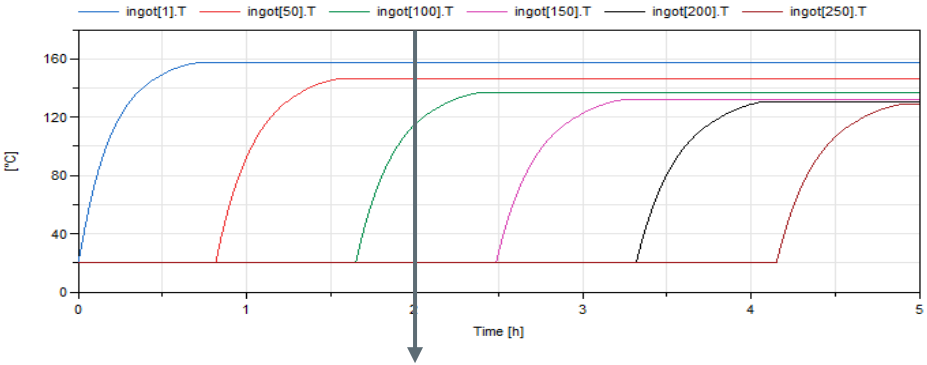


RESULTS – PREHEATING INGOTS

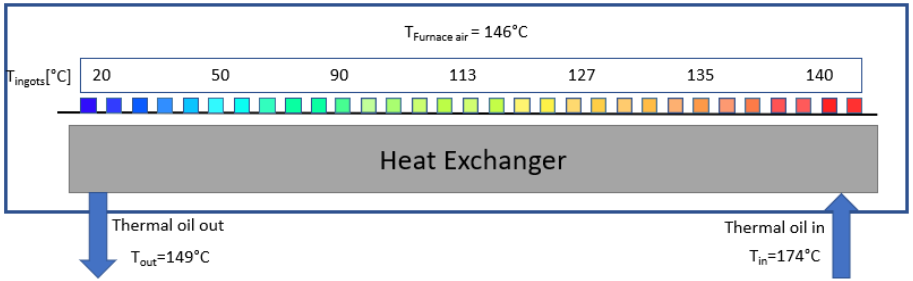
We designed a furnace with following parameters:

- Furnace length = 9 m
- Mass flow ingots = 7,5 kg/min
- Conveying velocity = 0,2 m/min

- 250 ingots have been successfully preheated to 130-160°C within the dwell time



Furnace temperatures after 2 hours



RESULT – ENERGY SAVINGS

- First proof of concept achieves 12% energy savings

<u>Savings for a typical aluminum die casting foundry:– Crosscheck</u>

- Assumptions: 30 GWh per year melting furnace, gas price 100€/MWh, CO2 price 80 €/t
- Reducing CO_2 Emissions from 5900 to 5200 tons per year
- Reduction of costs by more than 400 k€/a

OUTLOOK & CONCLUSION

- PCM storage can be integrated for preheating
- Preheating to elevated temperatures of 300°C – Advanced cooling concept
- Storage design adaption – Interconnection of larger storage modules
- By combining these measures energy savings up to 30% might be realized
- Investigated in the NEFI project envIoTcast (FFG, No. 880767)
  - Build at LKR Ranshofen to proof concept

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THANK YOU!

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