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Ministerium für Wirtschaft, Energie,
Bauen, Wohnen und Verkehr
des Landes Nordrhein-Westfalen

Automotive+Produktion.NRW

Gesucht: Die besten Ideen für die Zukunftsfelder der Automobil- und Produktionstechnik

3. Wettbewerbsaufruf

Formalia zur Teilnahme am Wettbewerb

Dr. Gisela Kiratli, Projektträger Jülich

Ziel2.NRW
Regionale Wettbewerbsfähigkeit und Beschäftigung

www.ziel2.nrw.de
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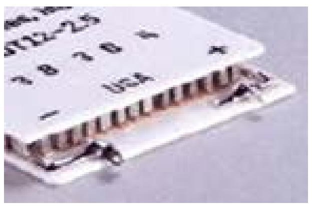
Development of an energy transducer for the energy recovery by thermoelectric generators from metal forming processes



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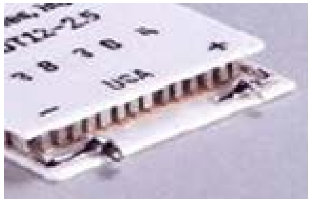
University of applied Science Düsseldorf, Germany

R. Herbertz,
Fachhochschule Südwestfalen University of Applied Sciences , Iserlohn, Germany

F. Pingel,
SEISSENSCHMIDTAG Precision Components, Plettenberg, Germany

Example: forging process



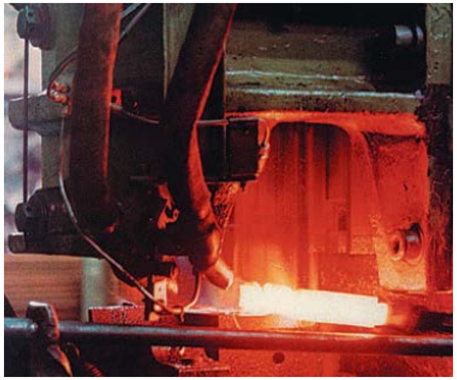
Forging temperature of steel:

1200° C

Heating needs about 500000 kJ/t

That corresponds to about 0.5 MWh/t

20% of the heat is lost radiative after the process within the first minute of cooling



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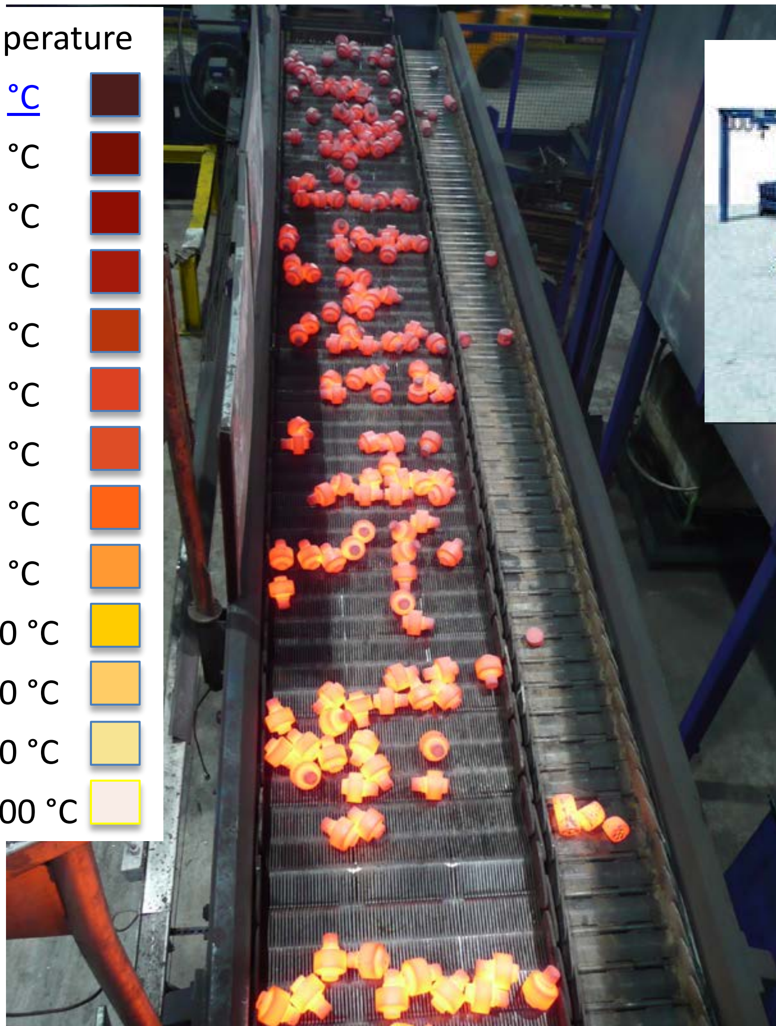
Forging process

temperature

550 °C
630 °C
680 °C
740 °C
780 °C
810 °C
850 °C
900 °C
950 °C
1000 °C
1100 °C
1200 °C
>1300 °C



process data

a) Material cart and bar magazine
b) Induction-heating facility
c) Forging unit
d) Unloading/cooling belt

Forging process

temperature
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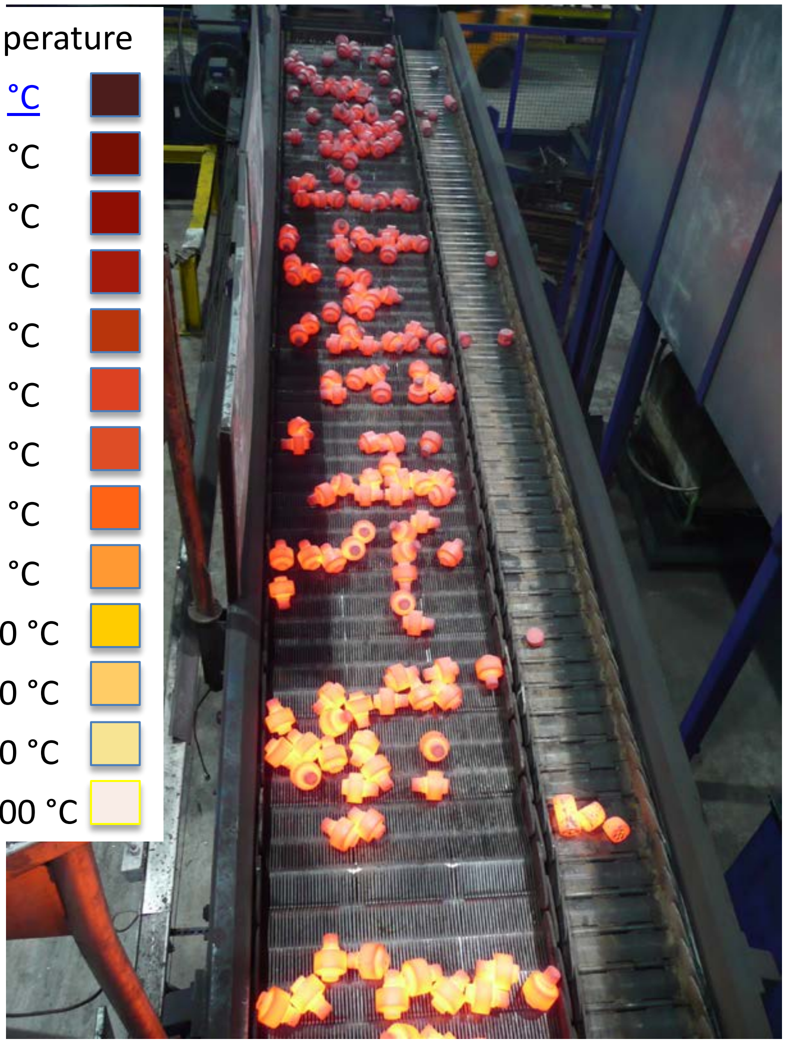

process data

- About 200 parts of 3kg at a time on the belt
- Cooling from 1200°C to 800°C
- Heat loss of about:

  $E_{loss} = C_{steel} * m * \Delta T$

  0,477kJ/(kg K)*600kg*400K

  = 114480 kJ

- 90% radiative heat loss
  5m² area, cooling time 60s
  results in
  400kW/m² radiation heat

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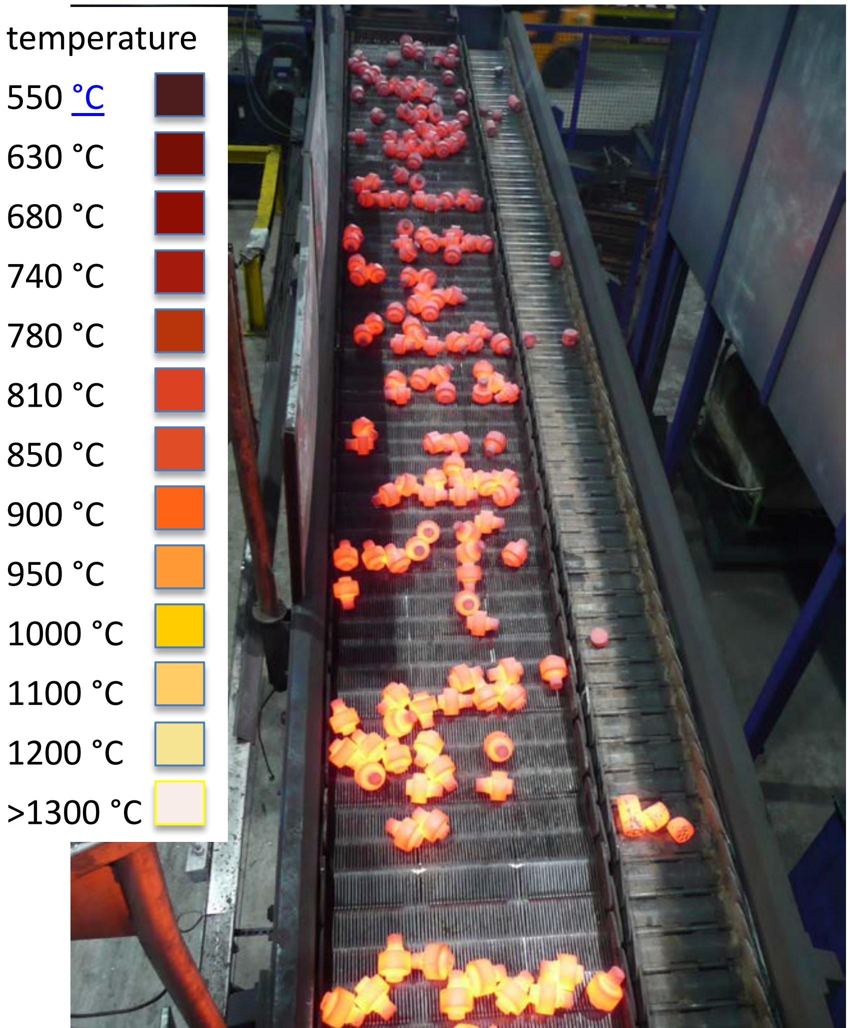
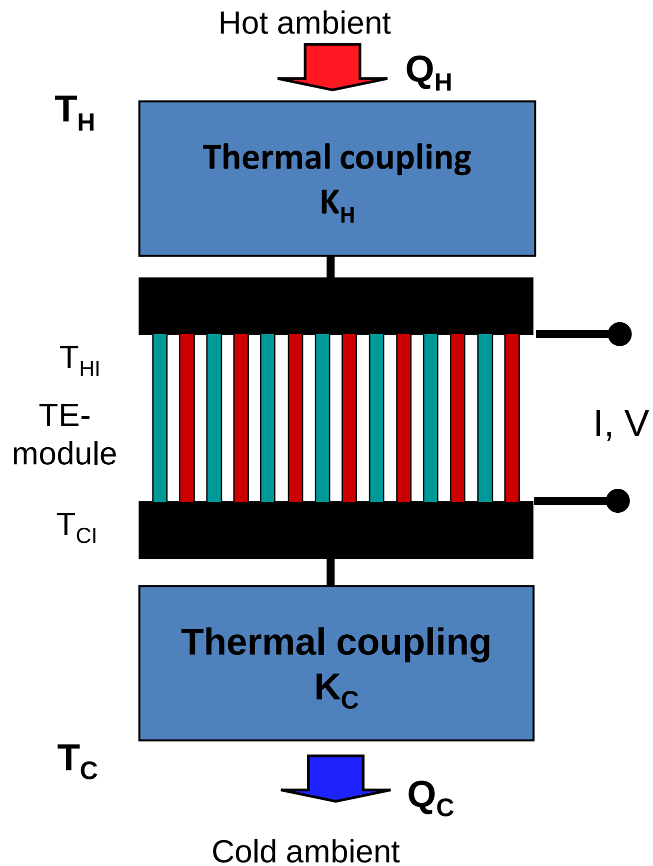
Forging process



Coupling TEG



P_{therm}= 100 kw
$P_{electr.}$= 4 kw

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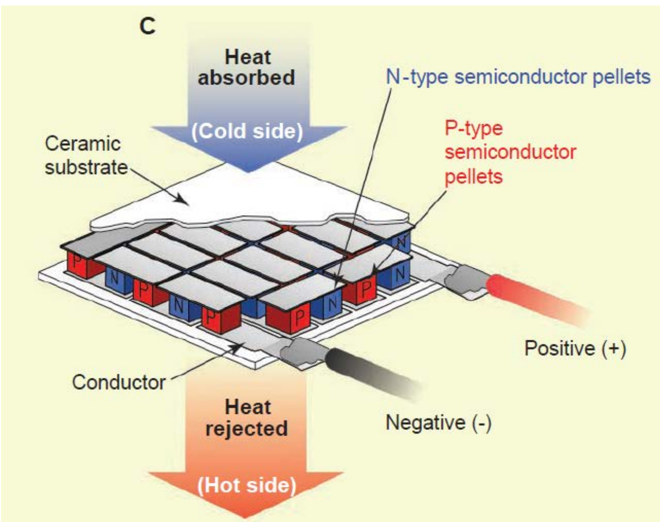
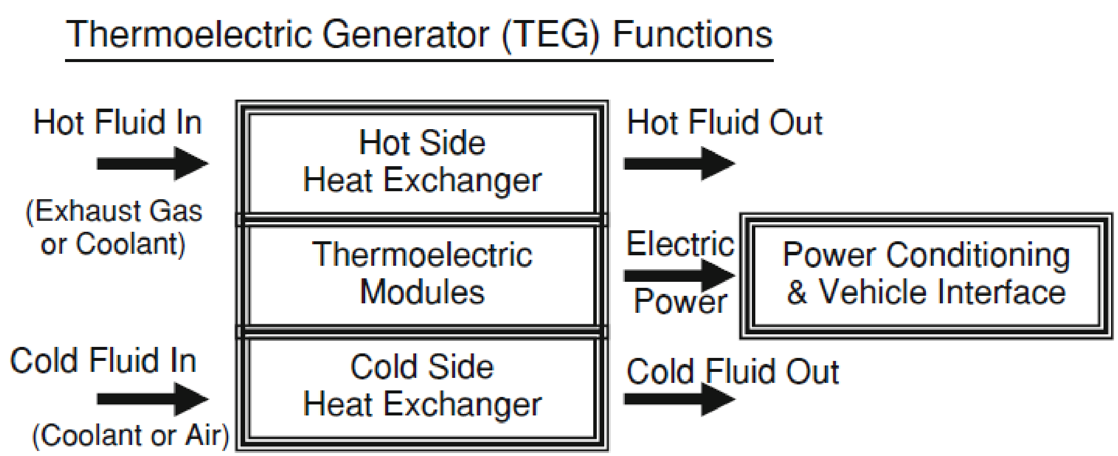
The task: system integration



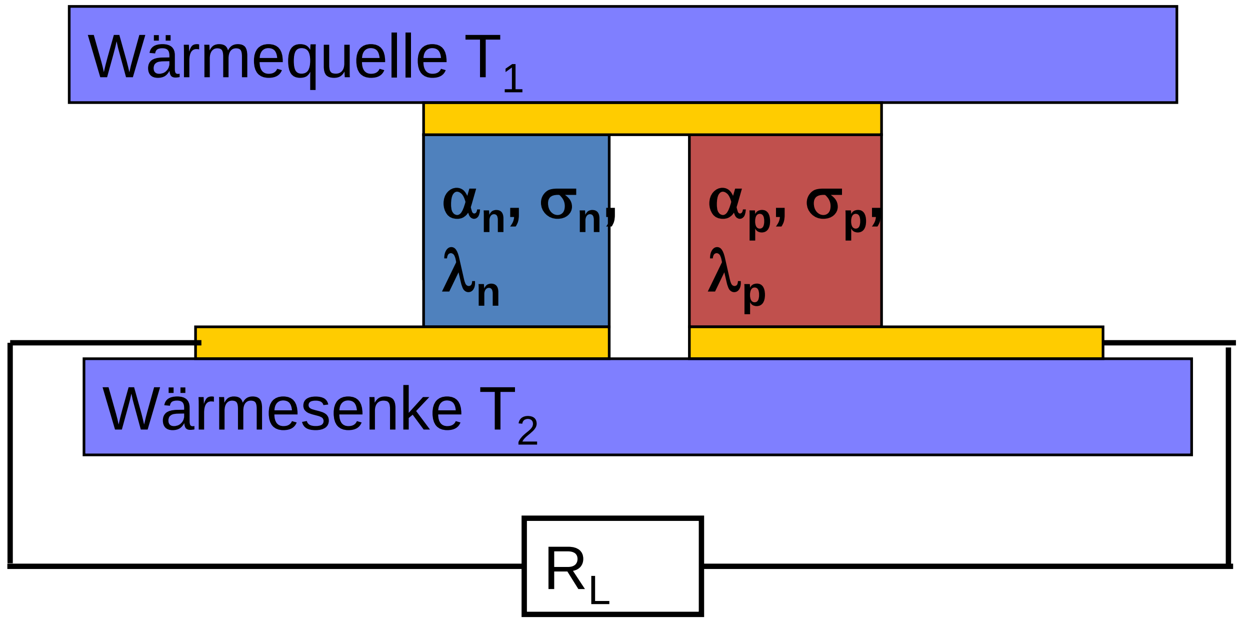


Thermoelektrische Kenngrößen

p- und n-Typ Material

-> elektrisch in Reihe

-> thermisch parallel



Seebeck-Koeffizienten

α_n und α_p

$U_0 = \alpha^* (T_H - T_K)$

Spezifische Leitfähigkeit

σ_n und σ_p

Thermische Leitfähigkeit

λ_n und λ_p

Peltier-Koeffizient

$J_Q = \Pi^* I$

Kelvin Gleichung

$\alpha = \Pi / T$

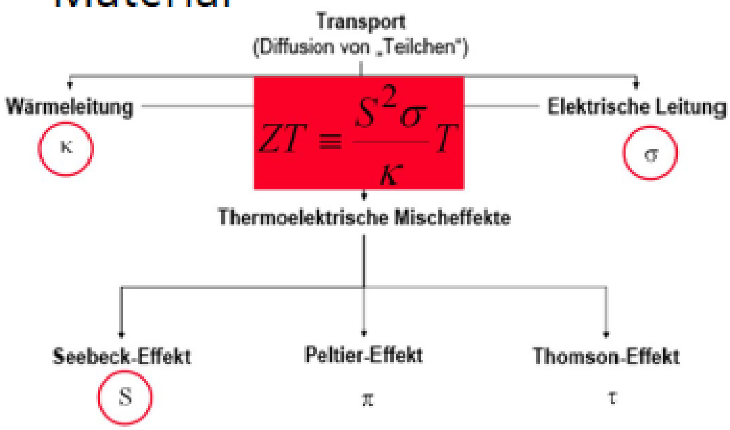
Güteziffer

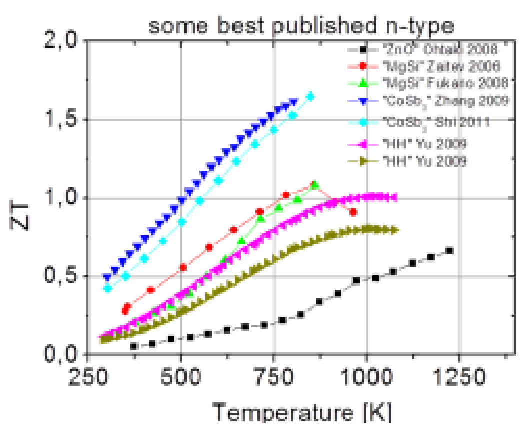
$$ZT = \frac{\alpha^2 \sigma}{\lambda} T$$

Messungen an Modulen

Thermoelectric standardisation

Material

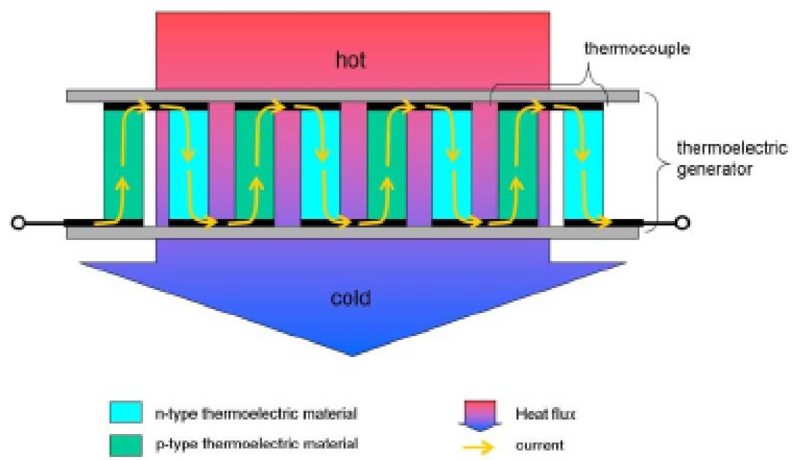




TEG

$$\eta_{TEG} \equiv \frac{P_{el}}{Q_H} = \frac{(T_H - T_C)}{T_H} \cdot \frac{\sqrt{1 + Z_{TEG}\frac{T_H + T_C}{2}} - 1}{\sqrt{1 + Z_{TEG}\frac{T_H + T_C}{2}} + \frac{T_C}{T_H}}$$

$$Z_{TEG} = \frac{(\alpha_n + \alpha_p)^2}{K \cdot R_i}$$



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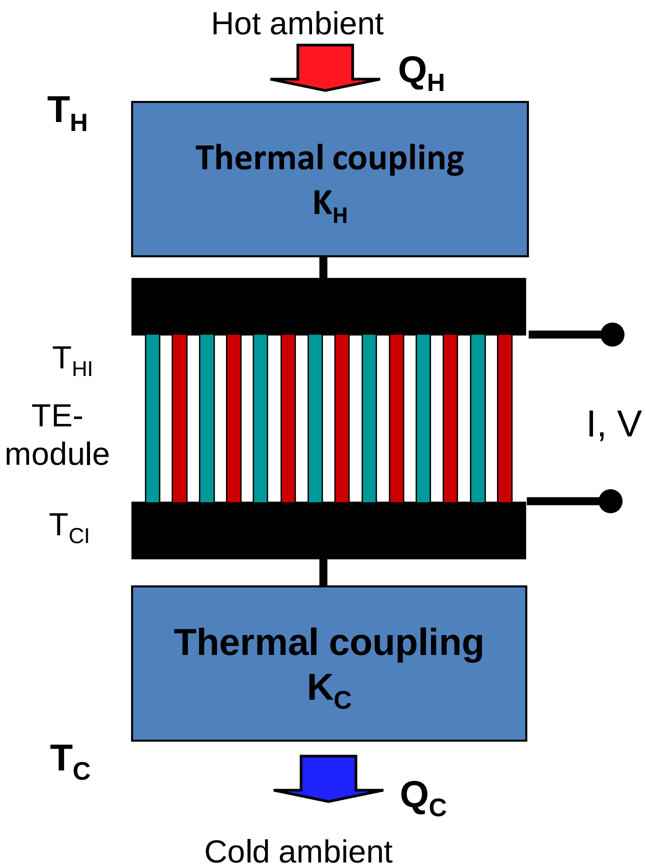
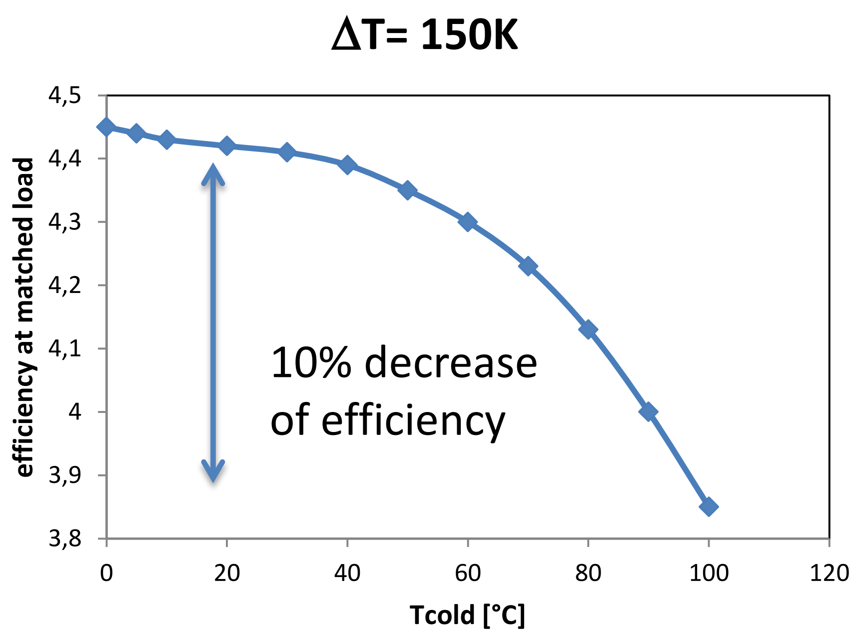
Coupling TEG – cold side

Cold side coupling with liquid

But cold side very sensitive to heat transfer as well

Drifting temperature at cold side





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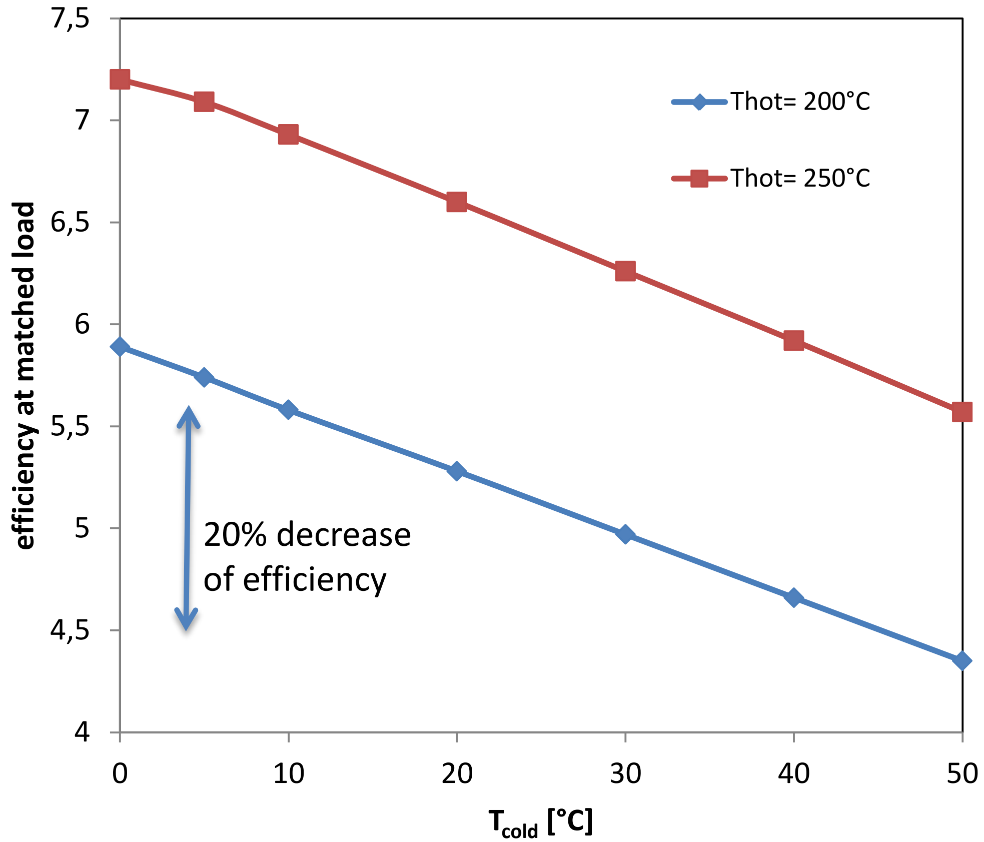
Dependence of the efficiency of a module on T_{cold}



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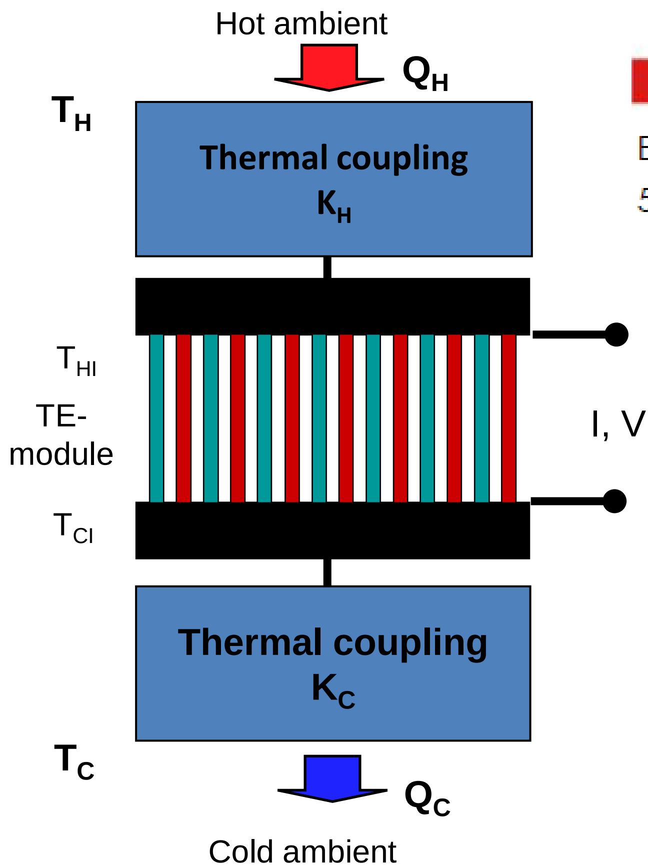
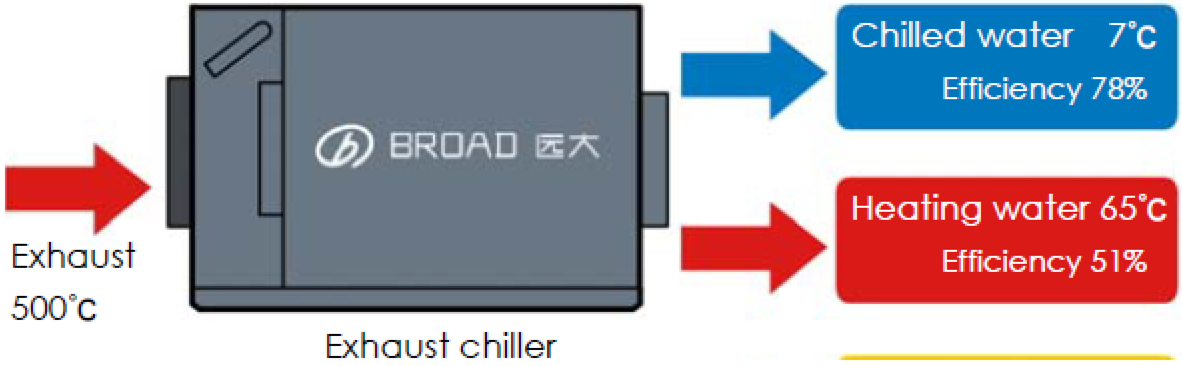
Option heat to cool





150 kW heat → 100 kW cooling @7°C

$P_{electr.}$ < 200W

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Forging process summary

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1200 °C
>1300 °C

100 kW radiative heat absorbed

Cooling by „heat to cool" 100 kW stabilizes cold side temperature, electrical consumption below 200W

- >4% efficiency expected

  → 4 $kW_{electr.}$

Perspective for other processes with waste heat temperature up to 200°C

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Project Partners

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D. Ebling: lab for thermoelectricity

M. Adam: E² - lab for renewable energy and energy efficiency, heat management

D. Arlt: lab for electric supply network feed in

A. Benim: Modelling

Fachhochschule Südwestfalen
University of Applied Sciences

R. Herbertz: Lab for massive forming processes, phase change materials

HBS
SEISSENSCHMIDT
Precision Components

F. Pingel: forging company, system adoption