INCREASE IN PRODUCTIVITY AND IN CONSEQUENCE COST REDUCTION BY MEANS OF EFFICIENT TEMPERING (HEATING/COOLING)

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1. Significance of tempering (heating / cooling) of dies (die casting and injection moulding)
2. Temperature transfer media
3. Preconditions for an efficient tempering
4. Effective heating/cooling equipment
5. Correctly designed tempering channels in dies
6. Free and clean tempering channels

1. Significance of tempering (heating / cooling) of dies (die casting and injection moulding)

Responsible for:
+ Loss in heat from the cast
+ Filling of die
+ Solidification
+ Life time of dies

* Major primary malfunction source:
  A die temperature suboptimal for casting technology

  * Faults caused by too low die temperature:
    - Poor demoulding properties (increased shrinkage forces)
    - Bad lubrication impact of the spraying agent
    - Cold lap (material overlap)
    - Wear of die (major thermal shocks)
    - Cold flow (pre-solidification)
    - Incomplete die filling

    Consequence: higher scrap rate → lower productivity

  * Faults caused by too high die temperature:
    - Extension of cycle time
    - Temporary welding of cast material
    - High consumption of spraying agent
    - Increased formation of pores caused by overuse of spraying agent
    - Increased shrinkage holes

    Consequence: longer cycle time, lower product quality → lower productivity

Advantages achievable by a tempering process:

+ Increased life time of die	Extension of tool life No tension crack No danger to overheat cores
+ Lower production costs	Shorter heating periods Less die repairs Less use of spraying agent
+ High product quality	High dimensional accuracy Clean surface Reproducible quality Thin-walled components High process stability

Tempering means:

+ HIGH PRODUCT QUALITY

+ LOWER COST OF PRODUCTION

+ HIGH PROCESS STABILITY

→ HIGH PRODUCTIVITY

2. Temperature transfer media:

Thermal fluid: Oil

Thermal fluid: Water

Oil:

- For components with thin wall thickness
- When high temperatures are required
- If the criterion of complete die filling is given

Water:

- For components with thick wall thickness
- When quick removal of energy is required
- Cycle time reduction up to 10% is achievable

3. Preconditions for an efficient tempering:

- Effective tempering equipment
  1. based on oil as thermal fluid
  2. based on water as thermal fluid
- Tempering channels sized and positioned correctly in the die
- Clean tempering channels

4. Effective heating/cooling equipment:

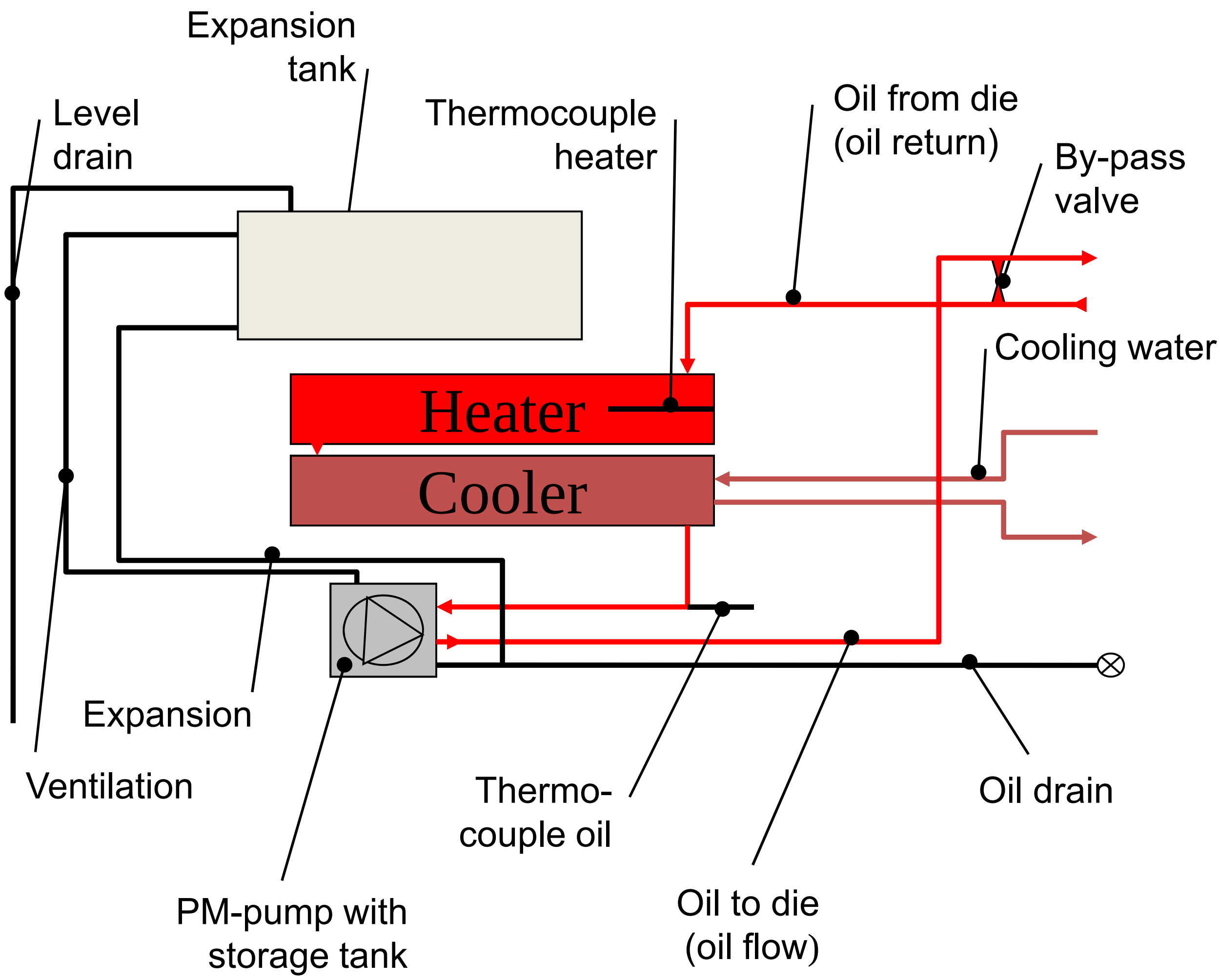
*** <u>based on oil</u> as thermal fluid**

Single circuit unit

Double circuit unit

Maximum temperature	Heating capacity KW	Cooling capacity KW	Pump flow rate liter/minute	Pump pressure bar	Model
250°C (482°F)	10 / 20	20 / 40 / 60	60	6	3201 / 3212
320°C (608°F)	10 / 20	20 / 40 / 60	60	6	4201 / 4212
350°C (662°F)	10 / 20 / 30	20 / 40 / 60	80	11	5201 / 5212
350°C (662°F)	40	40	80	11	5222

Scheme of oil unit



4. Effective heating/cooling equipment:

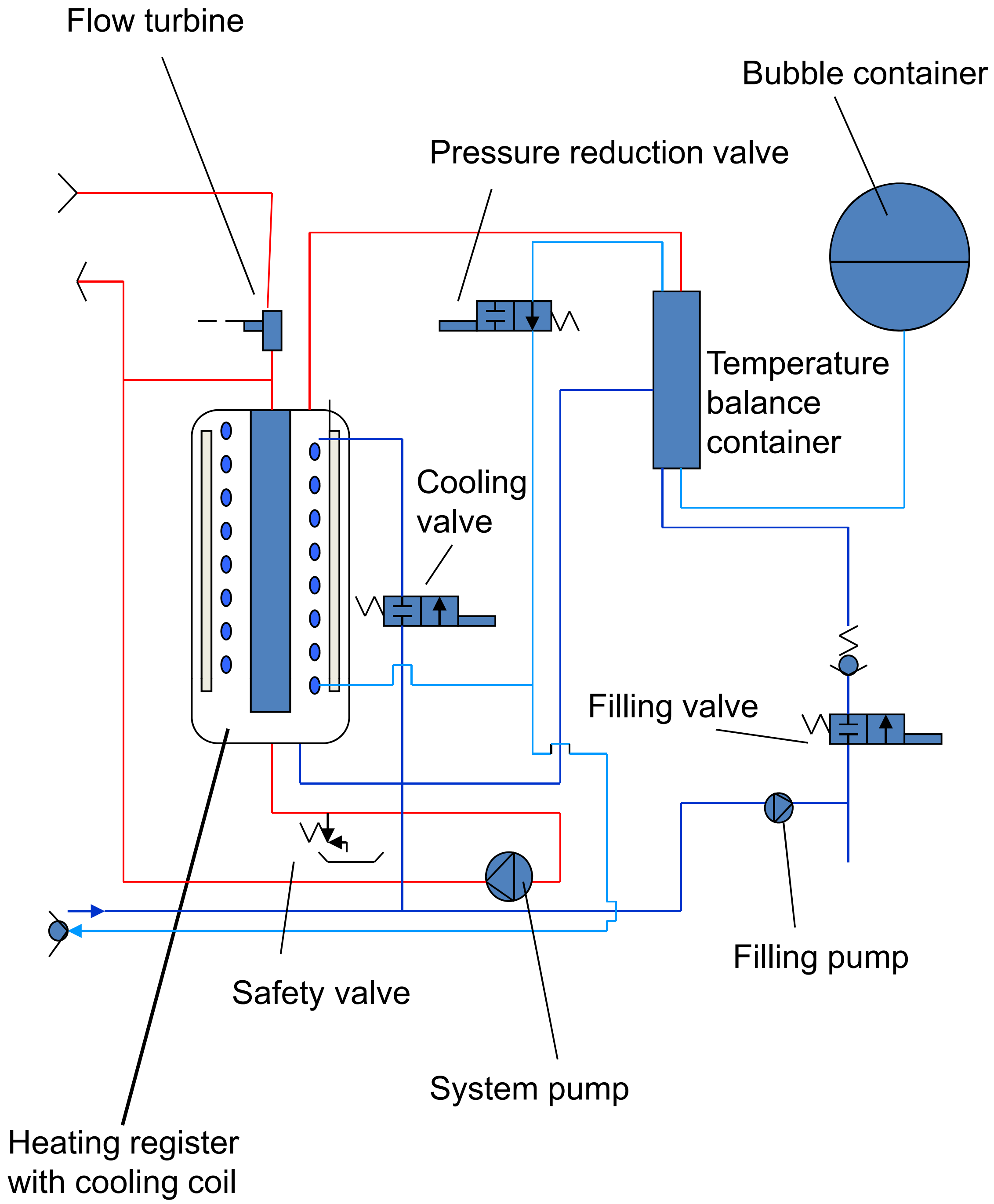
*** based on water as thermal fluid**

Double and single circuit unit

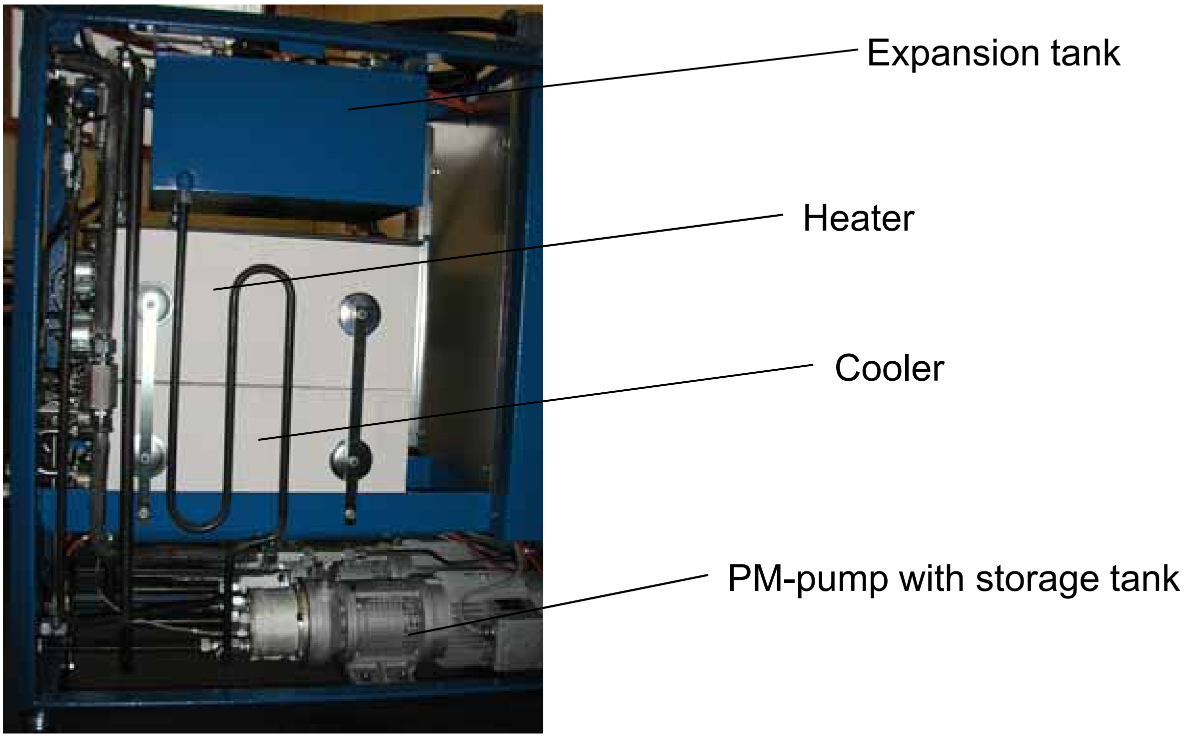
Double circuit unit

Maximum temperature	Heating capacity KW	Cooling capacity KW	Pump flow rate liter/minute	Pump pressure bar	Model
140°C (282°F)	6 / 12	35	45	6	2201 / 2212
160°C (322°F)	6 / 12	35	60	7.5	2201 / 2212
160°C (322°F)	12 / 18	35	80	11	2212

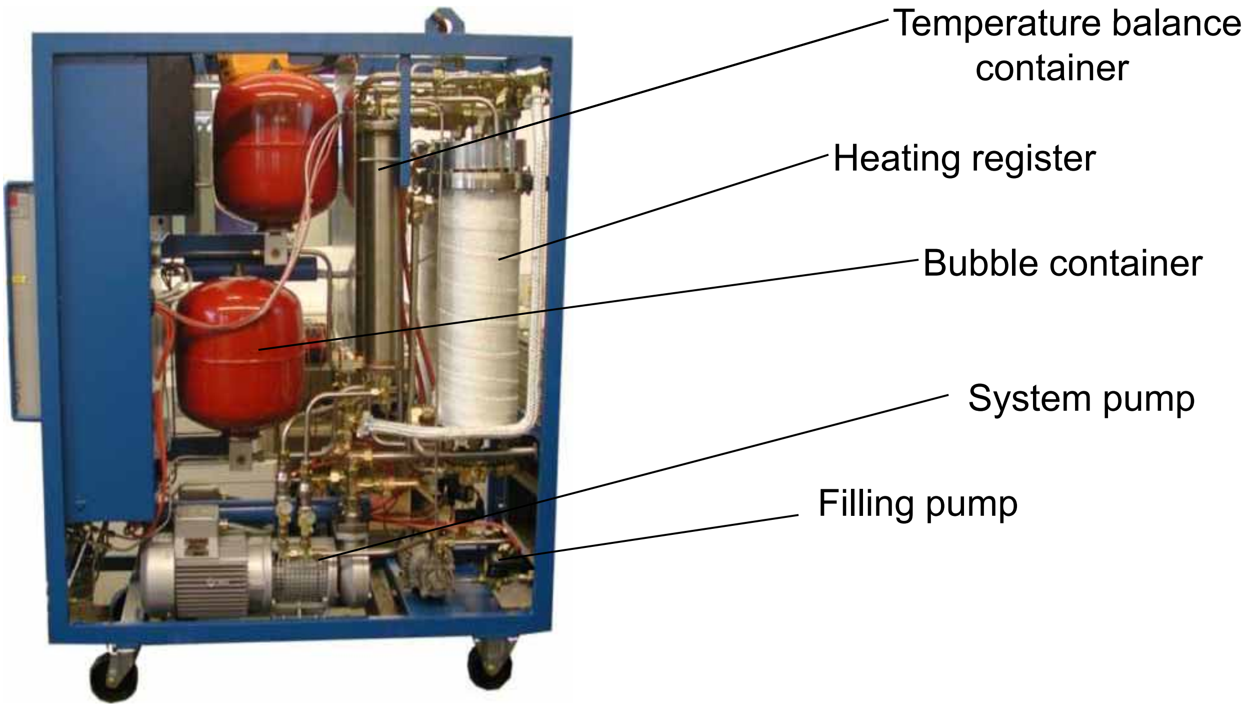
Scheme of water unit



Picture (interior view) of oil unit



Picture (interior view) of water unit



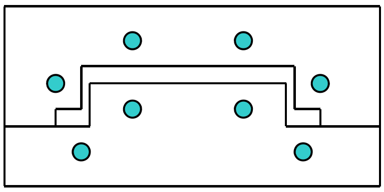
5. Correctly designed tempering channels in dies

Positioning of tempering channels in the die

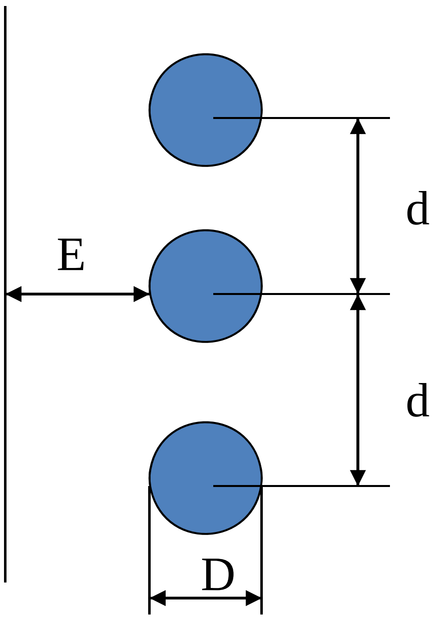
Basic rules for tempering channels:

- Basically it is true: The more channels the better
- Shielding of the area of die cavity by means of tempering channels.

O.K.



Distance of tempering channels:



Tempering channel distances:
E >1.5D
d approximately 3D to 5D depending on distance E

If the distance E is too small as well as with too large distance d an unsteady temperature distribution at the die contour will occur.

Oil: E >20mm, the film temperature of the oil must not be exceeded.
Guideline: D=12to13, E=22to32mm

Water: E>25mm otherwise too high gradient of temperature with the result, that thermal tension as well as boiling of water are possible.
Guideline: D=9to10, E=25to32mm

Calculation of required exchange area as well as required length of channel on the die:

$Q = \alpha \times A \times \Delta T$ (Heat flow of convection)

α = Heat transmission coefficient **oil** f (T, D)
= 1,6KW / m² K at 160°C oil temperature (Mobiltherm 605)

α = Heat transmission coefficient **water**
= 3,2KW / m² K

$\Delta T = 40K = (T_{oil} - T_{wall\ of\ channel})$

Oil	**Water**
$A = \dfrac{Q}{\alpha_{oil} \times \Delta T}$	$\dfrac{Q}{\alpha_{water} \times \Delta T}$
$A = \dfrac{21{,}33KW}{1{,}6KW/m^2K \times 40K}$	$\dfrac{21{,}33KW}{3{,}2KW/m^2K \times 40K}$
$A = 0{,}333m^2$	$0{,}166m^2$

Length of channel:

$A = D \times \pi \times L$ D = 13mm (Diameter of channel)

Oil	**Water**
$L = \dfrac{A}{D \times \pi}$	$\dfrac{A}{D \times \pi}$
$L = \dfrac{0{,}333m^2}{0{,}013m \times \pi}$	$\dfrac{0{,}166m^2}{0{,}013m \times \pi}$
$L = 8{,}15m$	$4{,}08m$

6. Free and clean tempering channels:

Any pollution of the tempering channels influences the temperature transfer in the die by
* reduction of flow
* creation of insulation layers. A layer of 1 mm causes a reduction of the temperature transfer of 30%.

The unit has been developed to
+ clean and decalcify the die tempering channels with hot water and admixture
+ check the tempering channels for leakage with hot water
+ to inspect the flow by means of a digital flow meter
+ blow completely dry the tempering channels

SUMMARY:
The tempering process has an essential influence on the productivity of the die casting as well as injection moulding process.