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Gases for Life

It doesen`t work without cooling (any more)!

Cement cooling - the new method for efficient concrete cooling

In a nutshell: The Messer profile

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The company
Messer is the world's largest family-run industrial gases specialist.

The products
Messer produces and supplies oxygen, nitrogen, argon, carbon dioxide, hydrogen, helium, shielding gases for welding, specialty gases, medical gases, food gases and many different gas mixtures.

The customers
Almost all industrial sectors, healthcare, research and science benefit from the products and application technologies.omers

Is cooling of fresh concrete necessary in summer?

Clear answer: If the weather plays along - NO!

For the production and processing of materials with constant quality,
the control of the temperature is indispensable!

Examples are:	Chemical industry	=>	pharmaceuticals, paints and varnishes,...
	Ceramic and glass industry	=>	porcelain production, technical ceramics, glass...
	Steel and metal industry	=>	steel production, steel hardening, alloy production,...
	Plastics industry	=>	production and processing of thermoplastics, thermosets...

In the production and processing of concrete, it should also be possible to control the temperature!
temperature should be controlled!

Calculation of fresh concrete temperature

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*Heat capacity of concrete: (Q=m*c*T)*

$C_{bo} = m_z * c_z + m_g * c_g + m_w * c_w$ [kJ/K]

z : Cement content [kg/m^3]
g : Aggregate content [kg/m^3]
w : Water content [kg/m^3]
c_z = 1,0 kJ/kgK: Heat capacity of Cemnet
c_g = 1,0 kJ/kgK: Heat capacity of Aggregats
c_w = 4,2 kJ/kgK: Heat capacity of Water
Tz : Temperatureof Cement [K]
Tg: Temperature of Aggregates [K]
Tw: Temperature of Water[K]

Temperature of the fresh concrete :

$$T_{bo} = \frac{m_z * c_z * T_z + m_g * c_g * T_g + m_w * c_w * T_w}{C_{bo}}$$

Temperature change of the fresh concrete :

$$\Delta T_{bO} = \frac{\Delta Q}{C_{bO}}$$

$DQ = m_{Ice} * (336 kJ/kg + c_w * T_w)$

What causes heat in concrete?

Heat input through raw materials :

- Water — on average 12-15°C in summer
- Aggregats — in normal case ambient temperature
- other Aggregates — in normal case ambient temperature
- Cement — higher then ambient temperature, up to 90°C

Heat input by chem. Reaction : (Activation energy and course of reaction)

Heat of hydration of different cements with complete hydration, determined with the Heat of solution method

Typ of Cement		Heat of hydration J/g
Portlandcement	CEM I	375 ... 525
Portlandpuzzolancement	CEM II/A-P	315 ... 420
Portland oil shale cement	CEM II/A-T	360 ... 480
Blast furnace slag cement	CEMIII/A	355 ... 440
Clay based cement		545 ... 585

Why is concrete cooling necessary?

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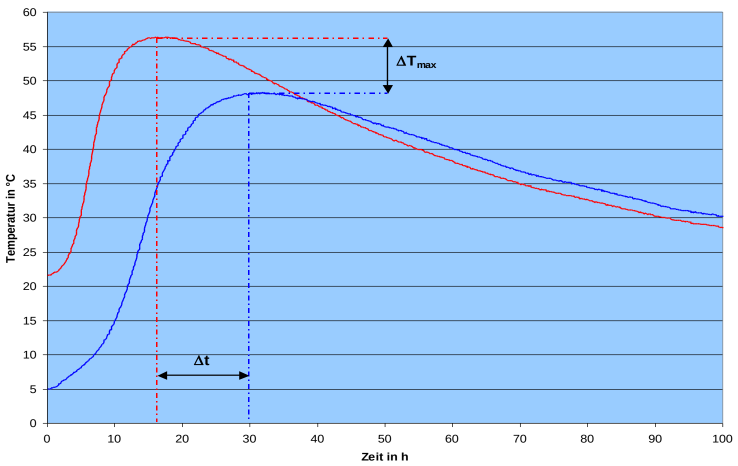
To avoid cracks!

caused by too fast hardening and temperature stresses of the concrete

To maintain the compressive strength

of the type of concrete used (above 55°C concrete core temperature changes the chemical processes)



Comparison of the heat of hydration of a cooled (blue) and an uncooled concrete (red)

Which processes are in use?

Lance cooling with liquide Nitrogen(LIN)

Cooling directly before installation, low investment costs

Concrete quality is affected

Aggregate cooling (gravel, grit), passive/active

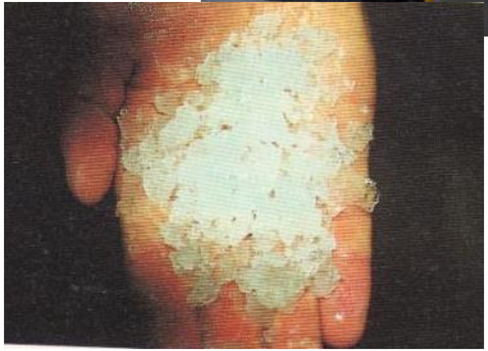
Shading and water sprinkling

Generation of cold air (4°C) or ice
by refrigeration plant (electric)

Addition of flake ice

Good heat transfer

Limited cooling capacity due to ice temperature (max. -7°C) and w/c ratio



Development of new cooling methods for LIN

Requirements:	high heat (cold) transfer in short time high "cold" capacity with fast transmission possibility high transfer area or long transfer time
Water	heat exchanger (brine (electric); cryogenic gases)
Aggregates: ***Sand***, ***gravel***, ***grit***	Sprinkling/flow through (cold water; cold gases (0-5°C))
Cement	cold gases
Forced mixer	Heat exchanger/direct cooling (brine, cryogenic gases)
Fresh concrete	Heat exchanger/direct cooling (brine, cryogenic gases)

Cement cooling ZK-I

Cooling of the cement to the ambient temperature => no energy losses

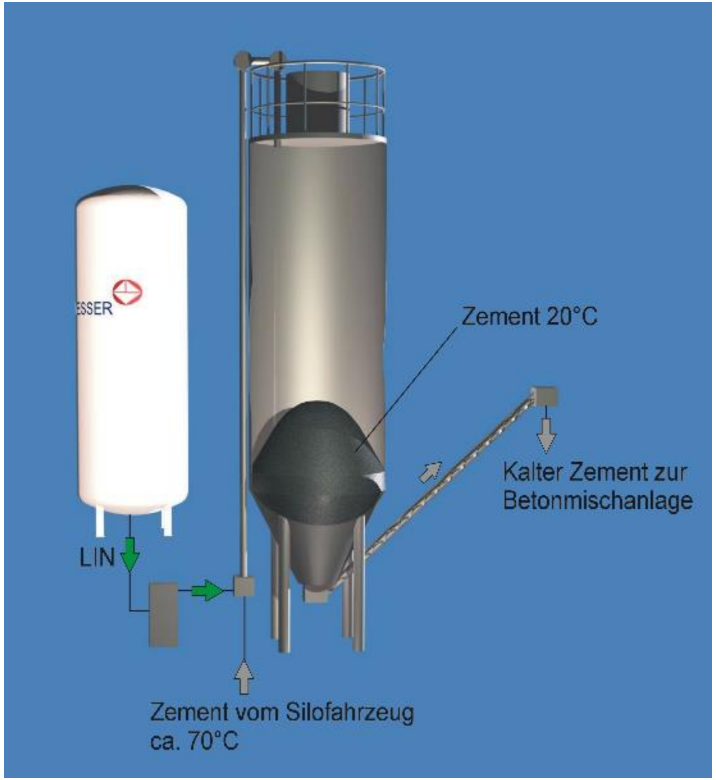
max. cooling of the cement to min. -20 °C possible => no condensation

Cooling before silo storage

all cement is cooled

10°C cooling in the cement results in a fresh concrete cooling of approx. 1°C

When the cement is cooled below ambient temperature => Risk of energy losses



Cement cooling ZK-I

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Cement cooling I, the "simple" technology

Target temperature of the cement after cooling: -10°C to 20°C

Which technology should be used?

Cement cooling MIX

Cooling down to -50°C

2 silos with identical cement

1 x "warm"; 1 x "cold

Mixing the two cements in the scale

Setting concrete temperature via mixing ratio

Energy Losses!!!!!!!!!!

➡ Silo paint stripping

Which technology should be used?

Investment and operating *costs* (low; ↓ medium; → very high ↑)

Technology	flake ice;	lance;	H2O ;	cement I ;	cement MIX
Invest-K	↑	↓	↓	↓	→
Operating K Losses	↘	↑	↓	↓	↘
Max. Cooling rate[K]	8-10	3-6	2-3	1-10	1-22

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Calculation „cooling "energy

Basics for technology selection:

- Amount of concrete to be cooled (absolute) over what period of time
- Maximum required cooling rate
- Amount of concrete to be cooled per hour

Technology selection:

Lance cooling is suitable for cooling the concrete by a few °Celsius with small and medium concrete quantities and a corresponding time window.

Water and aggregate cooling is suitable for small and medium concrete quantities for low hourly outputs and small time windows

Cement cooling I, MIX and II are suitable for small, medium and large concrete quantities, high outside temperatures and large hourly outputs.

The only process that allows the fresh concrete temperature to be set in a wide range.

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the new method for efficient concrete cooling

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Thank you very much for your attention