Seminar Series – 24 February 2025

NETCASTPL4.0
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NetCastPL4.0 Seminars Series – 24 February 2025

Today's seminar presentations are focused on **Green Molding technologies**, specifically inorganic foundry binders for sand molding processes

Presentations

- State-of-the-art and challenges in inorganic binder systems
- Potential of solid inorganic foundry binders

Questions can be added during presentations through the QA function

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Aalto University
School of Engineering

State-of-the-art and challenges in inorganic binder systems

Kalle Jalava

Background

Foundries are major players in metals industry

Negative environmental effects of foundries result from **thermal processes** and the use of **organic and mineral additives**

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Background

In the making of moulds and cores **various additives are used to bind sand**

In the binding of sand and pouring of metal, **reaction and decomposition products are generated**

Background

Inorganic binder systems can be an answer for the future needs for sustainable manufacturing of ferrous castings

...while certain technological challenges remain to be solved

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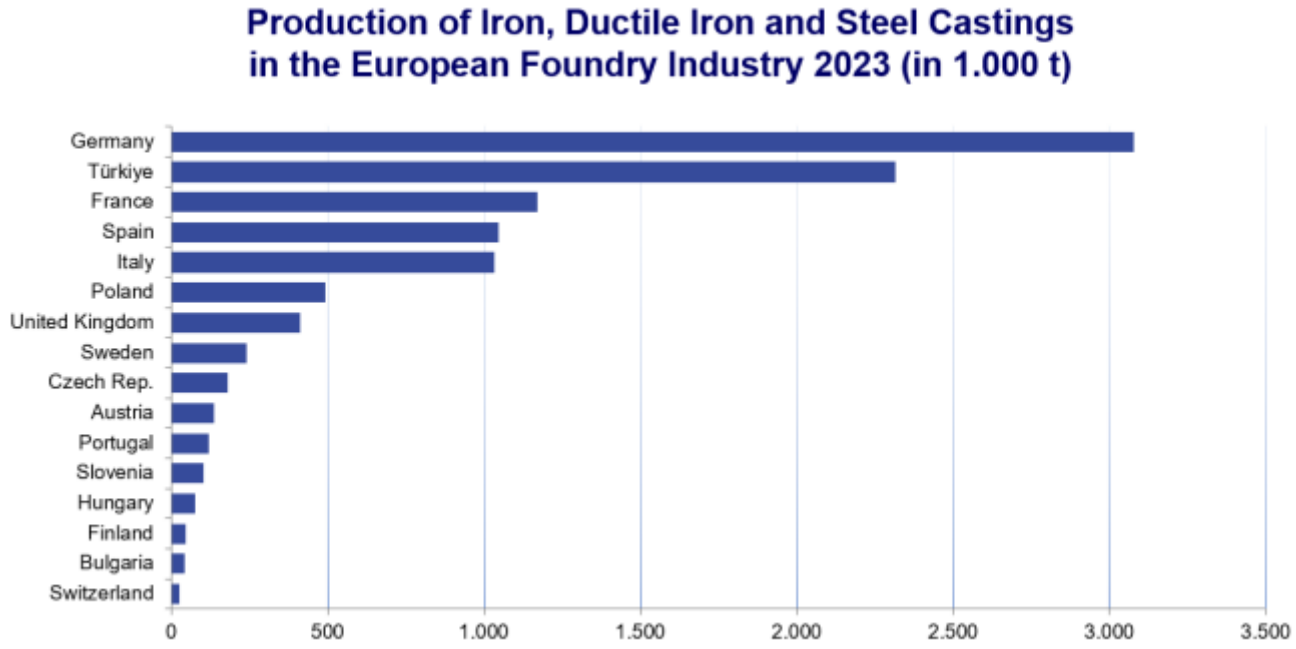

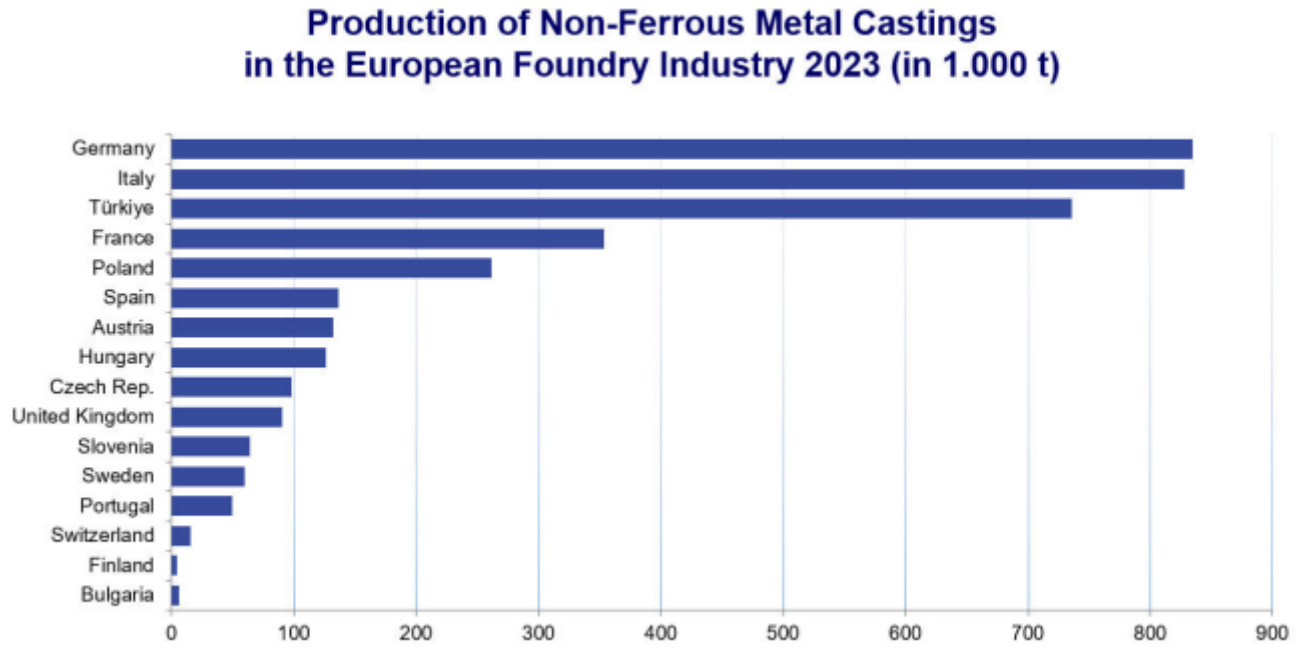

Foundry binders – to name a few

Organic

- Furan, phenolic, …

Inorganic

- Sodium silicates
- Geopolymers

Semi-inorganic

- Chemically cured silicates and geopolymers (aluminosilicates)

Why the need for change?

A lot of the used organic resin binder systems are classified as **harmful or hazardous**

Even though the application properties are **good, tried and tested**, it will be increasingly harder to comply with future regulations

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In foundries, hazardous substances and substances of very high concern which are used in moulding and core-making and which are listed in Regulation (EC) No 1272/2008 include, for example:

- *Furan*: Classified as carcinogen (Category 1B – H350: 'May cause cancer').
- *Phenol:* Classified as mutagen (Category 2 – H341: 'Suspected of causing genetic defects').
- *Methylene diphenyl diisocyanate (MDI):* Classified as carcinogen (Category 2 – H351: 'Suspected to be carcinogenic').
- *Formaldehyde:* Classified as carcinogen (Category 1B – H350: 'May cause cancer') and mutagen (Category 2 – H341: 'Suspected of causing genetic defects').
- *Furfuryl alcohol:* Classified as carcinogen (Category 2 – H351: 'Suspected to be carcinogenic').
- *Benzene:* Classified as carcinogen (Category 1B – H350: 'May cause cancer') and mutagen (Category 1B – H340: 'Germ cell mutagenicity').

EU SF BREF

Why the need for change?

Upcoming and future regulation on the emissions for foundries will limit the use of the industrial standard **organic binder systems**

Table 4.9: BAT-associated emission levels (BAT-AELs) for channelled emissions to air of dust, benzene, formaldehyde, phenol and TVOC from casting, cooling and shake-out processes in foundries using lost moulds including the full mould process

Substance/Parameter	Unit	BAT-AEL (Daily average or average over the sampling period)
Dust	mg/Nm^3	1 – 5
Benzene		< 1 – 2 (1)
Formaldehyde		< 1 – 2 (2)
Phenol		< 1 – 2 (3)
TVOC	mg C/Nm^3	15 – 50 (4)

(1) The BAT-AEL only applies when aromatic binders/chemicals are used or when the full mould process is used.
(2) The BAT-AEL only applies when the substance concerned is identified as relevant in the waste gas streams based on the inventory of inputs and outputs mentioned in BAT 2.
(3) The BAT-AEL only applies when phenolic-based binder systems are used in moulding and/or core-making.
(4) The upper end of the BAT-AEL range may be higher and up to 100 mg C/Nm^3 when organic binder systems generating low or no emissions of substances classified as CMR 1A, CMR 1B or CMR 2 (see techniques (d), (e) and/or (f) in BAT 25) are used in core-making.

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The potential

The generated harmful emissions from inorganic and semi-organic systems are **a fraction of the fully organic systems**

Code	Per 1 g of binder, [µg]		Per 1 kg of molding sand, [mg]		
	Total BTEX	Benzene	Total BTEX	Benzene	
MF	43,852	40,158	658	602	Furan
MA	32,994	30,911	495	464	Phenolic
MA/MF	0.752	0.770	0.752	0.770	
MG	3342	2837	60	51	Geopol. + ester
MG/MF	0.076	0.071	0.091	0.085	
MC	715	496	24	16	Sodium silicate
MC/MF	0.016	0.012	0.036	0.026	
MB	2510	2301	176	161	Greensand
MB/MF	0.057	0.057	0.267	0.267	
MI	860	556	22	14	Sodium silicate
MI/MF	0.020	0.014	0.033	0.023	

R. Danko et al.

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Inorganic binder systems

The good

Little to no emissions

Work well for non-ferrous castings

The bad

Additional hardening at elevated temperatures, leading to challenges with **ferrous castings**

Inorganic binders

Inorganic binders generally achieve **high strength**

Semi-organic systems **do not reach exactly the same levels**

Modifiers/additives are used to customize properties

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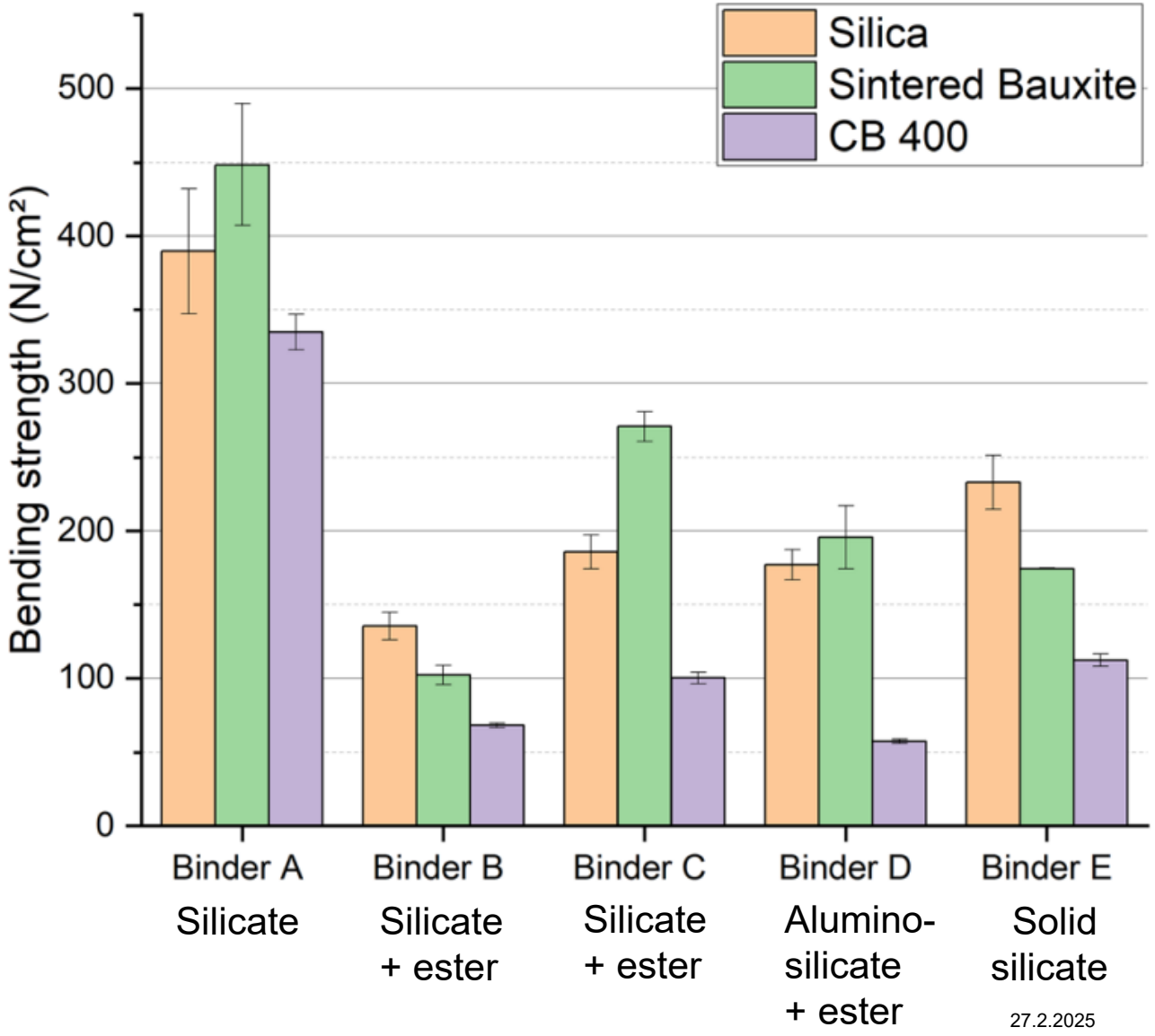
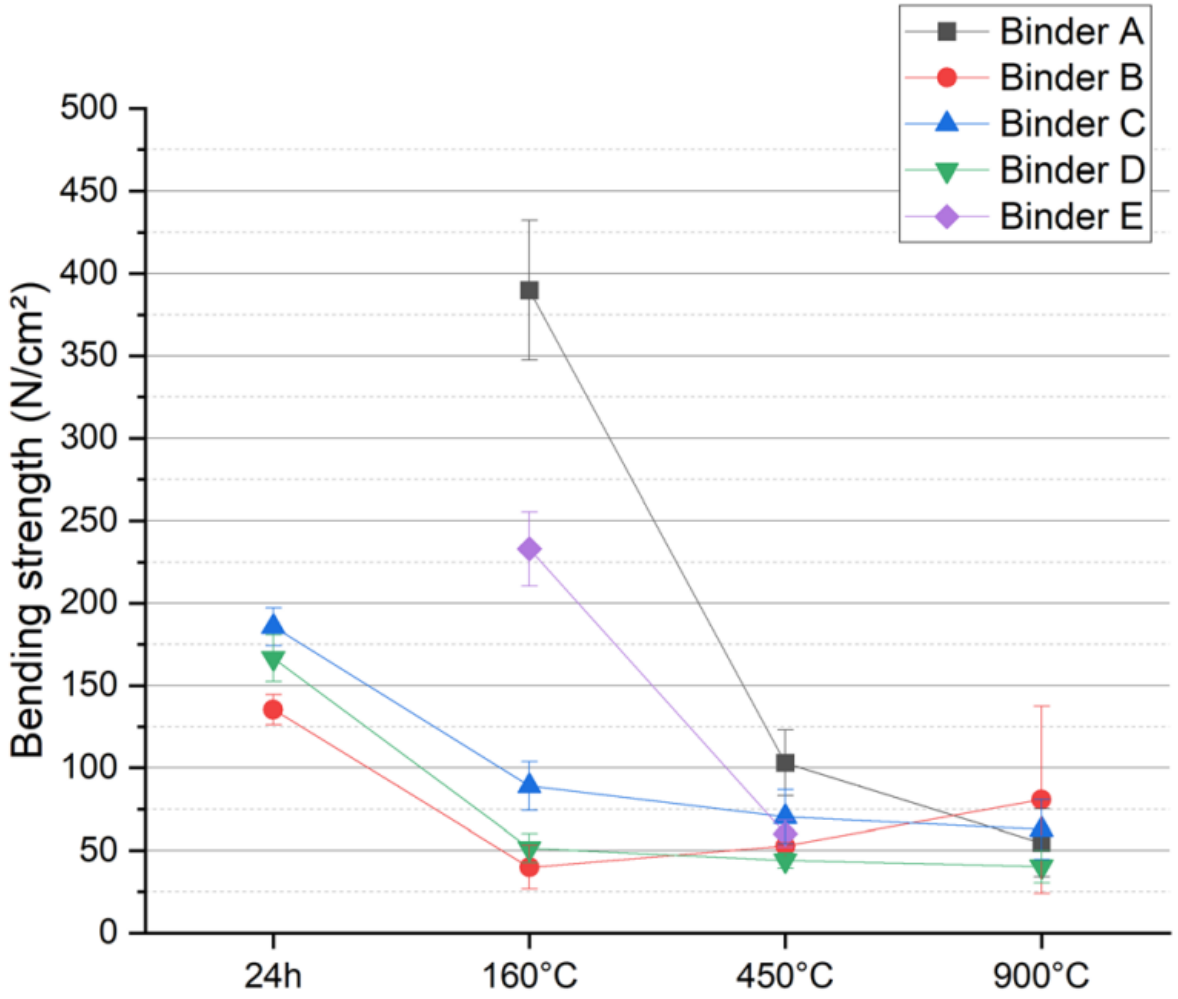


Challenges

Organic binders exhibit great collapsibility due to **thermal degradation**

Inorganic binders do not exhibit this same behavior, leading to challenges with **ferrous castings**



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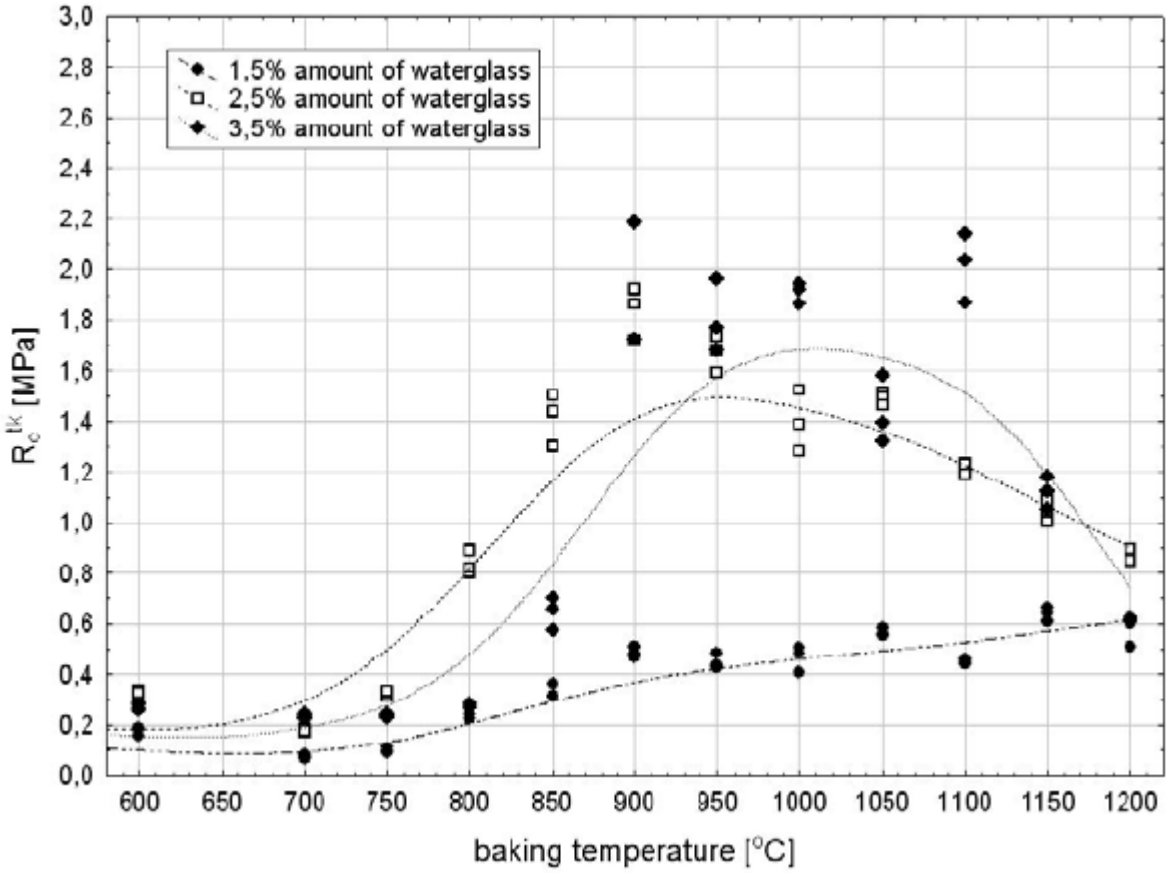

M. Stachowicz et al.

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Inorganic binder development in the industry

Modified sodium silicates

Chemically hardened sodium silicates

Geopolymers

The solution to all challenges?

Future

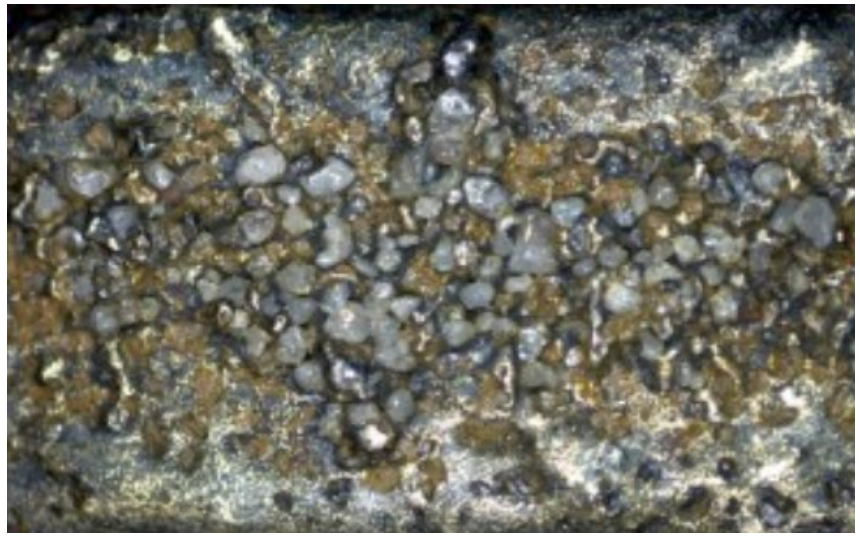
Fully inorganic systems will naturally have **the lowest emissions**

…while they are technologically hardest to implement

Semi-organic systems (geopolymers and silicates with hardeners) have potential in replacing **no-bake organic binder systems**

…ease of use

…collapsibility



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Future needs for inorganic binder system use

Pattern technologies

- Compatibility with fully inorganic systems?

Collapsibility

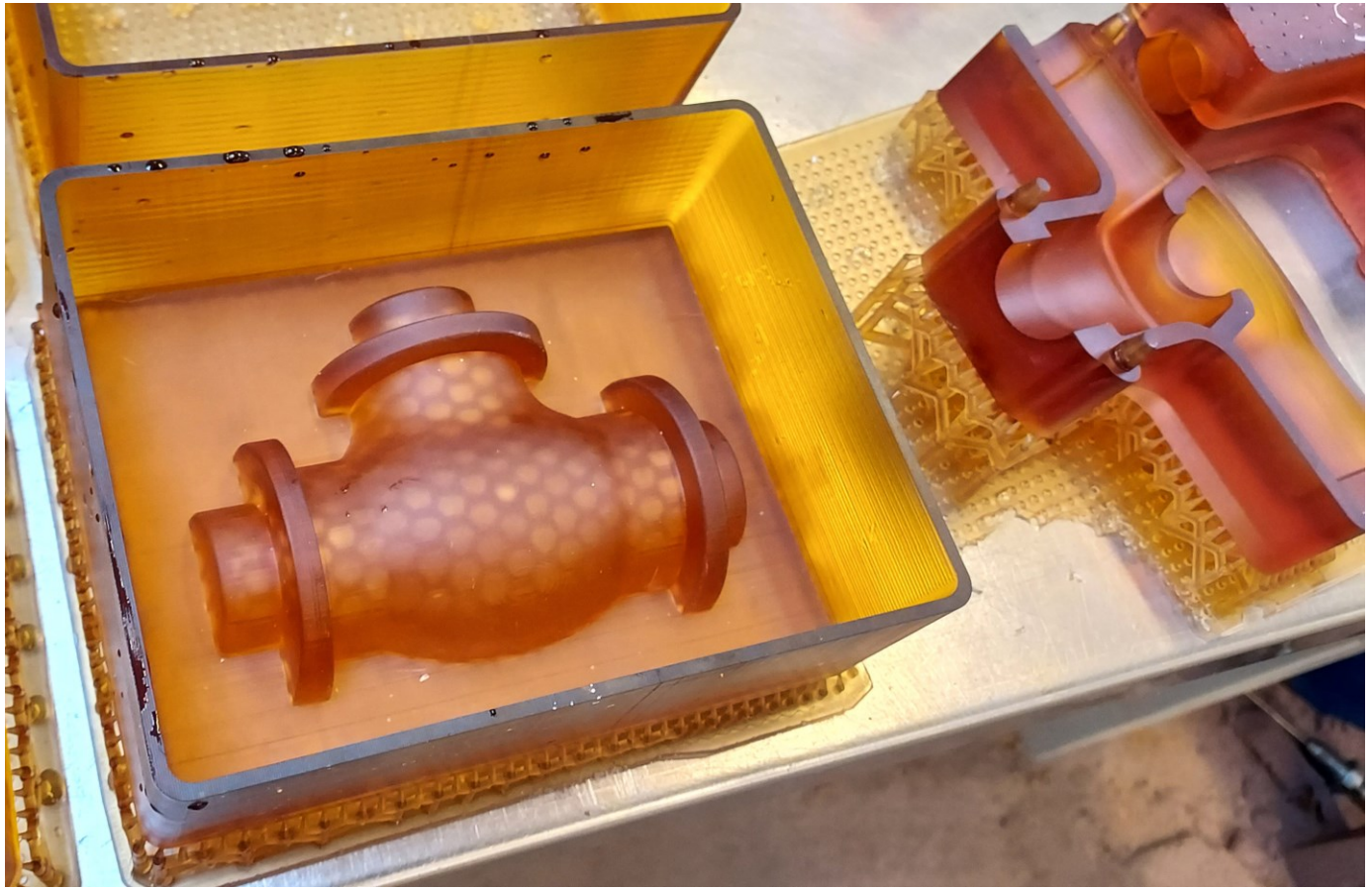
- Modification needs?

Mold coatings

- Aid in collapsibility?

Sand reclamation

- Mechanical, wet?



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