OPTIMIZATION OF SAND RECIRCULATION

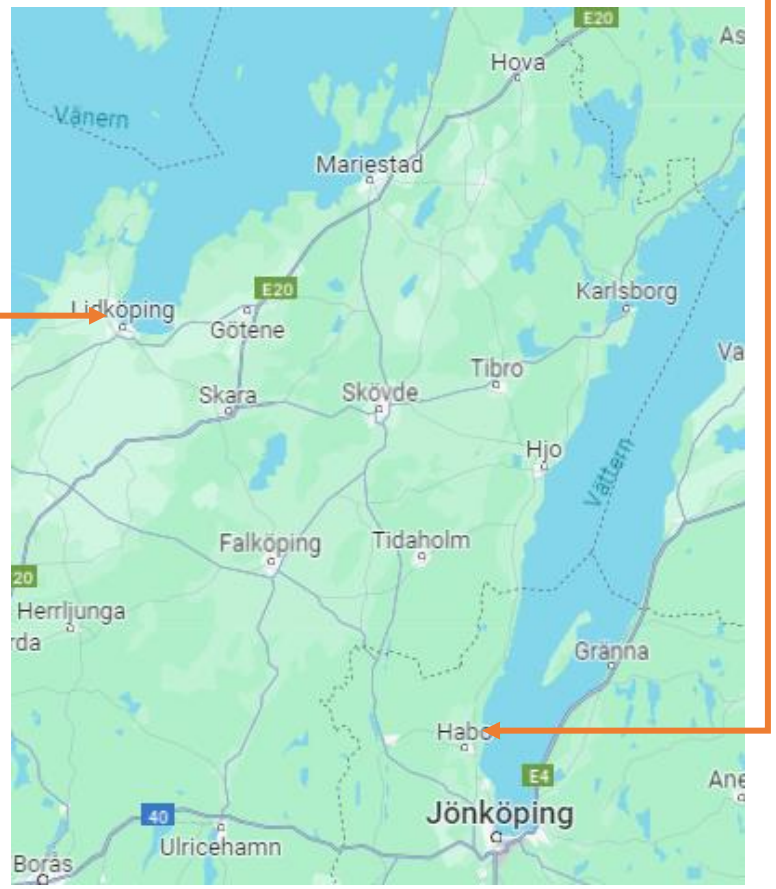
INDUSTRIAL PHD PROJECT

ALAIN DUGU

SCANIA

Sand Supplies for Classic and New Foundries

Råda Sand



Baskarp sand

Sand is a finite resource

Classic Foundry vs and New Foundry

- Classic Foundry, all our sand was recycled into Molding sand
- New Foundry, we're also recycling the core,
- Currently, **45 %** of the core is reclaimed I some product
- The goal is to increase this to more than **THAT !**

Agenda

- How we separate sand from casting material at Scania.
- How we reclaim the sand core
- Optimization of In-House Sand Reclamtion

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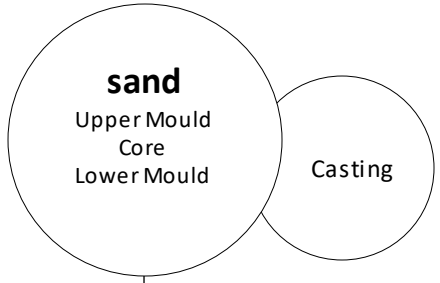
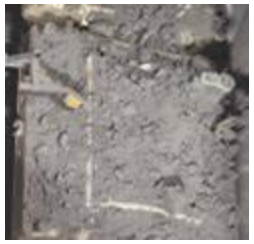
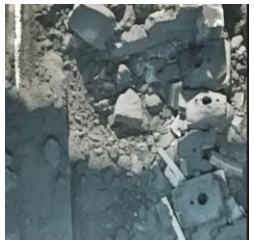
Separation of Sand from Casting

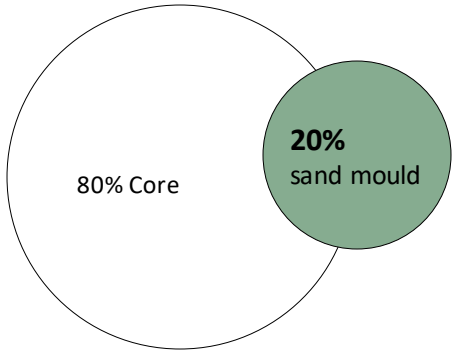


Upper Mould | **Casting** | **Core** | **Lower Mould**

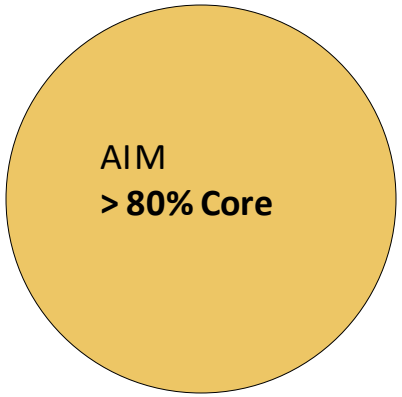
Separation →

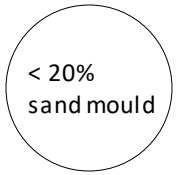




After separation →



Core Sand Reclamation ⇠

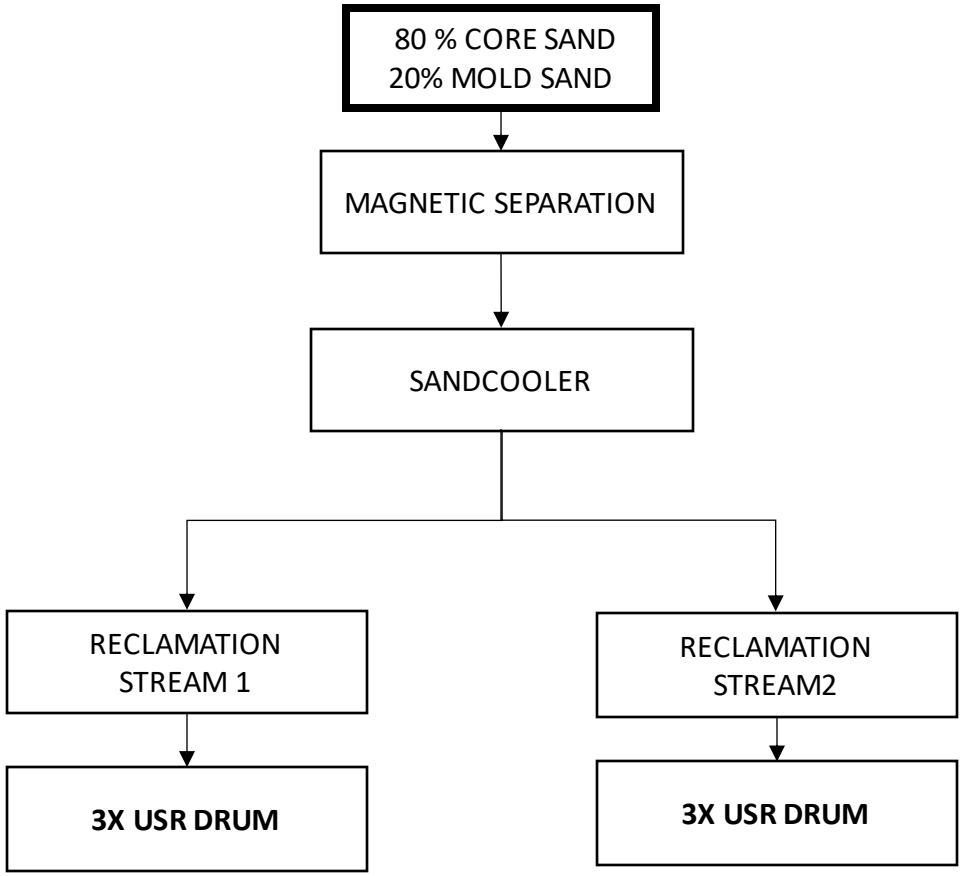




Agenda

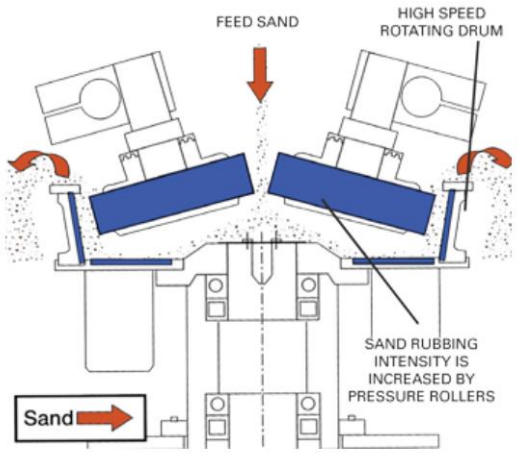
- How we separate sand from casting material at Scania.
- How we reclaim the sand core
- Optimization of In-House SandReclamtion

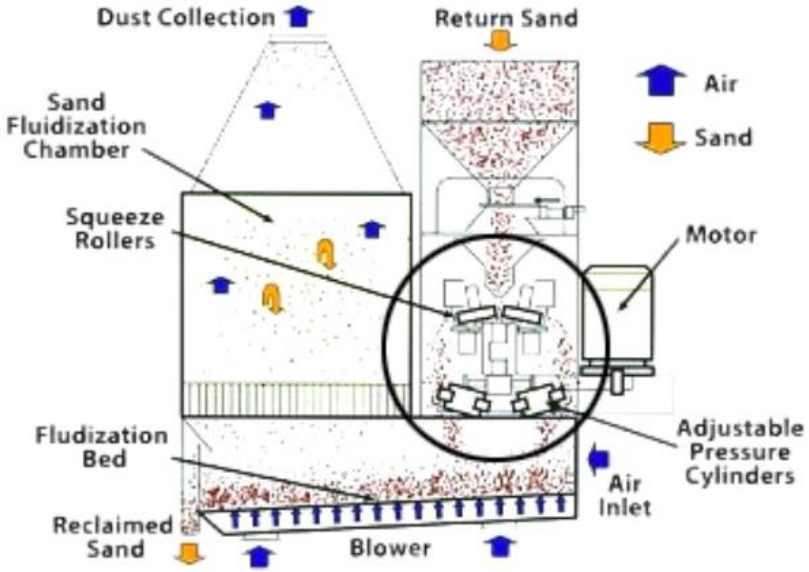
OMEGA Mechanical Sand Separation



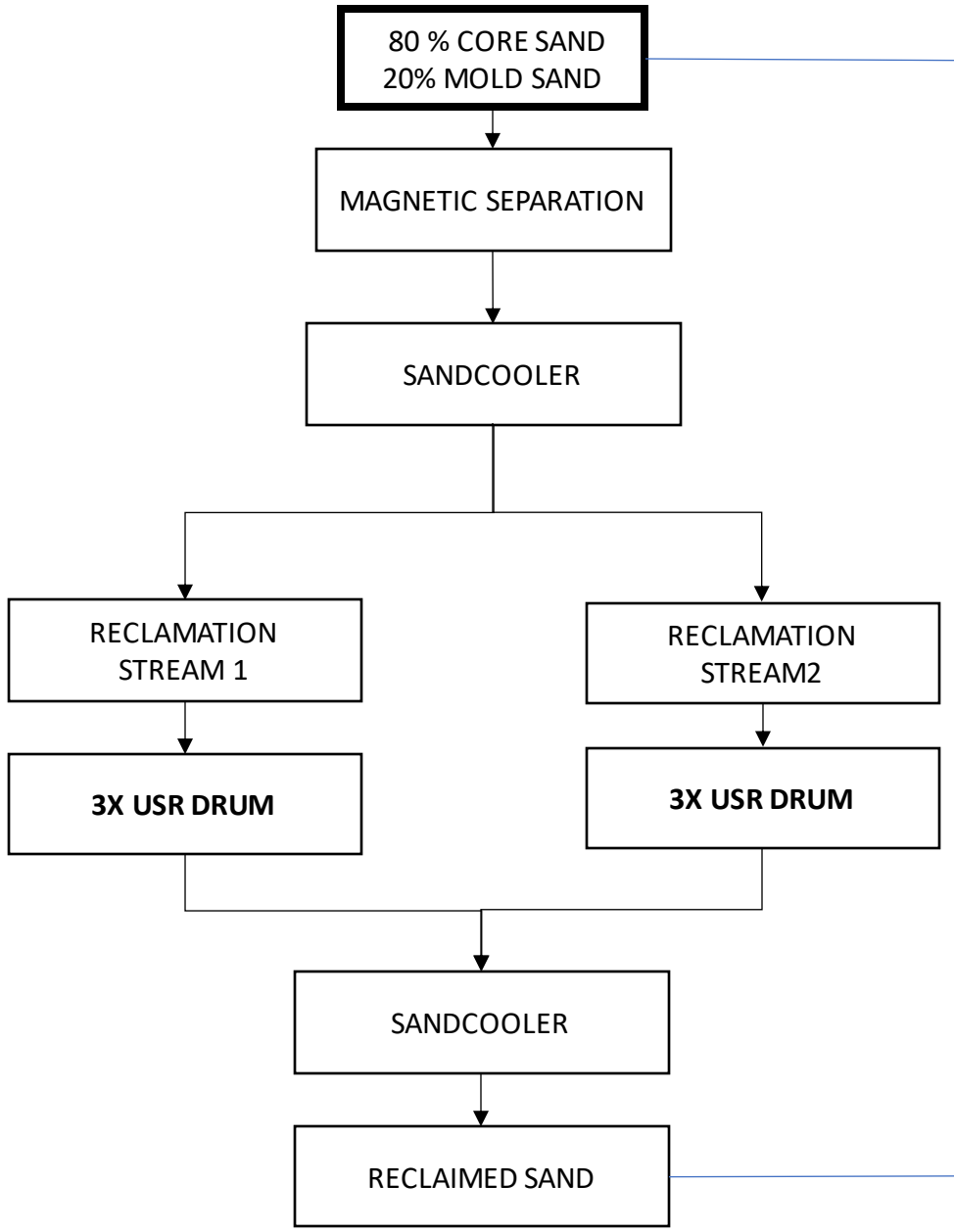
OMEGA MECHANICAL SAND RECLAMATION

USR DRUM





OMEGA Mechanical Sand Separation



Pre-Reclamation
pH and Condusctu

Post-Reclamation
pH , Conductivity And LOI

OMEGA MECHANICAL SAND RECLAMATION

The mechanical process from Omega involves:

- Abrasion of the sand grains
- The removal of fine particles and impurities through suction after scrubbing

Agenda

- How we separate sand from casting material at Scania.
- How we reclaim the sand core
- Optimization of In-House SandReclamtion

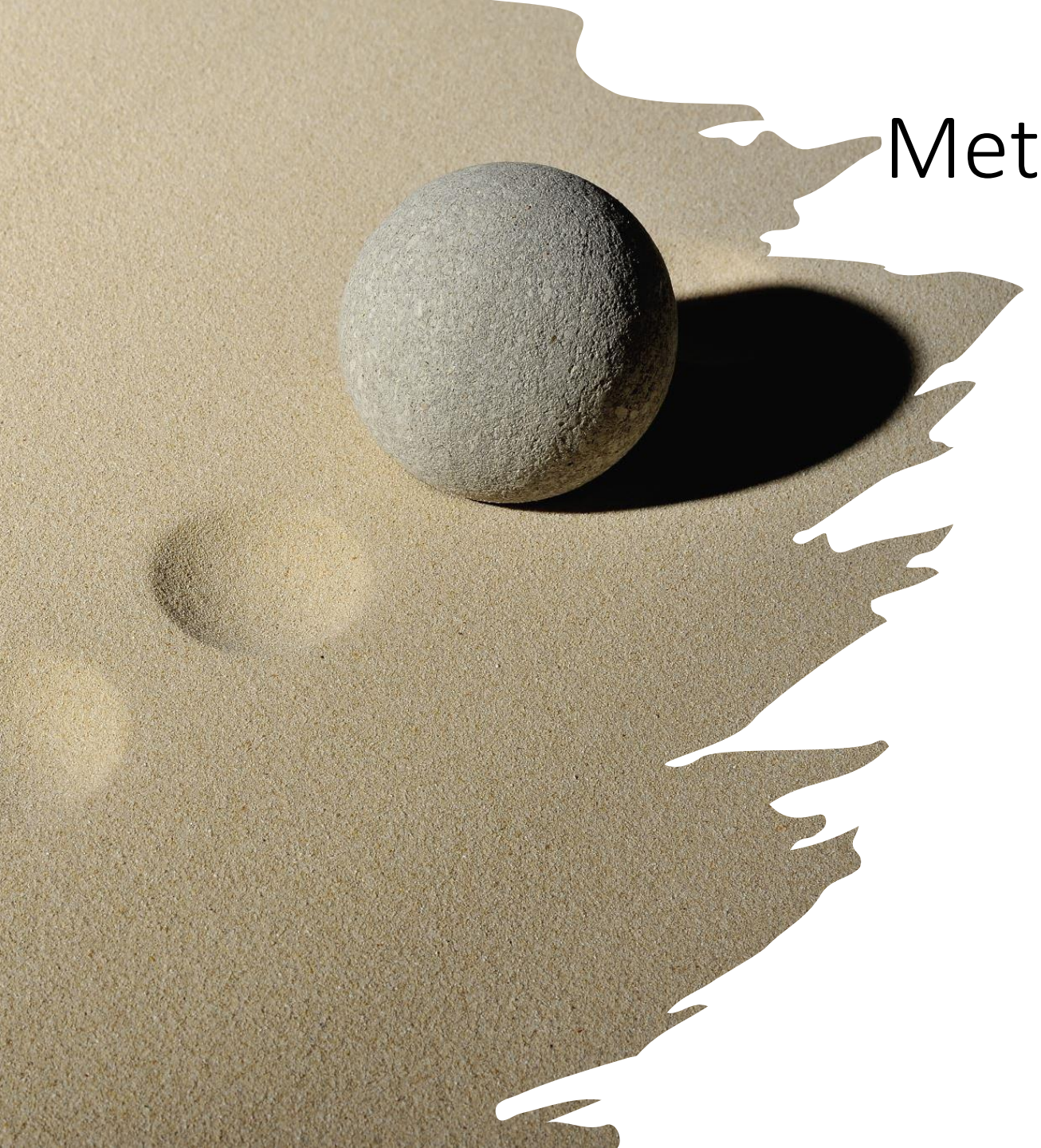
Overiew of Research

Topic 1: Properties of in-house Sand

Topic 2 : Effect of Sand Properties on Core Production

Topic 3: Permeability & Thermal conductivity

Topic 4: Impact of Sand Properties on Cast Metal Parts



Methodology approach

Following presentation only on :

Topic 1: Properties of In-house Sand

Topic 2: Effect of Sand Properties on Core Production

Methodology approach

- Literature review: State-of-the-art in sand reclamation of core and mold materials in cast iron foundries
- Experimental :
  - **Topic 1**: Properties of in-house Sand and
  - **Topic 2**: Effect of Sand Properties on Core Production
- Chemical composition and Physical properties

XRF, XRD, SEM, Morphology of the sand gain, pH, conductivity, strength of the core and Bench-Life

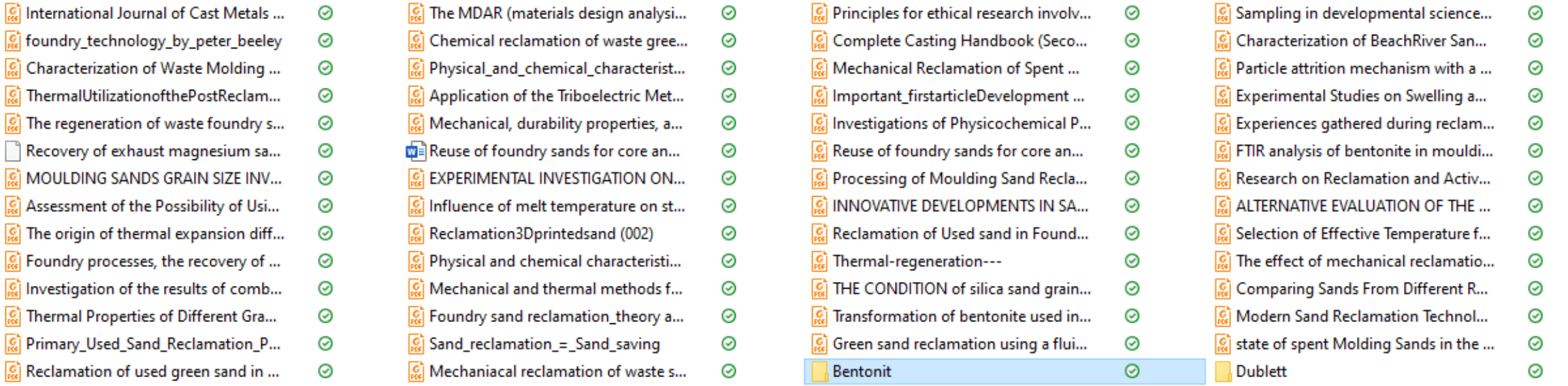
Literature review :

State-of-the-art in sand reclamation of core and mold materials in cast iron foundries

From 56 papers, 2 major types of sand reclamation systems:

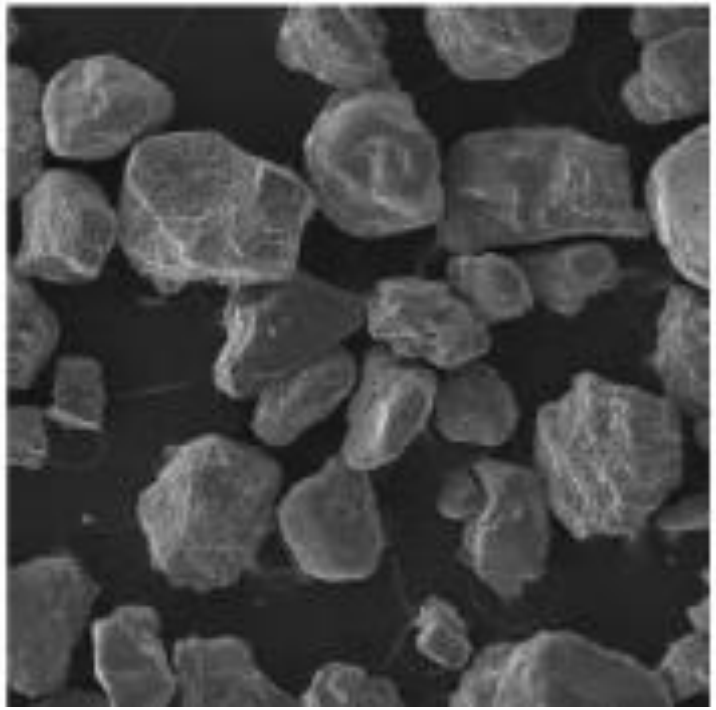
- Mechanical
- Thermal

Besides, chemical reclamation

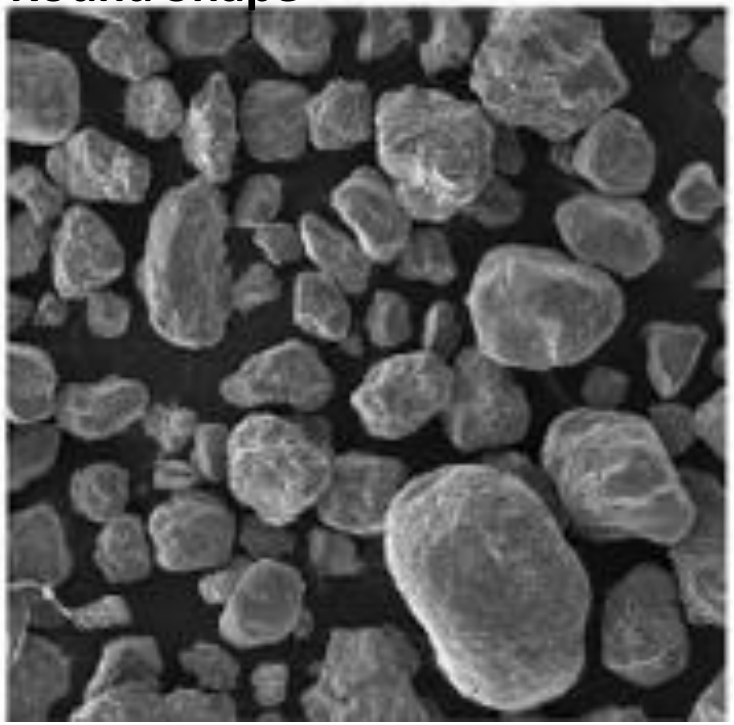


Literature review: State-of-the-art in sand reclamation of core and mold materials in cast iron foundries

Before Reclamation, **sub-angular shape**



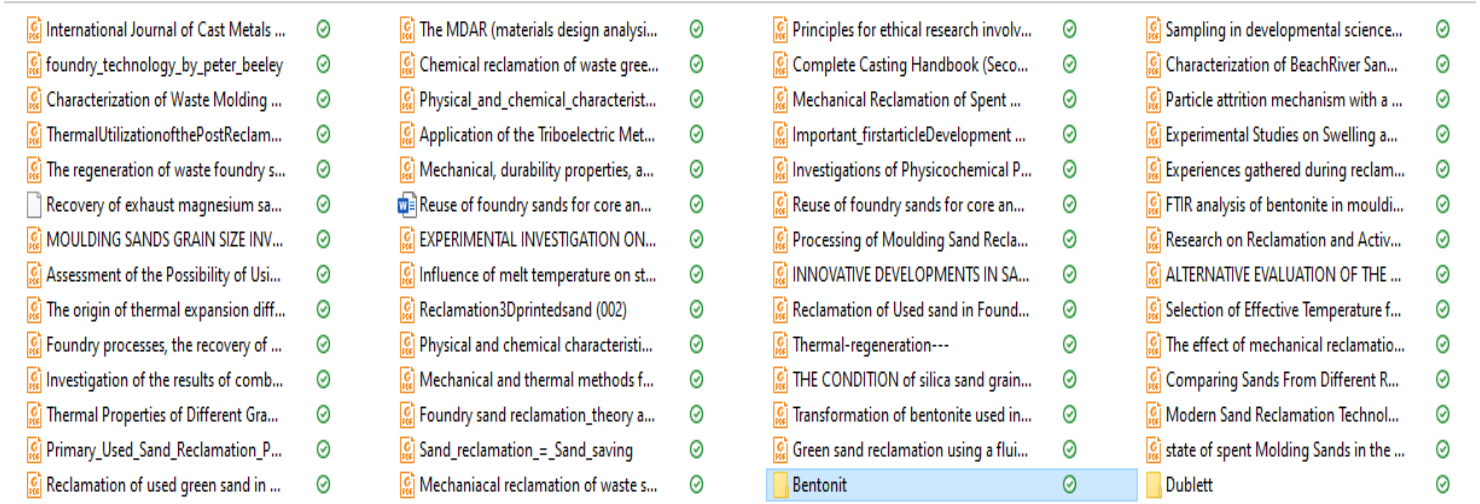
Post-Mechanical process, **Round Shape**



Literature review : State-of-the-art in sand reclamation of core and mold materials in cast iron foundries

From 56 papers

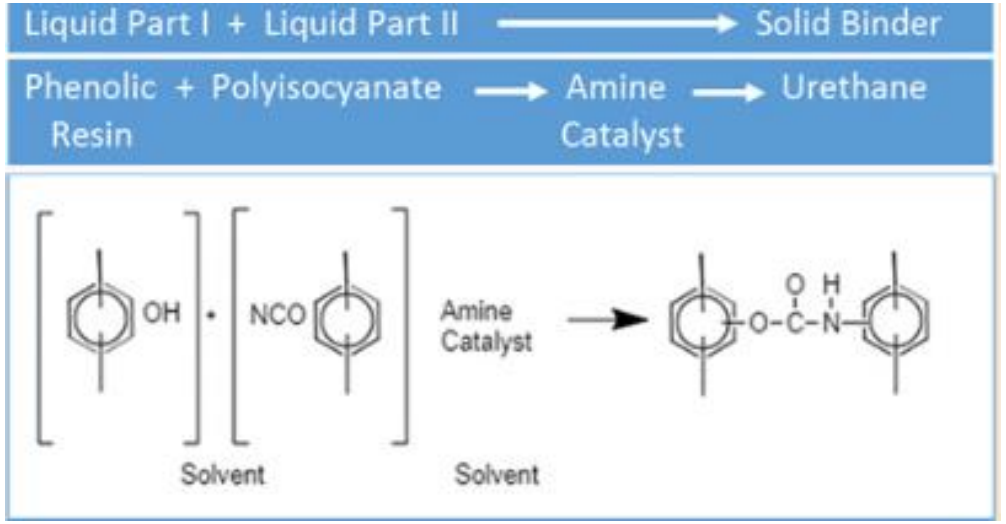
- **Mechanical approaches** work well for sands bonded **with inorganic materials** or **weaker organic binders**,
- **Thermal** shine with sands associated with **organic binders**, which require high temperatures to break down.
- **Hybrid methods** are best for complex sand mixes or situations where step-by-step treatments can enhance overall sand recovery



Scania uses the Cold Box process

The Cold Box process is a **three-part organic-based** binder system consisting

- Resin part - I ; a phenol – formaldehyde
- Hardener part – II; polymeric MDI
- and Catalyst part – III; Liquid Tertiary Amine or MDEA



Experimental

Sample to be analysis

Sand	Sample 1	Sample 2	Sample 3	Sample4	Sample5
Recycled sand	0% wt%	45wt%	55 wt%	80w%	100w%
New sand	100 wt %	55w%	45wt%	20wt%	0% wt%

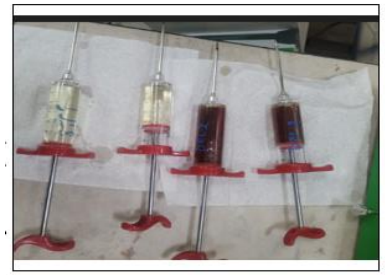
Experimental

Calibration, Pilot vs Production

Laboratory-intensive mixer with rotated bowl

Mini Core shooter

Strength Testing Machine



30 mL Medical Syringes for Binder Dosing

pH/Conductivity Benchtop Meter

Sand sample divider and Sieve Shakers

Weighing 10 kg :

- Mix the sand in the mixer.
  - ❑8 kg for bars for strength testing
  - ❑2 kg for sieve analysis, pH, and conductivity testing

The aim to get the same mixer as from real-life production

Time-consuming Autumn 2023 and part of Spring 2024

Experimental

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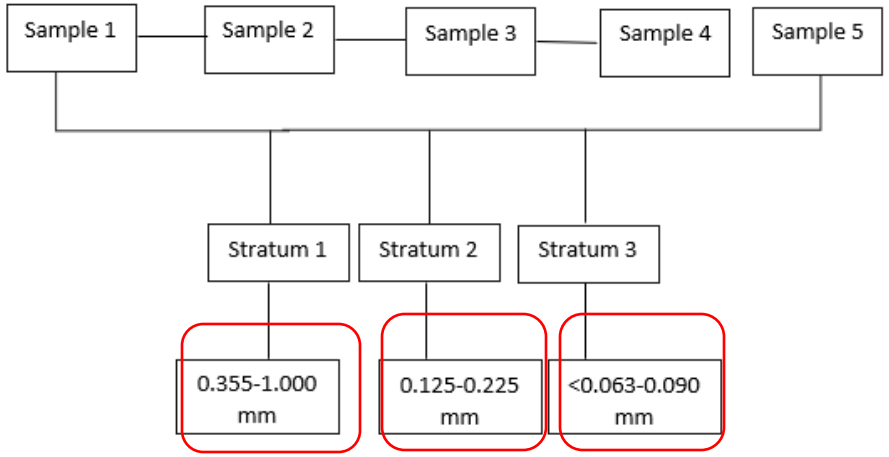
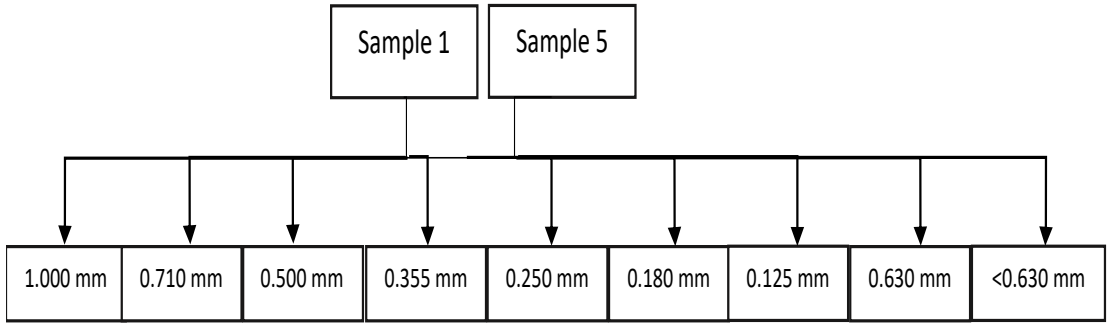


Divider in into 3 strata

- Coarse Particles
- Medium Grain Size
- Finer Particles



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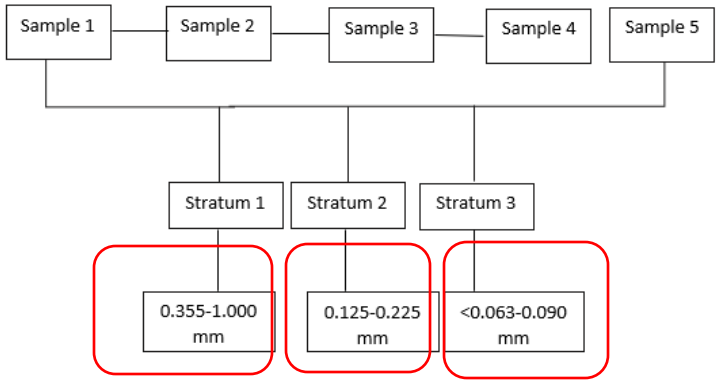
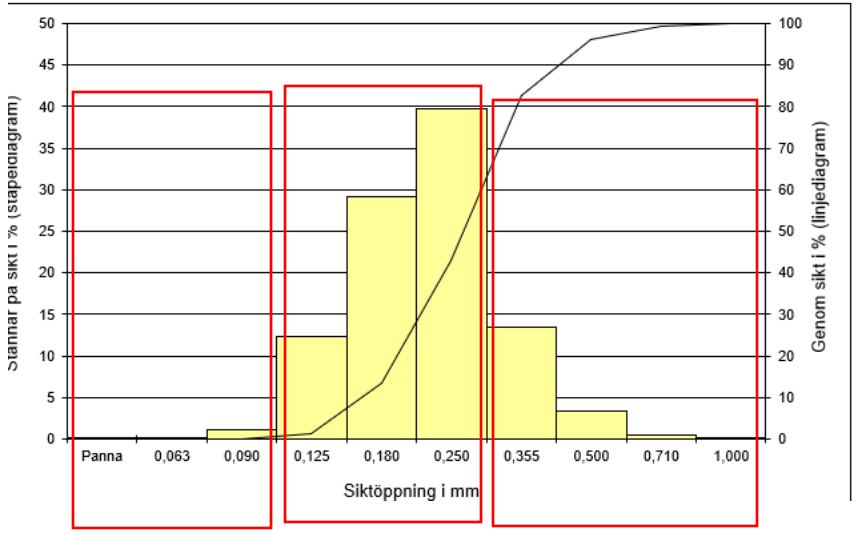


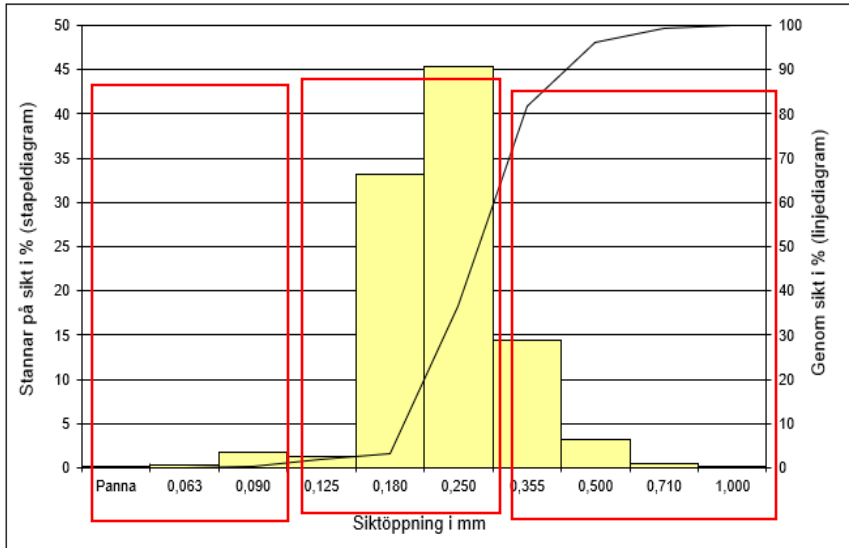
Fresh sand, 10 kg

nandelar (%)	Kornkoncentration (%)	Medelkorn (mm)	AFS-nr	Teo.Spec.Yta (cm2/g)
1,25	68,9	0,293	52,7	90,2



Reclaimed sand, 10 kg

Finandelar (%)	Kornkoncentration (%)	Medelkorn (mm)	AFS-nr	Teo.Spec.Yta (cm2/g)
2,11	76,0	0,313	50,0	84,6



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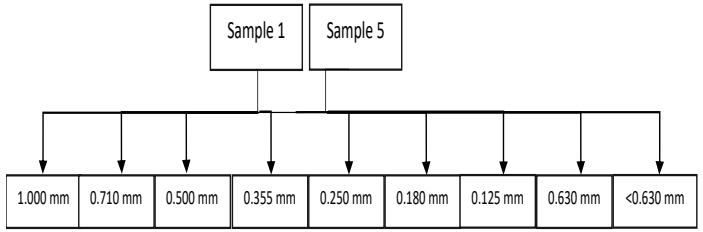

- Coarse Particles: 15-18 %
- Medium Grain Size: 80-85 %
- Finer Particles: 1-2 %

Experimental

Sand	Sample 1	Sample 2	Sample 3	Sample4	Sample5
Recycled sand	0% wt%	45wt%	55 wt%	80w%	100w%
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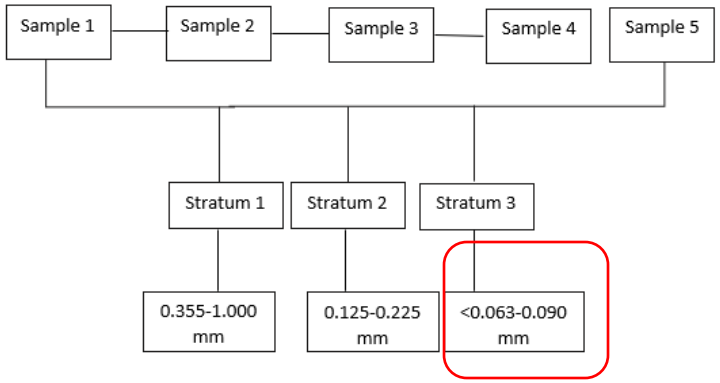

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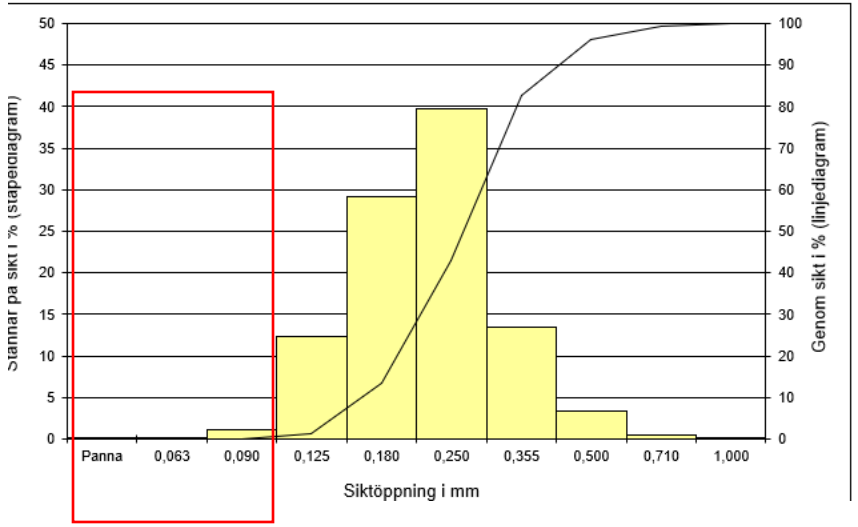

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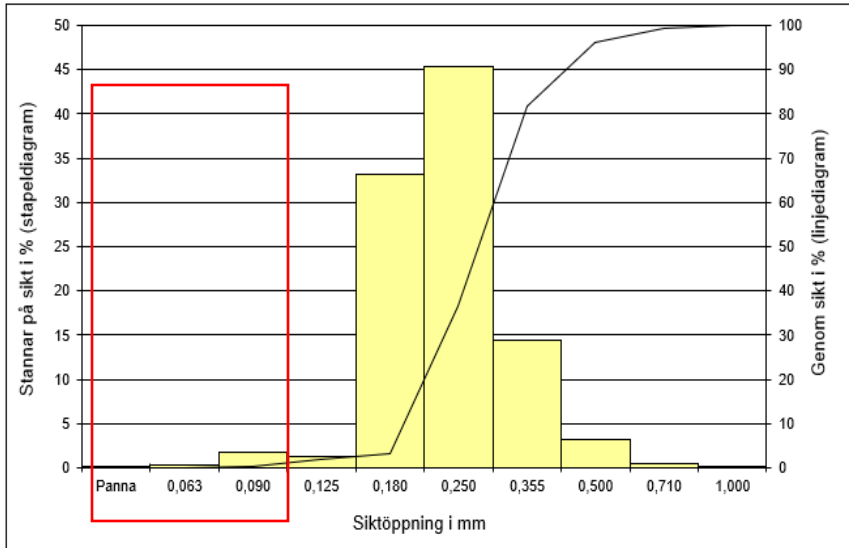
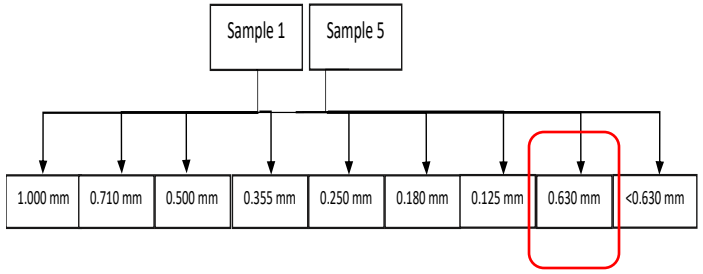




For XRF, XRD, SEM, and Particle Analysis:

Around 60 g for each stratum

Time-consuming :

- Need around 10 kg for stratum 3, around 1 wt% when sieving
- Need around 70 kg sand grain around 0,630 m

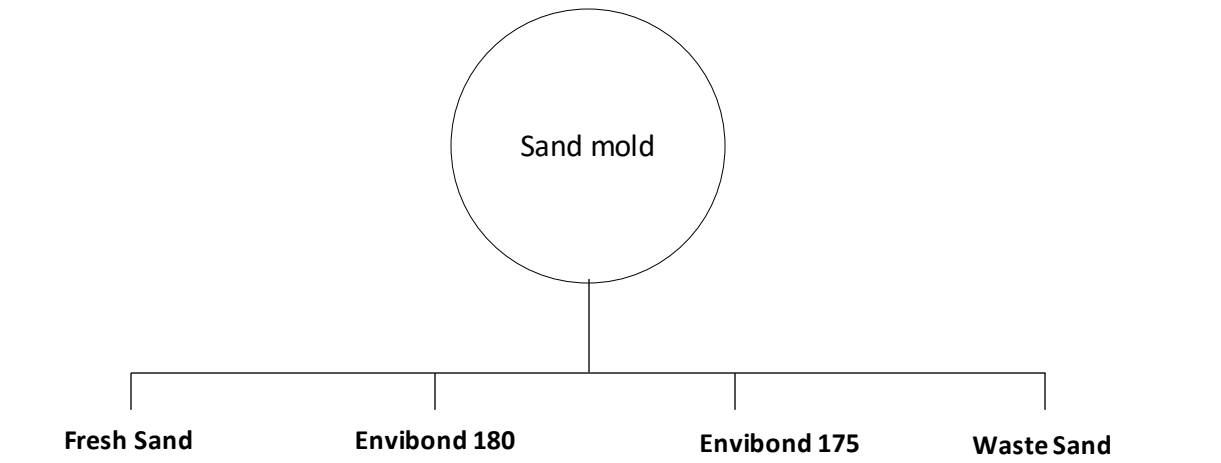
Current Parameters - Results I Will Share

- XRF: Chemical Composition
- Laser Particle Analysis : For Roundness
- pH and conductivity
- Analysis: Strength Bars

Results in House-Sand

- XRF: Chemical Composition
- Laser Particle Analysis : For Roundness
- pH and conductivity
- Analysis: Strength Bars

XRF, The materials used in both the core-making and the molding sand

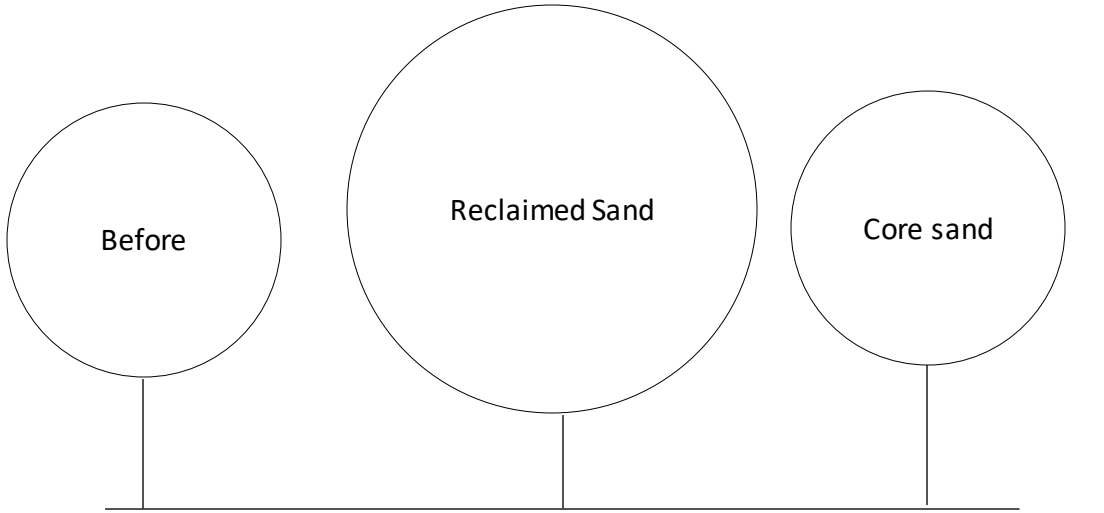


SiO_2	85,00%
Al_2O_3	8,16%
K_2O	4,17%
Na_2O	1,44%
Fe_2O_3	0,48%
CaO	0,41%
TiO_2	0,11%
MgO	0,08%

SiO_2	61,80%
Al_2O_3	20,00%
C	9,10%
Fukt	6,71%
Fe_2O_3	5,49%
MgO	3,51%
CaO	3,46%
Na_2O	2,27%

SiO_2	61,60%
Al_2O_3	20,00%
C	13,82%
Fukt	7,66%
Fe_2O_3	5,79%
MgO	3,55%
CaO	3,42%
Na_2O	2,46%

SiO_2	68,00%
Al_2O_3	17,40%
C	10,68%
CaO	3,00%
Fe_2O_3	2,96%
K_2O	2,31%
Na_2O	2,26%
MgO	2,24%

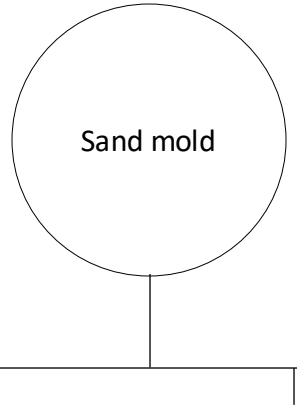


SiO_2	84,70%
Al_2O_3	8,07%
K_2O	2,88%
Na_2O	1,17%
Fe_2O_3	0,82%
CaO	0,55%
MgO	0,35%
SO_3	0,14%

SiO_2	87,80%
Al_2O_3	6,27%
K_2O	2,88%
Na_2O	1,07%
Fe_2O_3	0,54%
CaO	0,36%
MgO	0,14%
TiO_2	0,09%

SiO_2	88,30%
Al_2O_3	6,39%
K_2O	2,89%
Na_2O	1,21%
Fe_2O_3	0,62%
CaO	0,36%
TiO_2	0,06%
BaO	0,05%
BaO	0,05%
MgO	0,04%

XRF, The materials used in both the core-making and the molding sand



Fresh Sand

SiO_2	85,00%
Al_2O_3	8,16%
K_2O	4,17%
Na_2O	1,44%
Fe_2O_3	0,48%
CaO	0,41%
TiO_2	0,11%
MgO	0,08%

Envibond 180

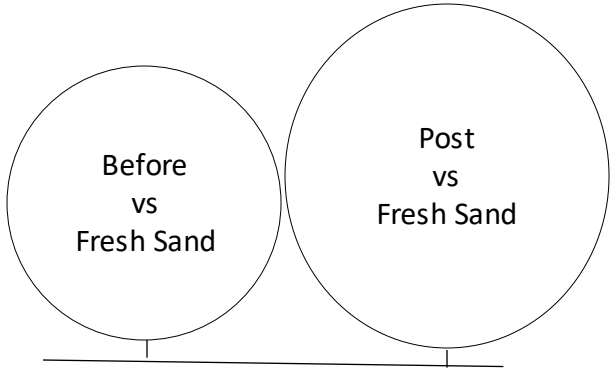
SiO_2	61,80%
Al_2O_3	20,00%
C	9,10%
Fukt	6,71%
Fe_2O_3	5,49%
MgO	3,51%
CaO	3,46%
Na_2O	2,27%

Envibond 175

SiO_2	61,60%
Al_2O_3	20,00%
C	13,82%
Fukt	7,66%
Fe_2O_3	5,79%
MgO	3,55%
CaO	3,42%
Na_2O	2,46%

Waste Sand

SiO_2	68,00%
Al_2O_3	17,40%
C	10,68%
CaO	3,00%
Fe_2O_3	2,96%
K_2O	2,31%
Na_2O	2,26%
MgO	2,24%



MgO	775%
TiO_2	100%
CaO	53%
Fe_2O_3	32%

MgO	250%
Cr_2O_3	50%
TiO_2	33%
BaO	20%

XRF, Sample 1 vs Sample 5

Sand	Sample 1	Sample 2	Sample 3	Sample4	Sample5
Recycled sand	0% wt%	45wt%	55 wt%	80w%	100w%
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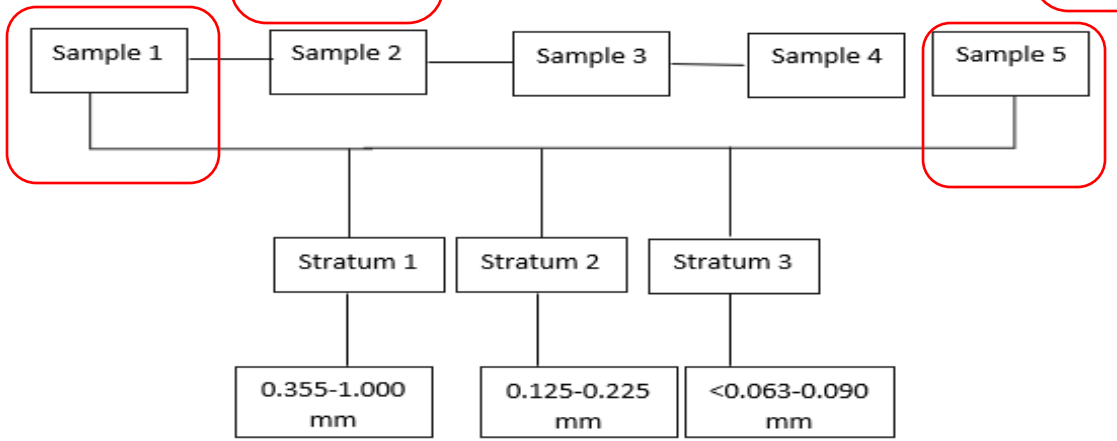
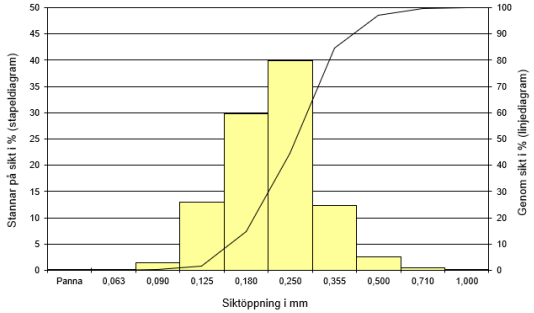


C	5250,00%
Cr_2O_3	200,00%
P_2O_5	33,33%
BaO	16,67%
Fe_2O_3	13,64%
SiO_2	1,04%
Utbyte	0,71%
MnO	0,00%
MgO	0,00%
TiO_2	0,00%

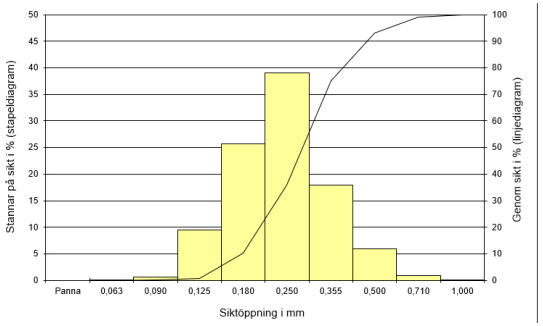
C	17400,00%
MgO	142,86%
CaO	32,35%
TiO_2	20,00%
Fe_2O_3	16,33%
SiO_2	0,46%
Cr_2O_3	0,00%

C	9718,18%
MgO	109,09%
CaO	21,71%
BaO	14,29%
Al_2O_3	12,33%
K_2O	1,55%
Na_2O	0,00%

Fresh sand



Reclaimed sand



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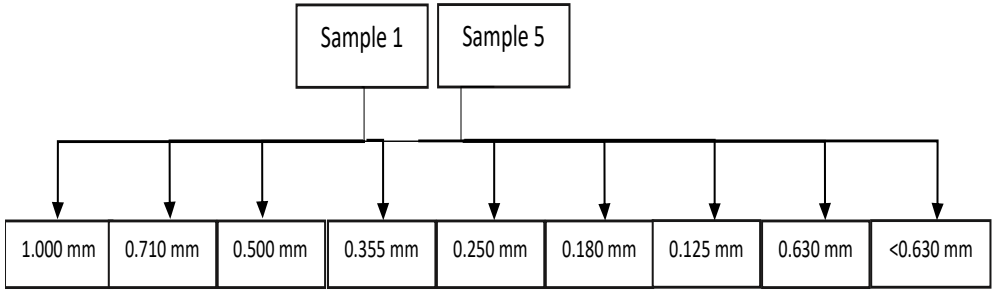
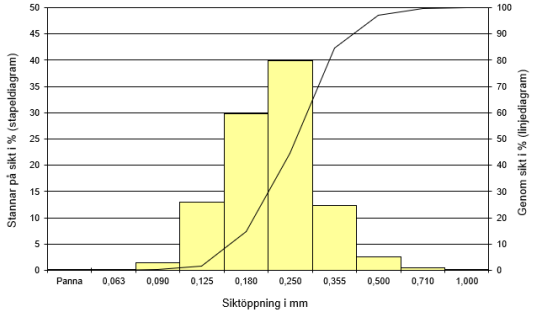
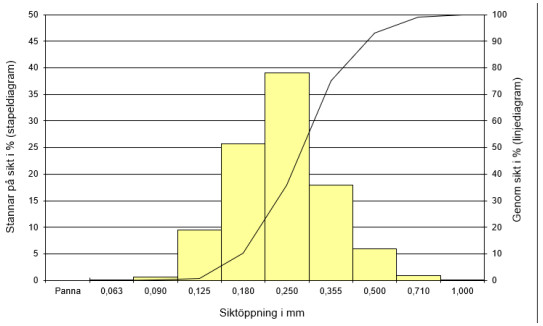


Fresh sand



Reclaimed sand



XRF, Fresh sand vs Reclaimed sand Sampl1 1 & Sample 5

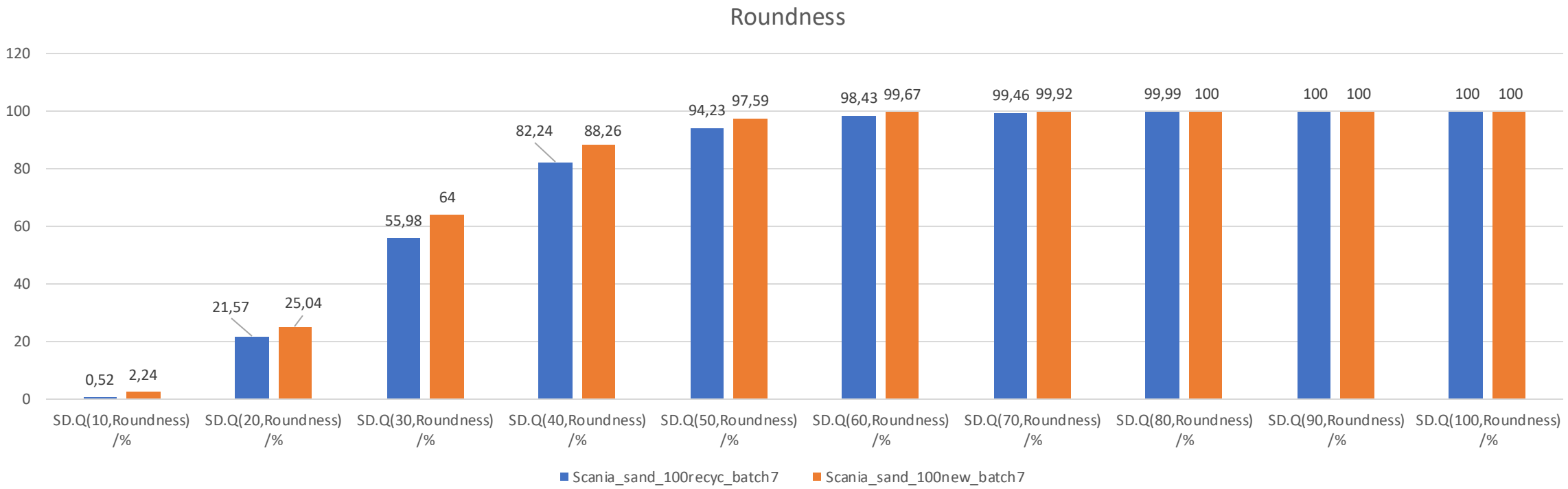
Compounds	100% åter. sand , 0,700mm 100% ny sand0,700mm	100% åter. sand , 0,500mm 100% ny sand0,500mm	100% åter. sand , 0,355mm 100% ny sand0,355mm	100% åter. sand , 0,250mm 100% ny sand0,250mm	100% åter. sand , 0,180mm 100% ny sand0,180mm	100% åter. sand , 0,125mm 100% ny sand0,125mm	100% åter. sand , 0,90mm 100% ny sand0,90mm	100% åter. sand , 0,63mm 100% ny sand0,63mm	100% åter. sand panna 100% ny sand panna
C	5729%	1414%	18650%	22900%	16900%	23650%	26900%	7713%	3667%
Fukt	-100%	#DIVISION/0!	150%	-50%	0%	0%	940%	32%	#DIVISION/0!
Utbyte	2%	1%	1%	0%	-1%	-1%	-1%	-2%	-2%
CaO	0%	25%	0%	50%	23%	9%	68%	-46%	-78%
MgO	71%	75%	0%	1300%	1400%	93%	167%	-29%	-66%
SiO2	-1%	-2%	0%	-2%	-1%	-3%	-6%	6%	17%
Al2O3	8%	14%	-1%	14%	5%	21%	44%	20%	-31%
MnO	0%	0%	#DIVISION/0!	#DIVISION/0!	#DIVISION/0!	0%	50%	-45%	-83%
Cr2O3	0%	50%	50%	-50%	25%	0%	33%	200%	-50%
TiO2	57%	-20%	0%	25%	100%	-19%	43%	-67%	-96%
Na2O	-11%	4%	-11%	10%	-3%	10%	23%	-6%	-35%
K2O	4%	6%	-4%	25%	-5%	13%	9%	21%	-18%
P2O5	-25%	0%	#DIVISION/0!	100%	0%	60%	40%	-69%	-100%
Fe2O3	-6%	11%	12%	11%	41%	11%	33%	-62%	-90%
SrO	0%	0%	0%	0%	0%	0%	0%	0%	0%
BaO	30%	83%	-22%	-17%	0%	40%	67%	433%	11%

Results in House-Sand

- XRF: Chemical Composition
- Laser Particle Analysis : For Roundness
- pH and conductivity
- Analysis: Strength Bars

Particle analysis

Roundness Fresh sand ,SEM	Reclaimed Sand
0,91	0,92



Topic 2: Effect of Sand Properties on Core Production

Samples to be analysed

Current Parameters - Results I Will Share

Sand	Sample 1	Sample 2	Sample 3	Sample4	Sample5
Recycled sand	0% wt%	45wt%	55 wt%	80w%	100w%
New sand	100 wt %	55w%	45wt%	20wt%	0% wt%

Results in House-Sand

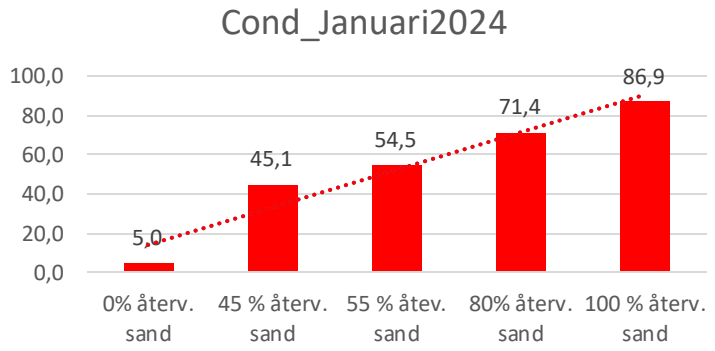
- XRF: Chemical Composition
- Laser Particle Analysis : For Roundness
- pH and conductivity
- Analysis: Strength Bars

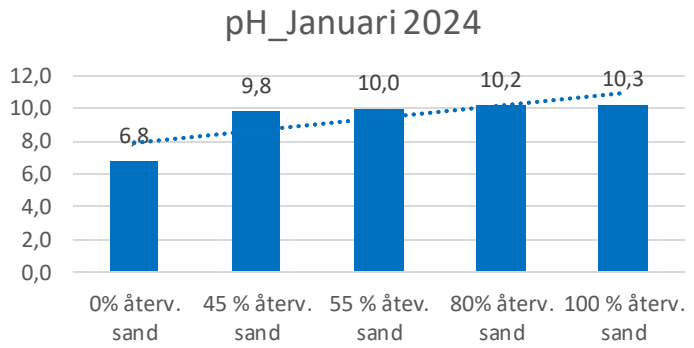
The materials used in both the core-making and the molding sand

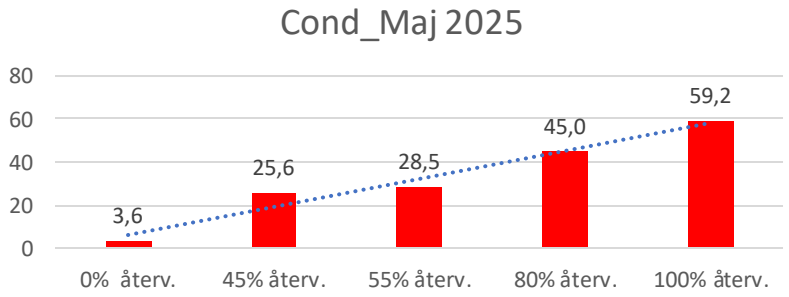
Freshsand	6,1	6,8
Waste	689,8	10,5
Envibond 175	1436,0	10,3
Envibond 180	1634,0	10,4
Feeder	359,2	9,6
Core Sand	5,0	6,8
Reclaimed Sand	86,9	10,3

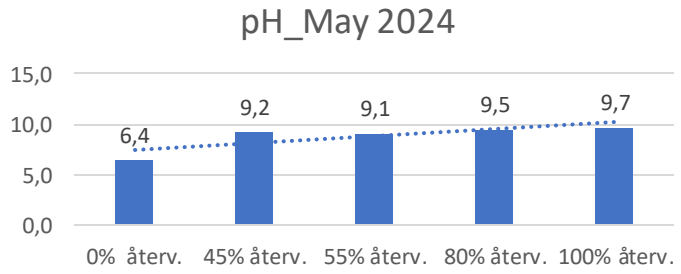
Samples, pH & Conductivity

Sand	Sample 1	Sample 2	Sample 3	Sample4	Sample5
Recycled sand	0% wt%	45wt%	55 wt%	80w%	100w%
New sand	100 wt %	55w%	45wt%	20wt%	0% wt%



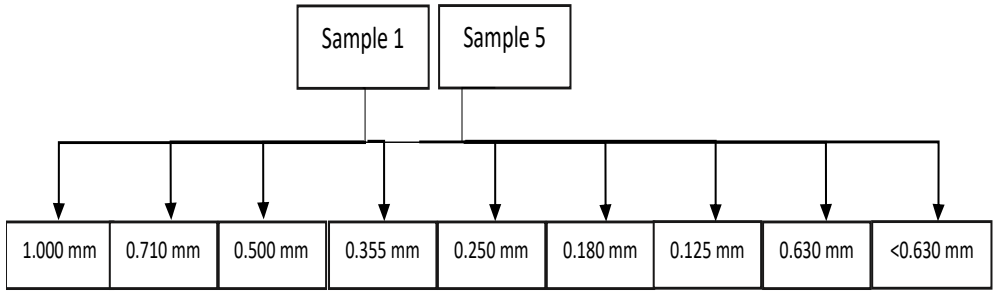


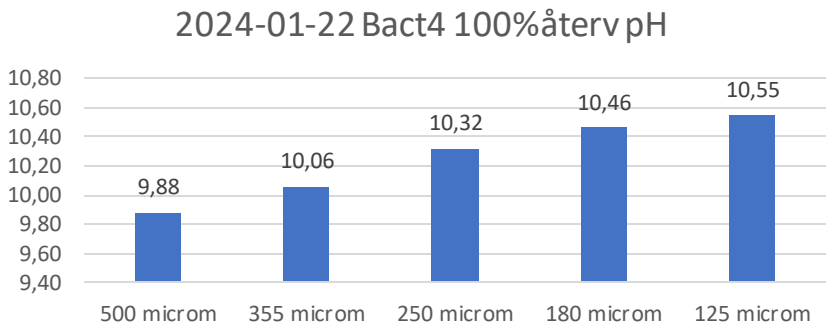


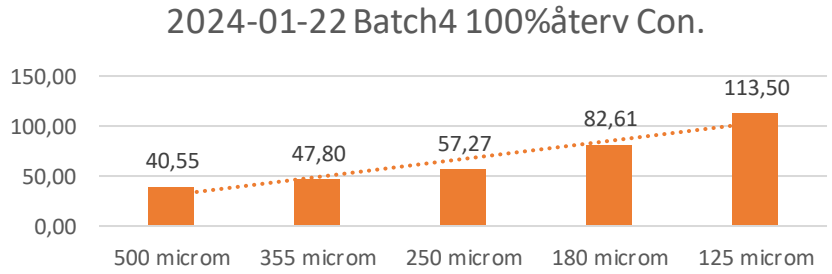


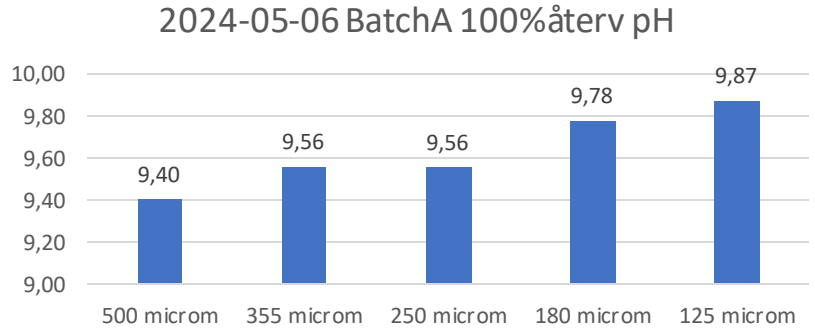
pH and Conductivity 100% reclaimed sand

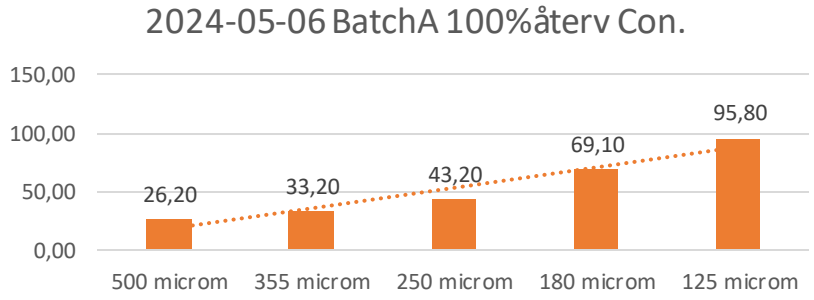
Sand	Sample 1	Sample 2	Sample 3	Sample4	Sample5
Recycled sand	0% wt%	45wt%	55 wt%	80w%	100w%
New sand	100 wt %	55w%	45wt%	20wt%	0% wt%











Results in House-Sand

- XRF: Chemical Composition
- Laser Particle Analysis : For Roundness
- pH and conductivity
- Analysis: Strength Bars

> Binder system 1 (Current binder HA) > Binder system 1 (Current binder HA) > > Binder system 2 (ASK ECB Pro)

Rec sand [%] **Fresh sand** 15 seconds

	0,50%	0,60%	0,70%	0,80%	0,90%	1,00%	1,10%
100%	68 24%	86 31%	104 37%	122 44%	140 50%	157 56%	175 63%
80%	79 28%	98 35%	118 42%	137 49%	157 56%	176 63%	196 70%
60%	89 32%	110 40%	132 47%	153 55%	174 62%	195 70%	217 78%
40%	99 36%	122 44%	145 52%	168 60%	191 69%	214 77%	237 85%
20%	110 39%	135 48%	159 57%	184 66%	209 75%	233 84%	258 93%
0%	120 43%	147 53%	173 62%	199 72%	226 81%	252 91%	279 100%

Binder amount [%]

Rec sand [%] **Bench life 1-h** 15 seconds

	0,50%	0,60%	0,70%	0,80%	0,90%	1,00%	1,10%
100%	-29 -10%	5 2%	40 14%	74 27%	108 39%	143 51%	177 64%
80%	0 0%	32 12%	65 23%	97 35%	129 46%	161 58%	194 70%
60%	29 10%	59 21%	89 32%	120 43%	150 54%	180 65%	210 75%
40%	58 21%	86 31%	114 41%	143 51%	171 61%	199 71%	227 81%
20%	87 31%	113 41%	139 50%	165 59%	191 69%	218 78%	244 87%
0%	116 42%	140 50%	164 59%	188 68%	212 76%	236 85%	260 93%

Binder amount [%]

Rec sand [%] **Bench life 1-h** 15 seconds

	0,50%	0,60%	0,70%	0,80%	0,90%	1,00%	1,10%
100%	-32 -11%	7 3%	46 16%	85 30%	124 44%	163 58%	201 72%
80%	0 0%	38 13%	75 27%	113 40%	150 54%	188 67%	225 81%
60%	32 11%	68 24%	104 37%	140 50%	176 63%	213 76%	249 89%
40%	64 23%	99 35%	133 48%	168 60%	203 73%	238 85%	272 98%
20%	96 34%	129 46%	162 58%	196 70%	229 82%	263 94%	296 106%
0%	128 46%	160 57%	192 69%	224 80%	256 92%	288 103%	320 115%

Binder amount [%]

Rec sand [%] **Fresh sand** 5 minutes

	0,50%	0,60%	0,70%	0,80%	0,90%	1,00%	1,10%
100%	72 21%	98 29%	125 36%	151 44%	177 52%	204 59%	230 67%
80%	89 26%	116 34%	144 42%	171 50%	198 58%	225 66%	253 74%
60%	106 31%	134 39%	163 47%	191 56%	219 64%	247 72%	275 80%
40%	123 36%	152 44%	182 53%	211 61%	240 70%	269 78%	298 87%
20%	141 41%	171 50%	201 58%	231 67%	261 76%	291 85%	321 93%
0%	158 46%	189 55%	220 64%	251 73%	282 82%	312 91%	343 100%

Binder amount [%]

Rec sand [%] **Bench life 1-h** 5 minutes

	0,50%	0,60%	0,70%	0,80%	0,90%	1,00%	1,10%
100%	-12 -4%	24 7%	60 17%	96 28%	132 39%	168 49%	204 60%
80%	20 6%	56 16%	93 27%	129 38%	166 48%	202 59%	239 70%
60%	51 15%	88 26%	125 36%	162 47%	199 58%	236 69%	273 80%
40%	83 24%	120 35%	158 46%	195 57%	233 68%	270 79%	308 90%
20%	114 33%	152 44%	190 55%	228 66%	266 78%	304 89%	342 100%
0%	146 43%	184 54%	223 65%	261 76%	300 87%	338 98%	376 110%

Binder amount [%]

Rec sand [%] **Bench life 1-h** 5 minutes

	0,50%	0,60%	0,70%	0,80%	0,90%	1,00%	1,10%
100%	17 5%	51 15%	84 25%	118 34%	151 44%	185 54%	218 64%
80%	46 13%	80 23%	115 34%	150 44%	185 54%	220 64%	255 74%
60%	74 21%	110 32%	146 43%	183 53%	219 64%	256 74%	292 85%
40%	102 30%	140 41%	178 52%	215 63%	253 74%	291 85%	329 96%
20%	130 38%	169 49%	209 61%	248 72%	287 84%	326 95%	366 106%
0%	159 46%	199 58%	240 70%	281 82%	321 94%	362 105%	403 117%

Binder amount [%]

Rec sand [%] **Fresh sand** 15 minutes

	0,50%	0,60%	0,70%	0,80%	0,90%	1,00%	1,10%
100%	68 16%	93 22%	117 28%	142 34%	166 39%	191 45%	215 51%
80%	88 21%	116 27%	144 34%	172 41%	200 47%	229 54%	257 61%
60%	108 26%	139 33%	171 41%	203 48%	235 56%	266 63%	298 71%
40%	128 30%	163 39%	198 47%	234 55%	269 64%	304 72%	340 80%
20%	147 35%	186 44%	225 53%	264 63%	303 72%	342 81%	381 90%
0%	167 40%	210 50%	252 60%	295 70%	337 80%	380 90%	422 100%

Binder amount [%]

Rec sand [%] **Bench life 1-h** 15 minutes

	0,50%	0,60%	0,70%	0,80%	0,90%	1,00%	1,10%
100%	16 4%	48 11%	80 19%	112 26%	144 34%	175 42%	207 49%
80%	46 11%	79 19%	113 27%	147 35%	180 43%	214 51%	248 59%
60%	75 18%	111 26%	146 35%	182 43%	217 51%	253 60%	288 68%
40%	104 25%	142 34%	179 42%	217 51%	254 60%	292 69%	329 78%
20%	134 32%	173 41%	212 50%	252 60%	291 69%	330 78%	370 88%
0%	163 39%	204 48%	246 58%	287 68%	328 78%	369 87%	410 97%

Binder amount [%]

Rec sand [%] **Bench life 1-h** 15 minutes

	0,50%	0,60%	0,70%	0,80%	0,90%	1,00%	1,10%
100%	80 19%	106 25%	132 31%	158 37%	184 44%	210 50%	236 56%
80%	99 23%	127 30%	156 37%	184 44%	213 50%	241 57%	270 64%
60%	117 28%	148 35%	179 42%	210 50%	241 57%	273 65%	304 72%
40%	136 32%	170 40%	203 48%	237 56%	270 64%	304 72%	337 80%
20%	155 37%	191 45%	227 54%	263 62%	299 71%	335 79%	371 88%
0%	174 41%	212 50%	251 59%	289 68%	328 78%	366 87%	405 96%

Binder amount [%]

Upcoming Activities

- **From XRF results, an increase in MgO is observed**.

Start discussions with the supplier!

- **Particle analyses indicate that the "Roundness" of the recycled sand is the same as that of new sand.**

There is potential to scrub the sand further to achieve greater purity.

- **pH and conductivity appear to be decreasing lately, following the calibration of the Omega and cleaning of the Suction system**.
- **Manufacture test bars using the current sand with low pH and conductivity.**
- **Continue with the research**.

THE END