

Influence of the rotation parameters on the solidification conditions during mechanical stirring

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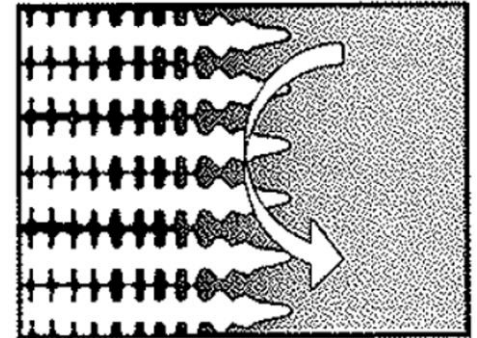
24.09.2024

| MOTIVATION

- › EMS-system reaches its technical limits
- › Mechanical stirring: **forced convection** at the solid/liquid interface at *every point* in the ingot over the *entire length*, right into the center, regardless of its dimensions

THEORETICAL BACKGROUND

- › Influence of fluid flow
 - › Melting of parts of the dendrites
 - › Reduction of the superheat



J.S. Dantzig, Solidification methods microstructure and modelling. Boca raton (2008), CRC Press.

Positive effect on the internal quality (equiaxed zone)

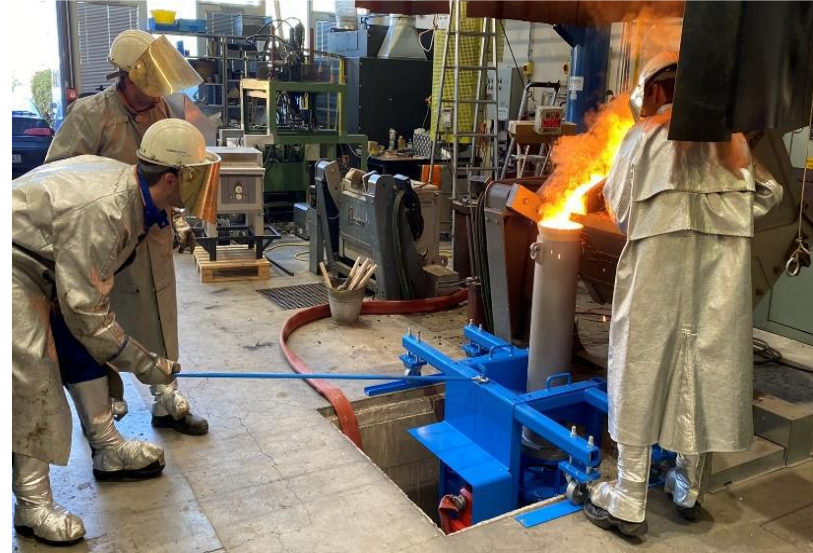
TRIAL SETUP

- › Mould dimension
 - › Height: 980 mm
 - › Inner diameter: 194,1 mm
- › Ingot weight: ~ 150 kg
- › 4 tests with different parameters
- › Alloy: Superaustenite



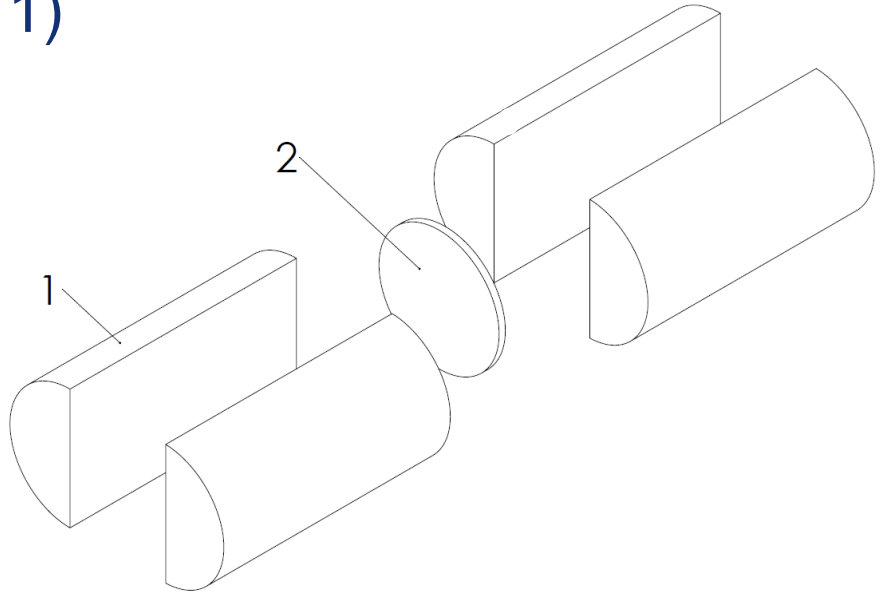
TRIAL EXECUTION

- › Placing the preheated funnel on the mould (400°C)
- › Start of the rotation (except for reference test 1)
- › Fastest possible casting from induction furnace
- › Adding of exothermic powder and casting powder
- › Rotation until complete solidification



| METALLOGRAPHY

- › 1 longitudinal sample (Pos. 1)
- › 1 round sample (Pos. 2)
- › V2A-etchant
 - › 100 ml H₂O
 - › 100 ml HCl
 - › 10 ml HNO₃
 - › 0,75 ml economy etchant according to Dr. Vogels
- › Etching time: 20 min at Room Temperature



| TEST PARAMETERS

› Alloy 1.4547 (X1CrNiMoCuN20-18-7)

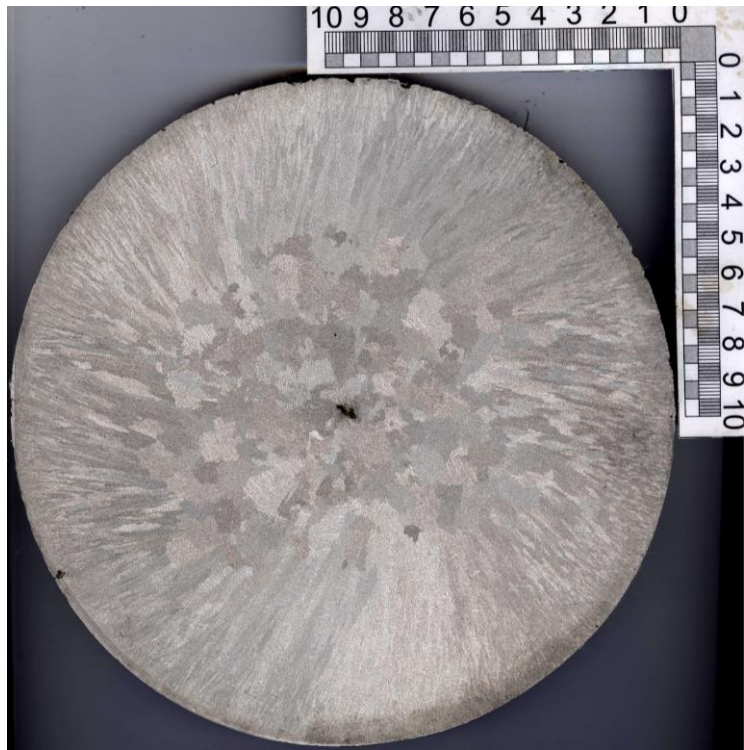
	C	Si	Mn	P	S	Cr	Mo	Ni	N	Cu
Target-Analysis [%]	0,015	0,2	0,6	0,004	-	19,8	6,3	18	0,19	0,65

› Parameters

	#1	#2	#3	#4	#5	#6
Rotation	-	Cont.	Alt.	Alt.	Alt.	Alt.
Rotation speed [turns/min]	-	73,8	73,8	24,6	9,84	4,92
Period length [s]	-	-	20	40	20	20
T (tapping) [°C]	1490	1491	1500	1505	1504	1501

| TEST #1

- › Reference test, no rotation

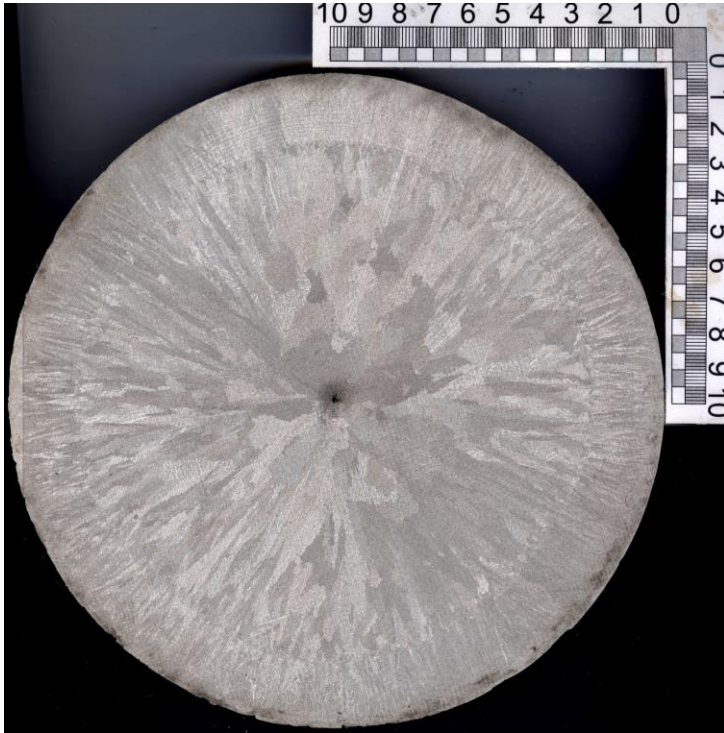


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TEST #2

- › Reference test, continuous Rotation
- › $v = 73,8 \text{ turns/min} = 0,75 \text{ m/s}$



TEST #3

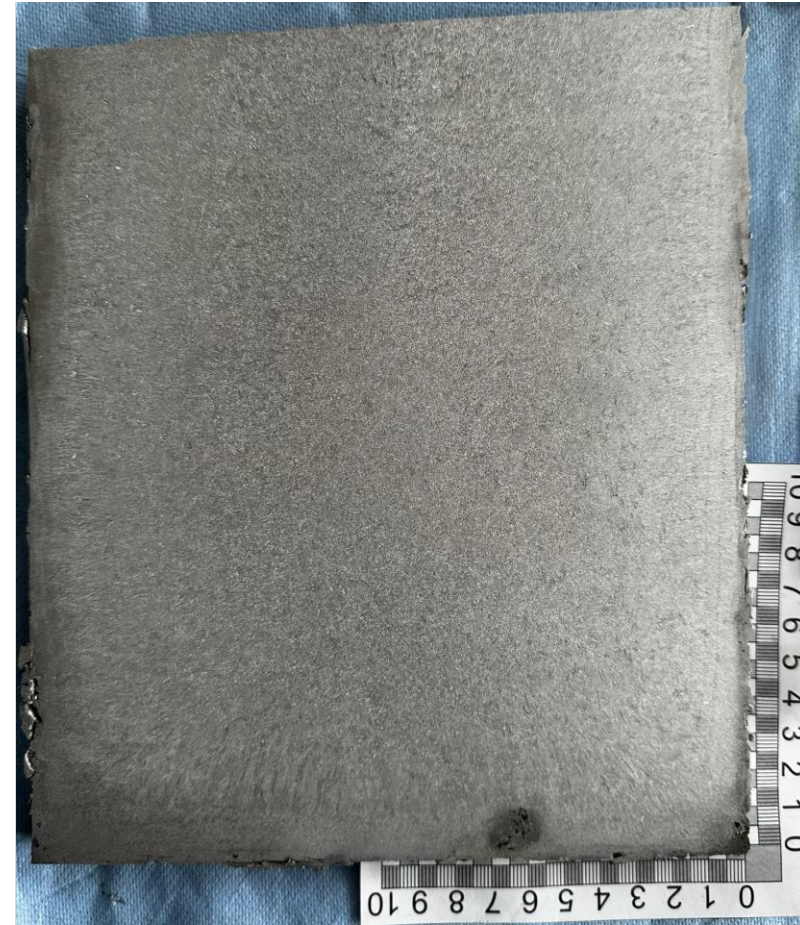
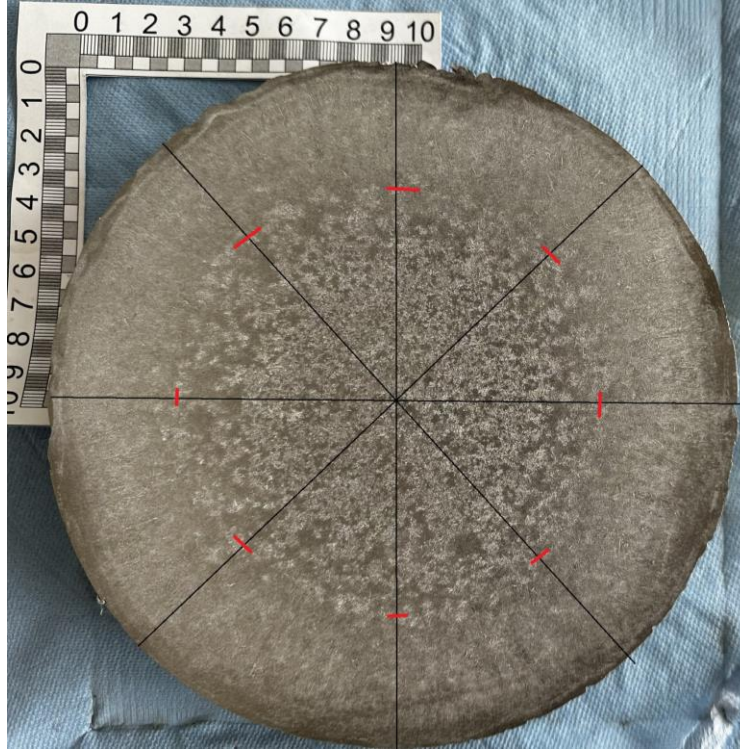
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- › Alternating rotation
- › $v = 73,8 \text{ turns/min} = 0,75 \text{ m/s}$, $T = 20 \text{ s}$



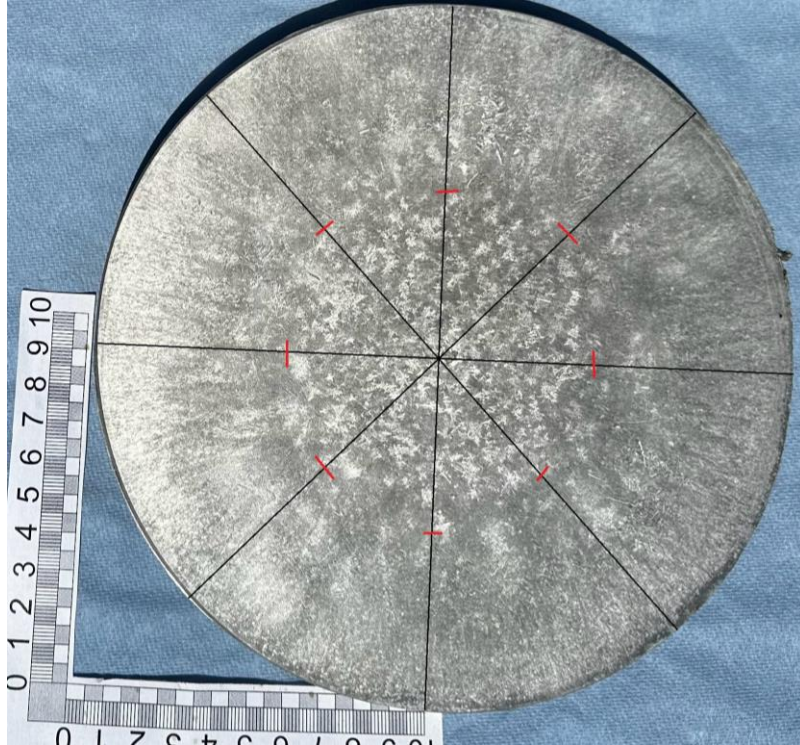
VERSUCH #4

- › Alternating Rotation
- › $v = 24,6 \text{ turns/min} = 0,25 \text{ m/s}$, $T = 40\text{s}$



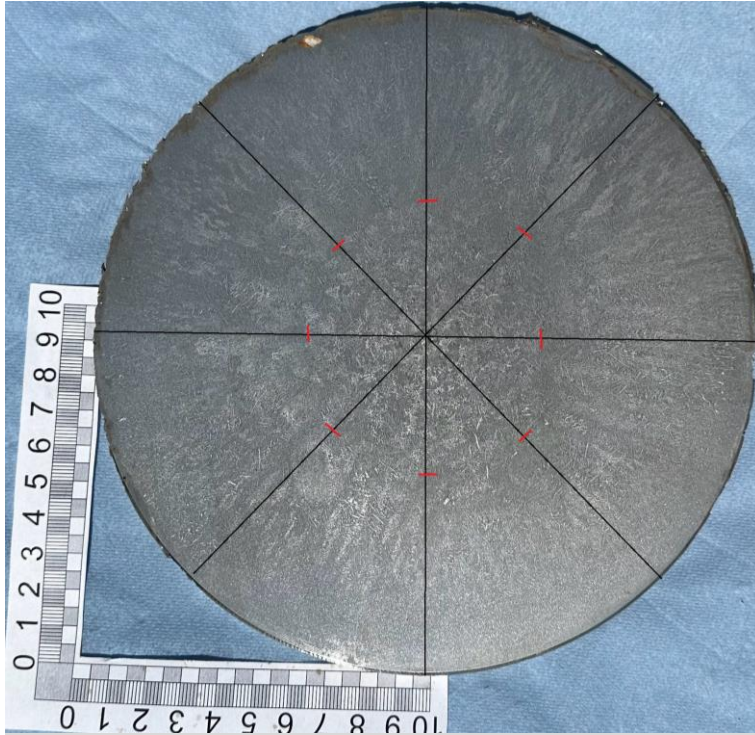
| TEST #5

- › Alternating Rotation
- › $v = 9,84 \text{ U/min} = 0,1 \text{ m/s}$, $T = 20 \text{ s}$

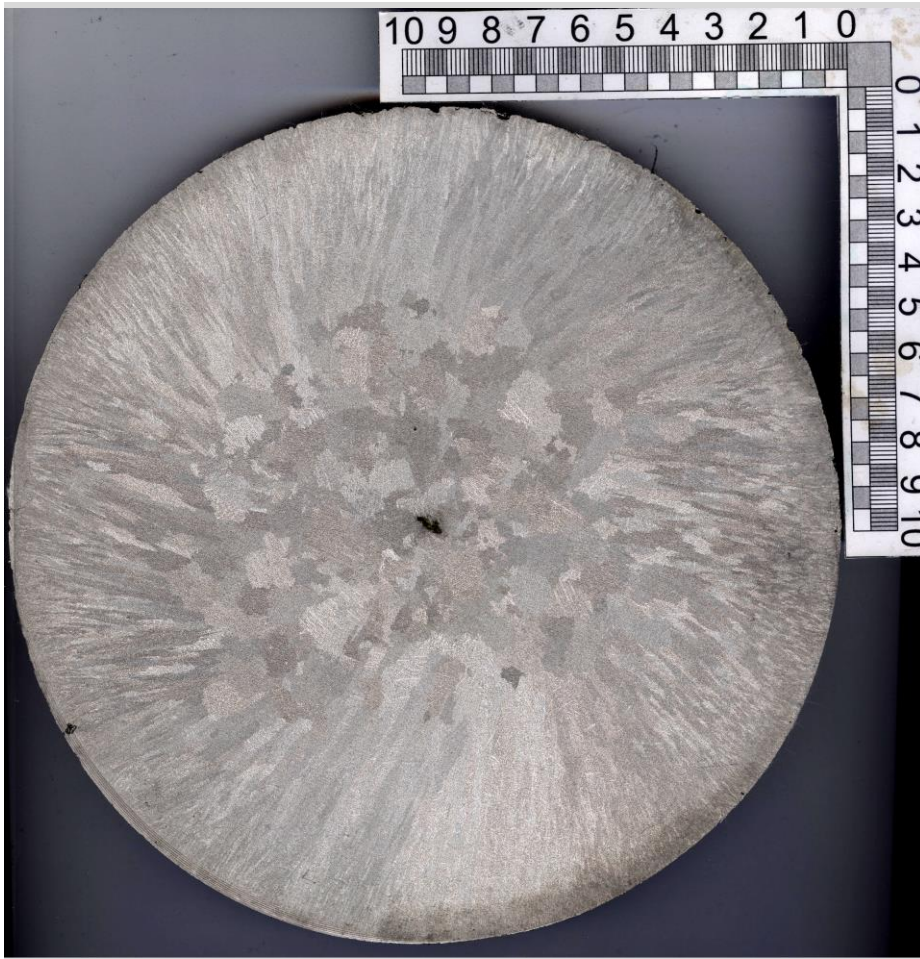


| TEST #6

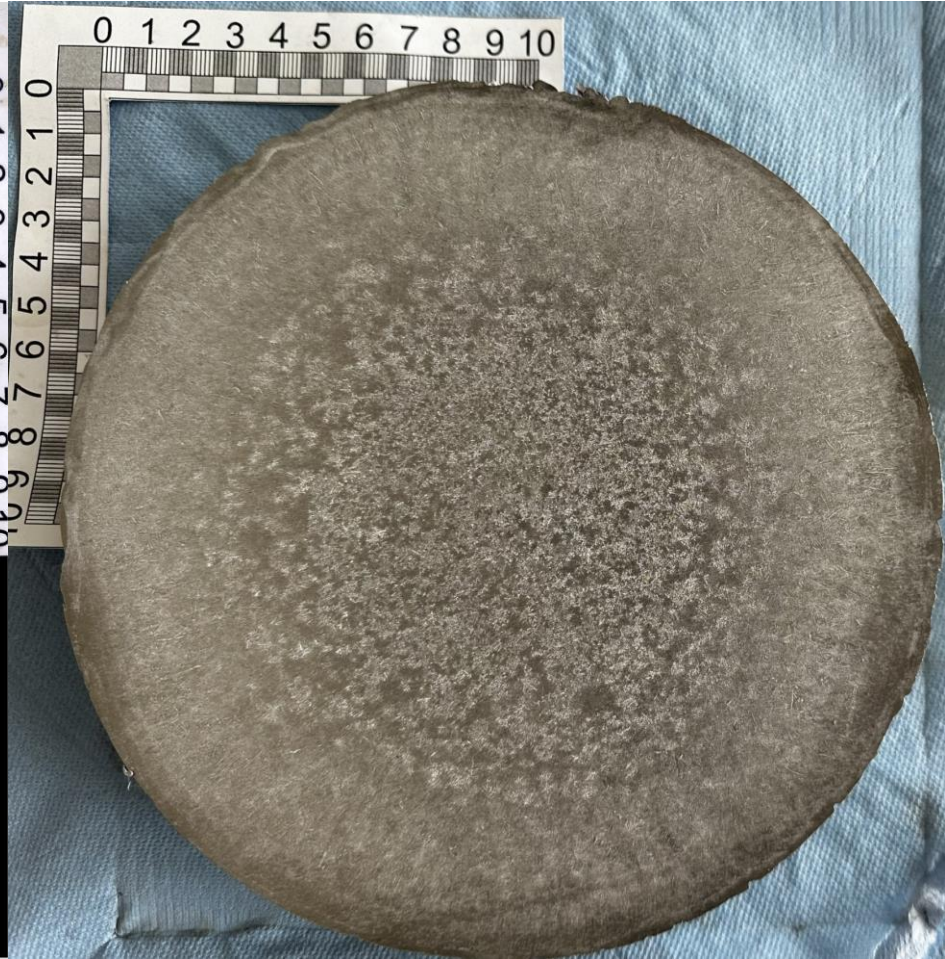
- › Alternating Rotation
- › $v = 4,92 \text{ U/min} = 0,05 \text{ m/s}$, $T = 20 \text{ s}$



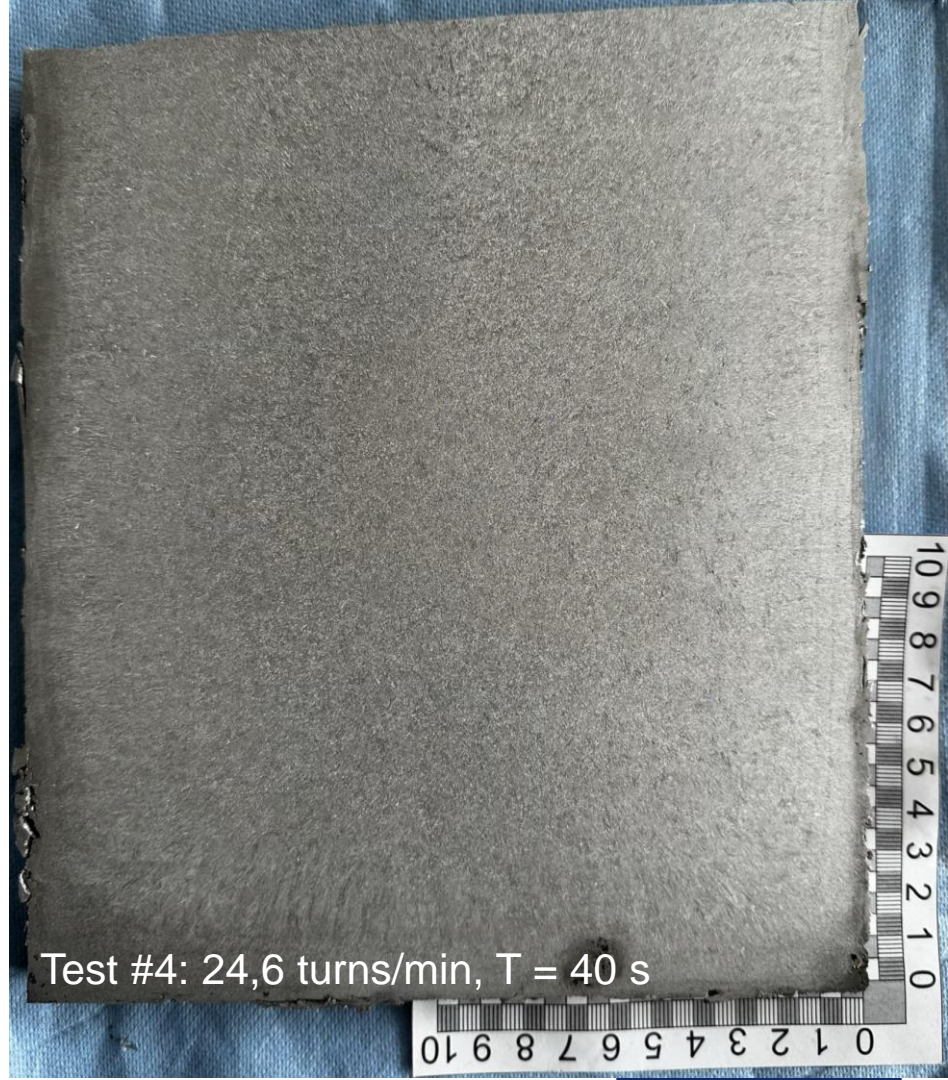
COMPARISON

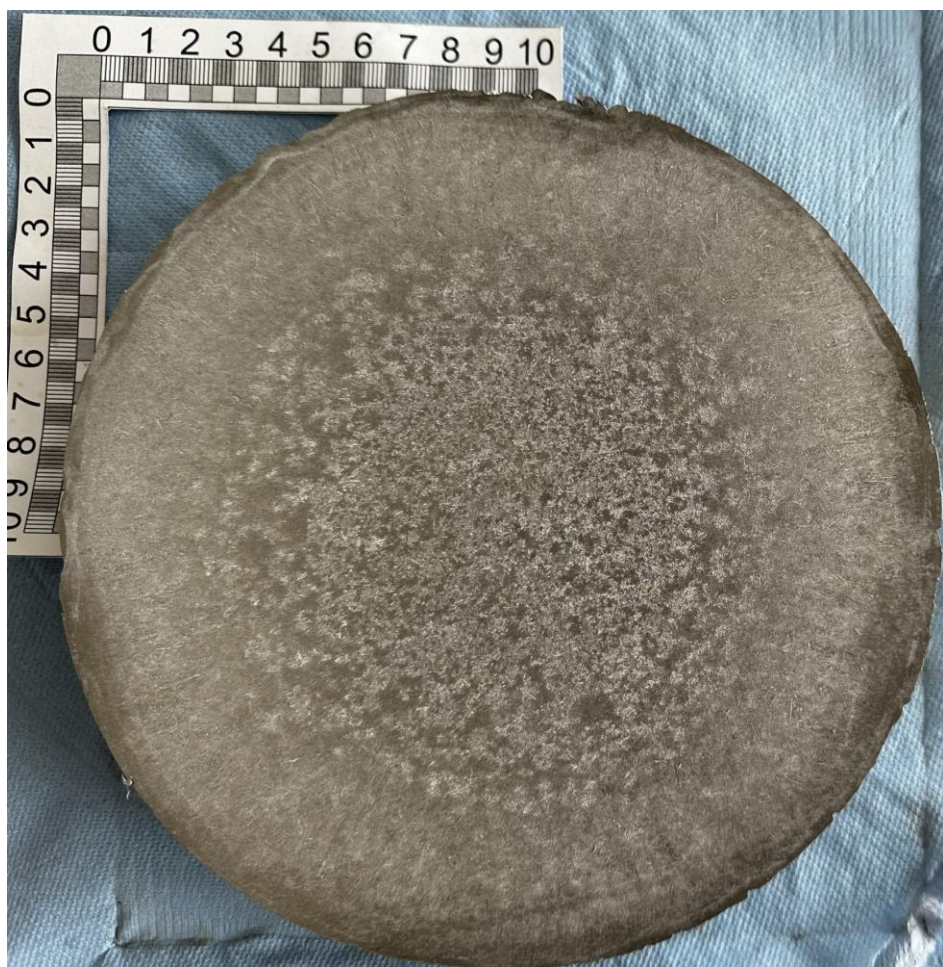


Test #1: No Rotation

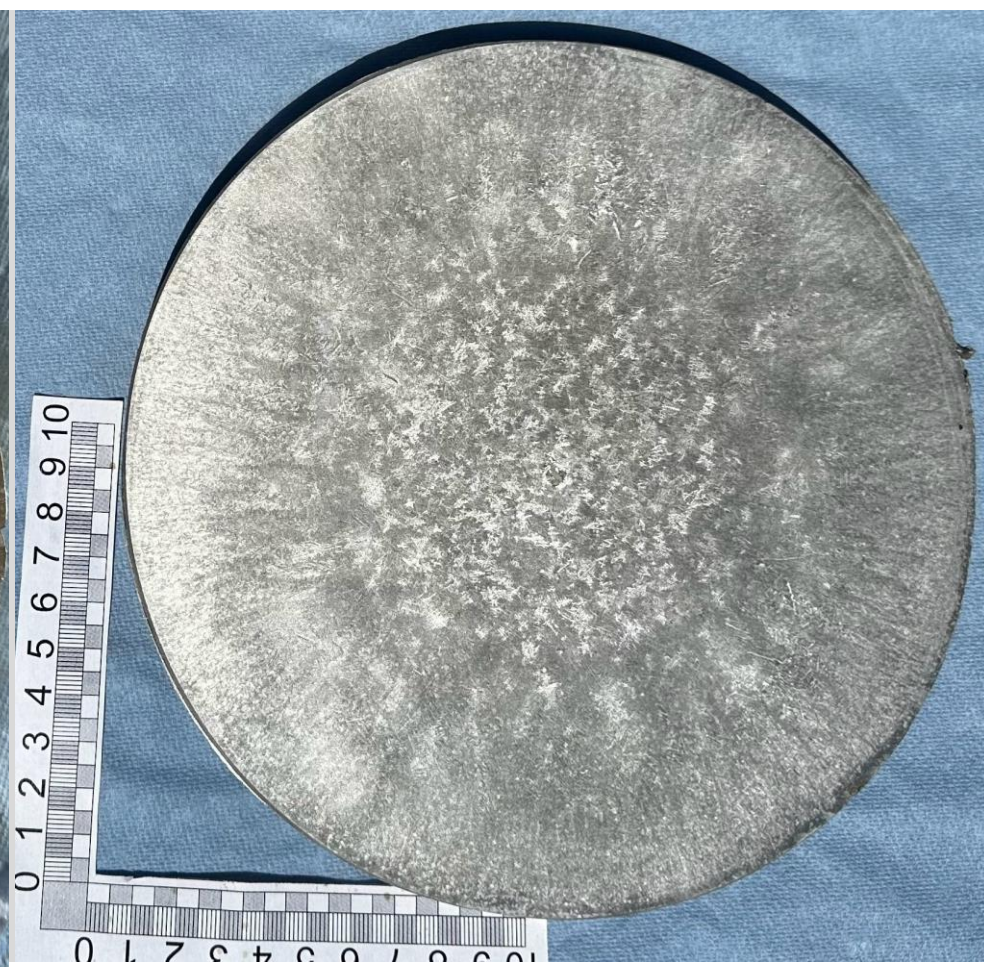


Test #4: 24,6 turns/min, $T = 40$ s

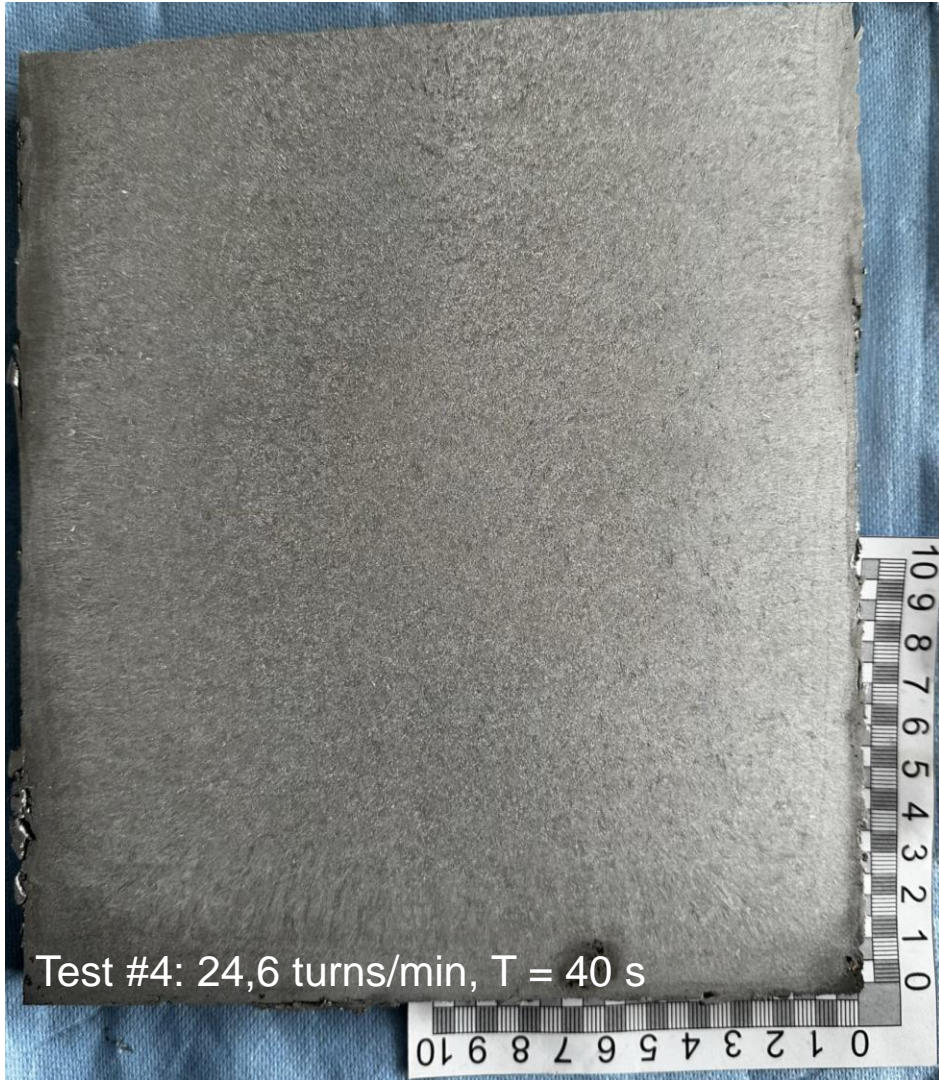




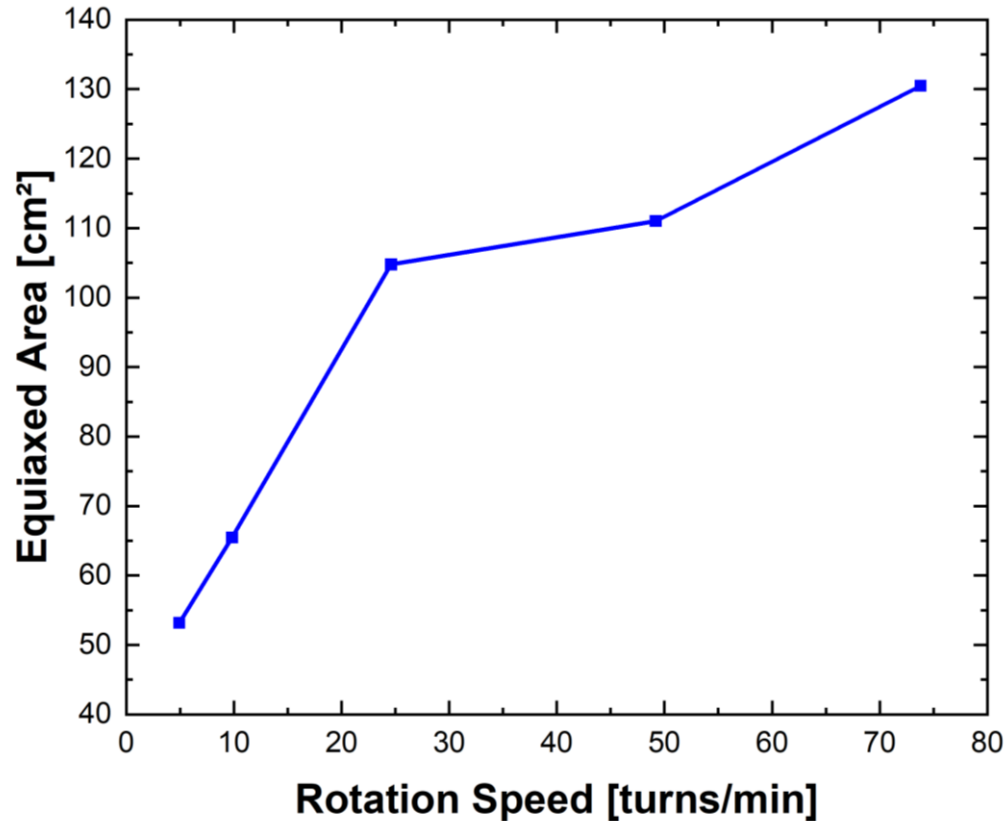
Test #4: 24,6 turns/min, $T = 40$ s



Test #5: 9,84 turns/min, $T = 20$ s



EQUIAXED AREA

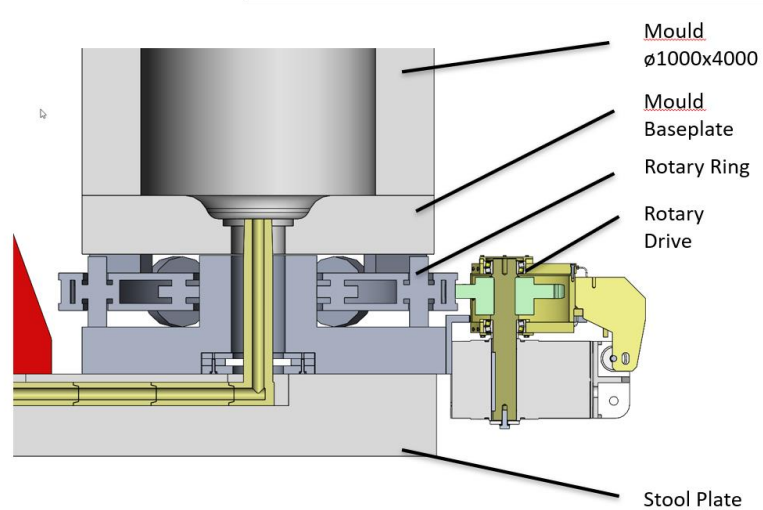
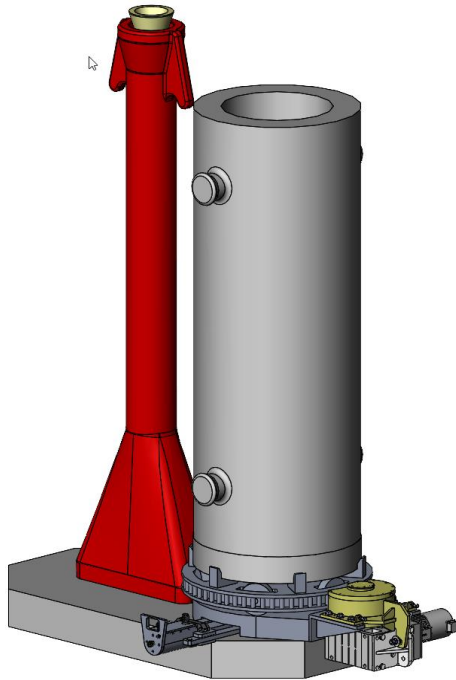


| CONCLUSIO

	#3	#4	#5	#6
Rotation speed [turns/min]	73,8	24,6	9,84	4,92
Period length [s]	20	40	20	20
T (tapping) [°C]	1500	1505	1504	1501
Start equiaxed zone [cm]	3,3	3,8	5,2	5,6
Stirring bands	Yes	No	No	No
Center porosities	Yes	No	No	No

| NEXT STEPS

> Upscaling (Ingot diameter = 1000mm)



THANK YOU

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