Óbuda University – Doctorate School on Materials Science and Technologies Obuda University, Hungary

Testing in Semi-Solid State

by

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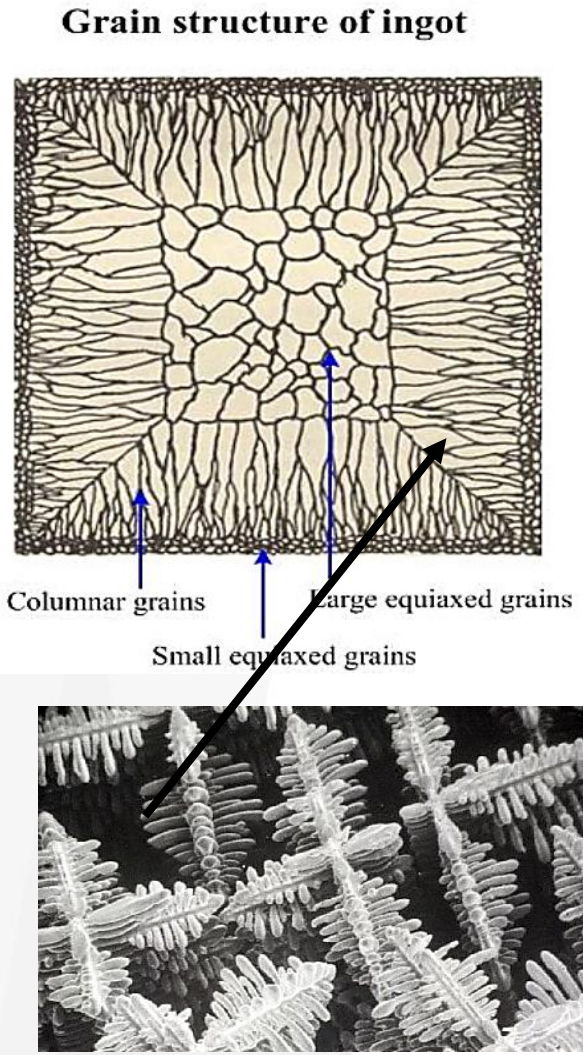
Outline

- ✓ Background of Dendritic and Non-Dendritic Structure
- ✓ Microstructures in Semisolid Metalworking
- ✓ Semi-Solid Process Window
- ✓ Background of Semi-Solid
- ✓ Aluminum Alloys
- ✓ Previous work
- ✓ Results and Conclusion
- ✓ Activity of all Semesters
- ✓ Future Research Plan

Dendritic and Non-Dendritic Structure

What is dendritic structure?



Dendritic structure of material

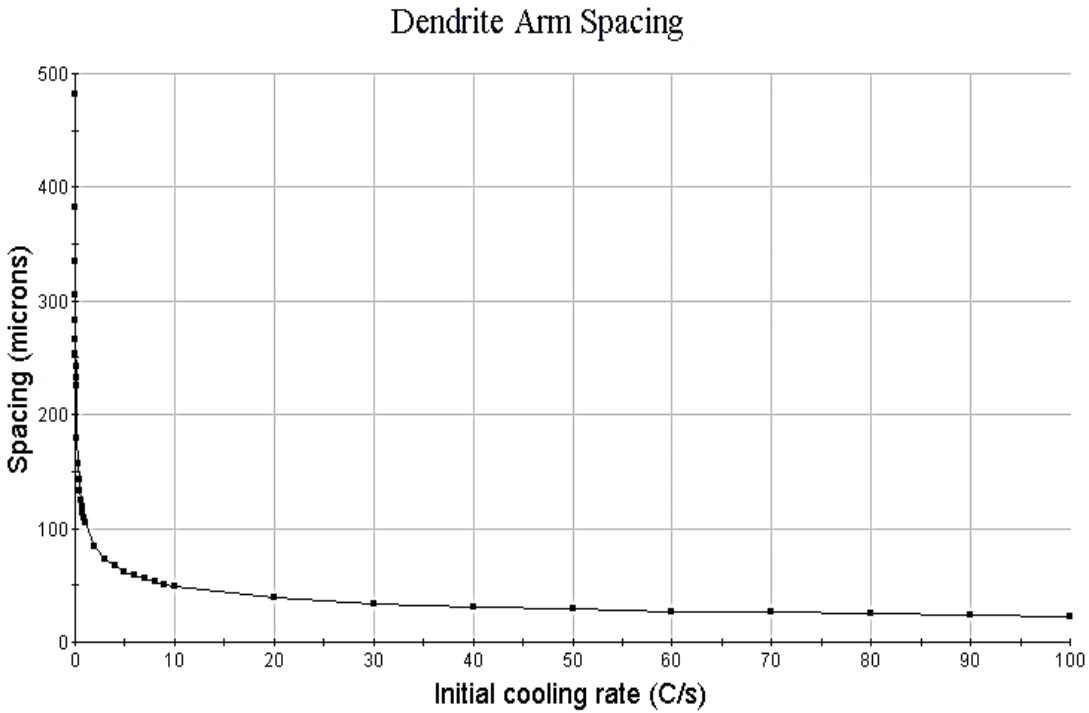


Figure 1. Dendritic arm spacing

Dendritic and Non-Dendritic Structure

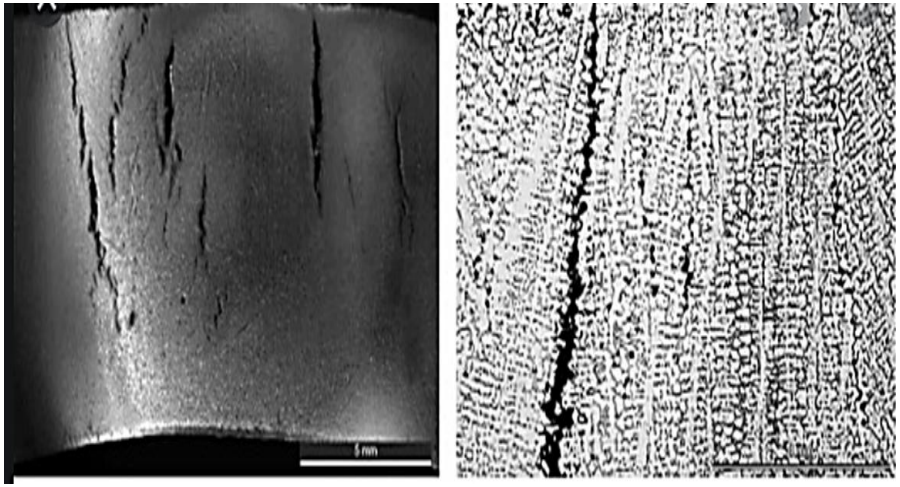
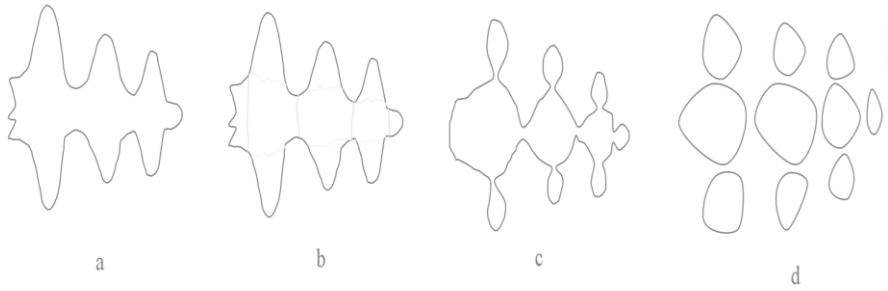


Figure 2. Failure Arm Dendritic structure



Dendritic arm structure **Spheroidal shape**

(a and b) The shear stresses change the shape of the solid particles from dendritic (c and d) to globular

Microstructural changes

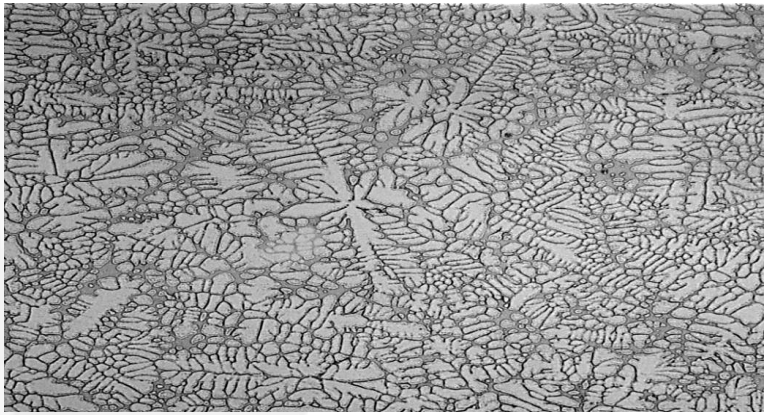
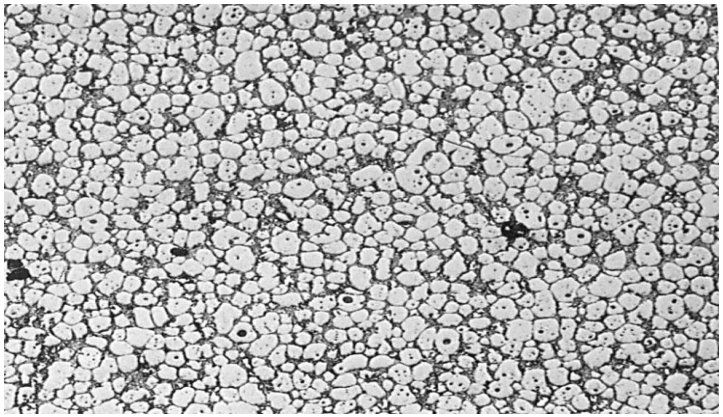
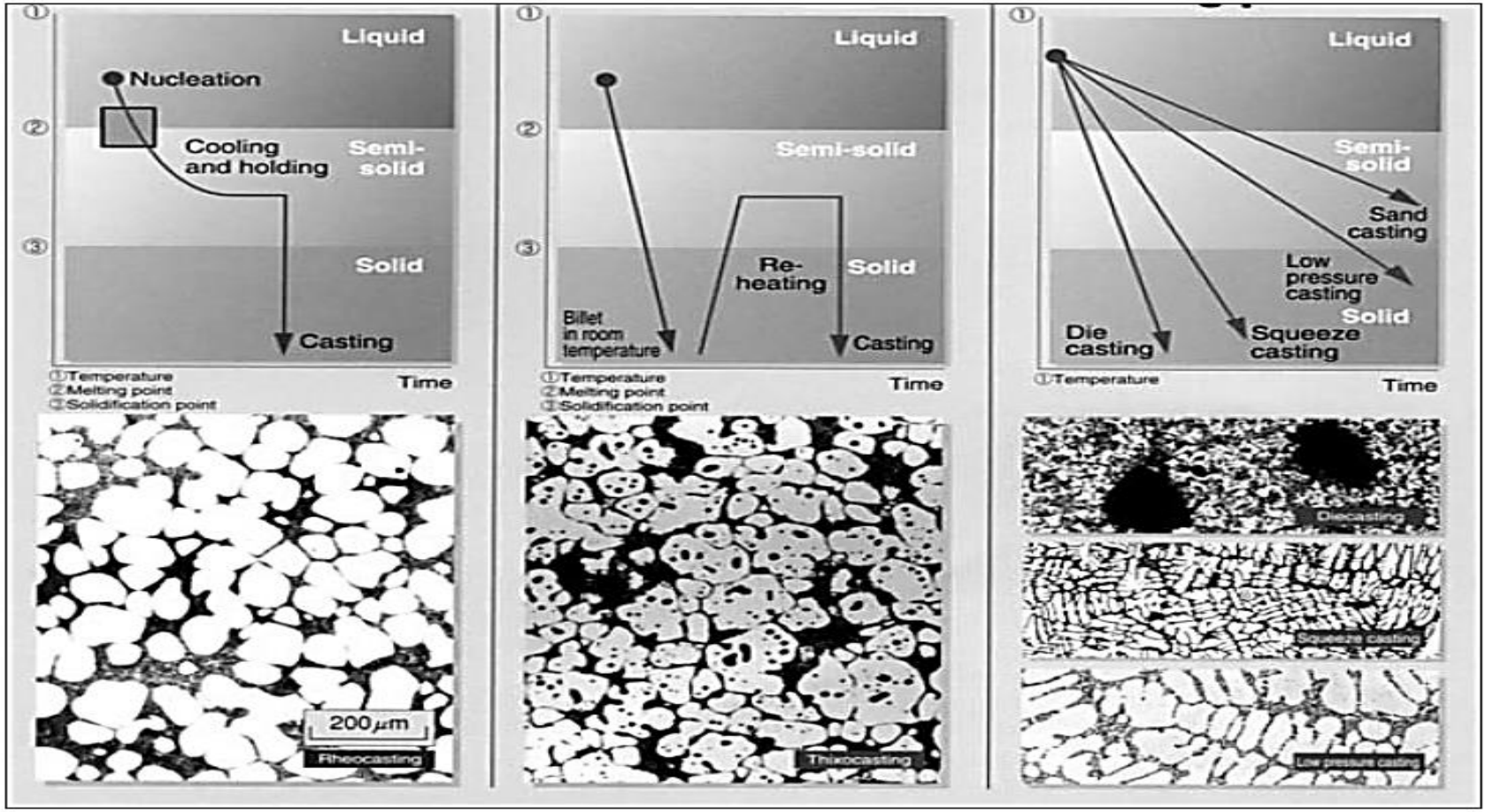


Figure 3. a.Typical Dendritic Microstructure



b.Typical Non Dendritic Microstructure

Microstructures in Semisolid Metalworking



(a) (b) (c)

Figurev4. Process comparison between (a) direct semi-solid metalworking, (b) indirect semi-solid metalworking, and (c) conventional casting processes

Semi-Solid Process Window

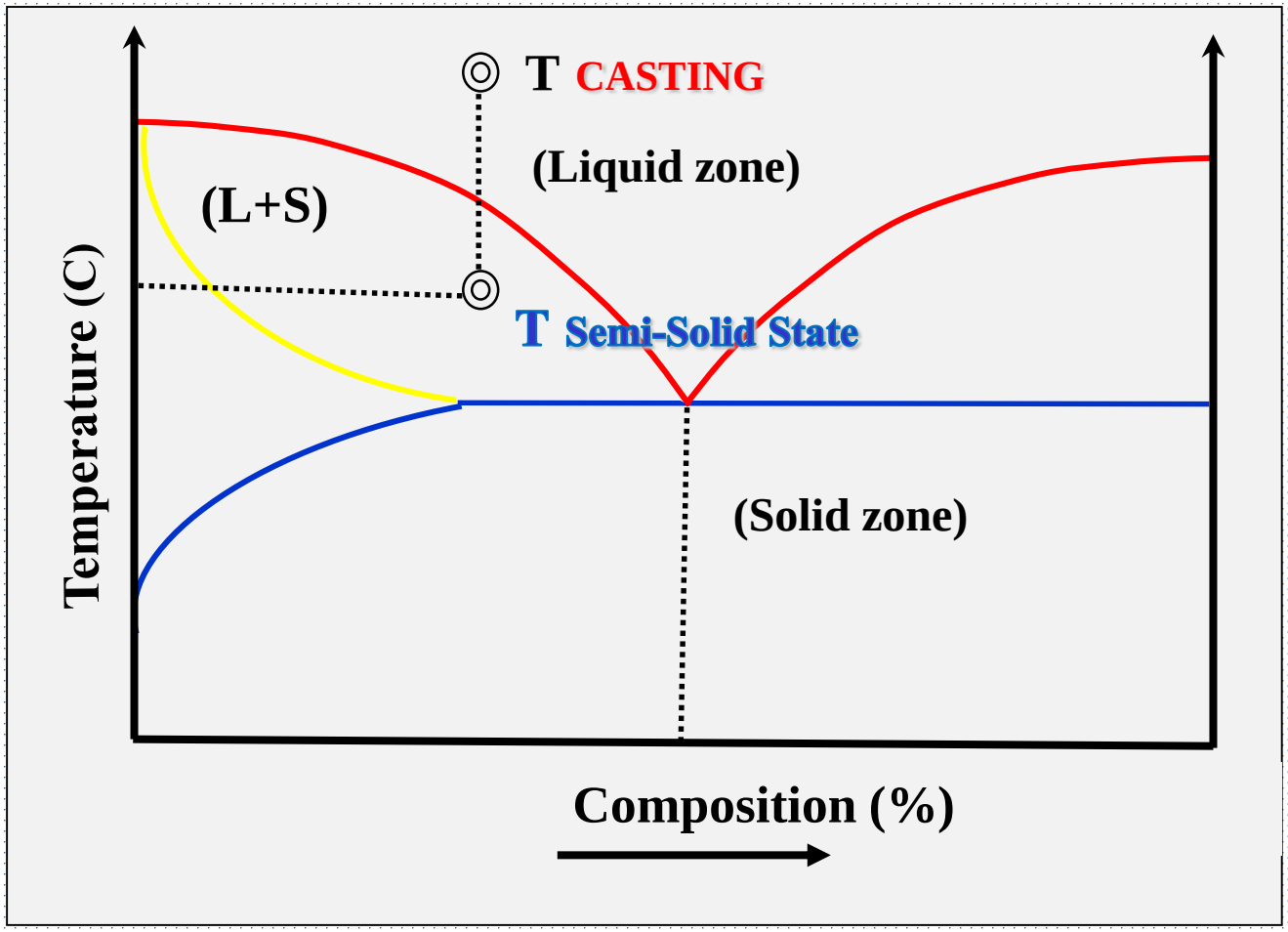


Figure 5. Phase diagram

Background of Semi-Solid

Semi - Solid Methods

1. Semi-Solid Rheocasting (SSR) process
2. Magneto Hydrodynamic (MHD) Method vertical, horizontal, and helical
3. Cooling Slope Method (CS)
4. SSR with CS techniques (SSR + CS)

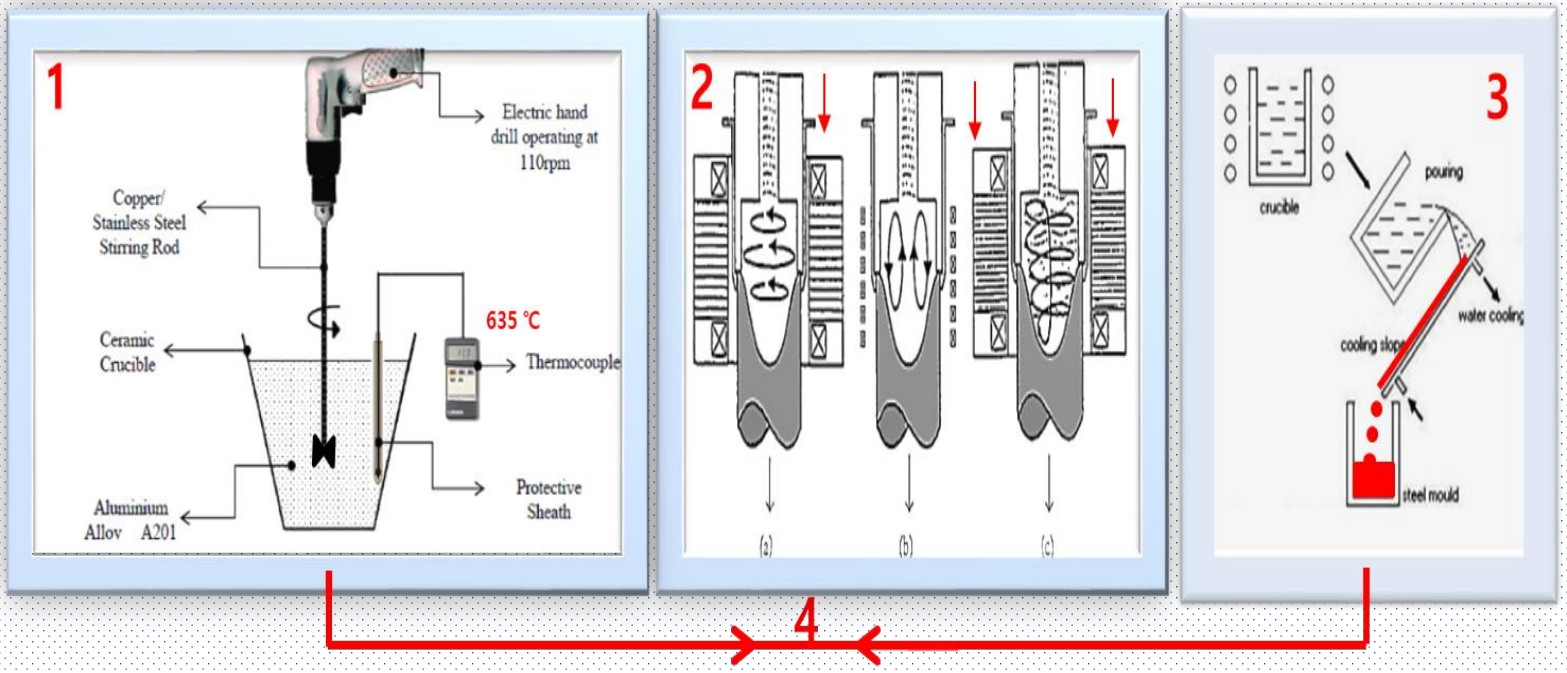


Figure 6. Semi - Solid Methods

Aluminum Alloys

Al alloys	Wt %	Cu	Mn	Mg	Si	Fe	Ti	Ag	Ca	Cr	Zn	Ni	Pb	Sn
EN AW 2011	Bal.	4.7	0.31	0.28	0.10	0.05	0.21	0.59	-	-	-	-	-	-
EN 6063-T6	Bal.	0.002	0. 1	0.45	0.32	0.26	0.1	-	0.00 1	0.25	0.00 1	-	-	-
EN AW 6082	Bal.	0.1	0.4	0.5	0.33	0.25	0.1	-	-	0.25	0.2	-	-	-
EN AB 4244	Bal.	0.15	0.35	0.25	0.7	0.45	0.05	-	-	-	0.15	0.15	0.15	0.15

Table 1. Chemical composition of all aluminium alloys

Previous work

Microstructure Results

Aluminum EN AW 2011 alloy

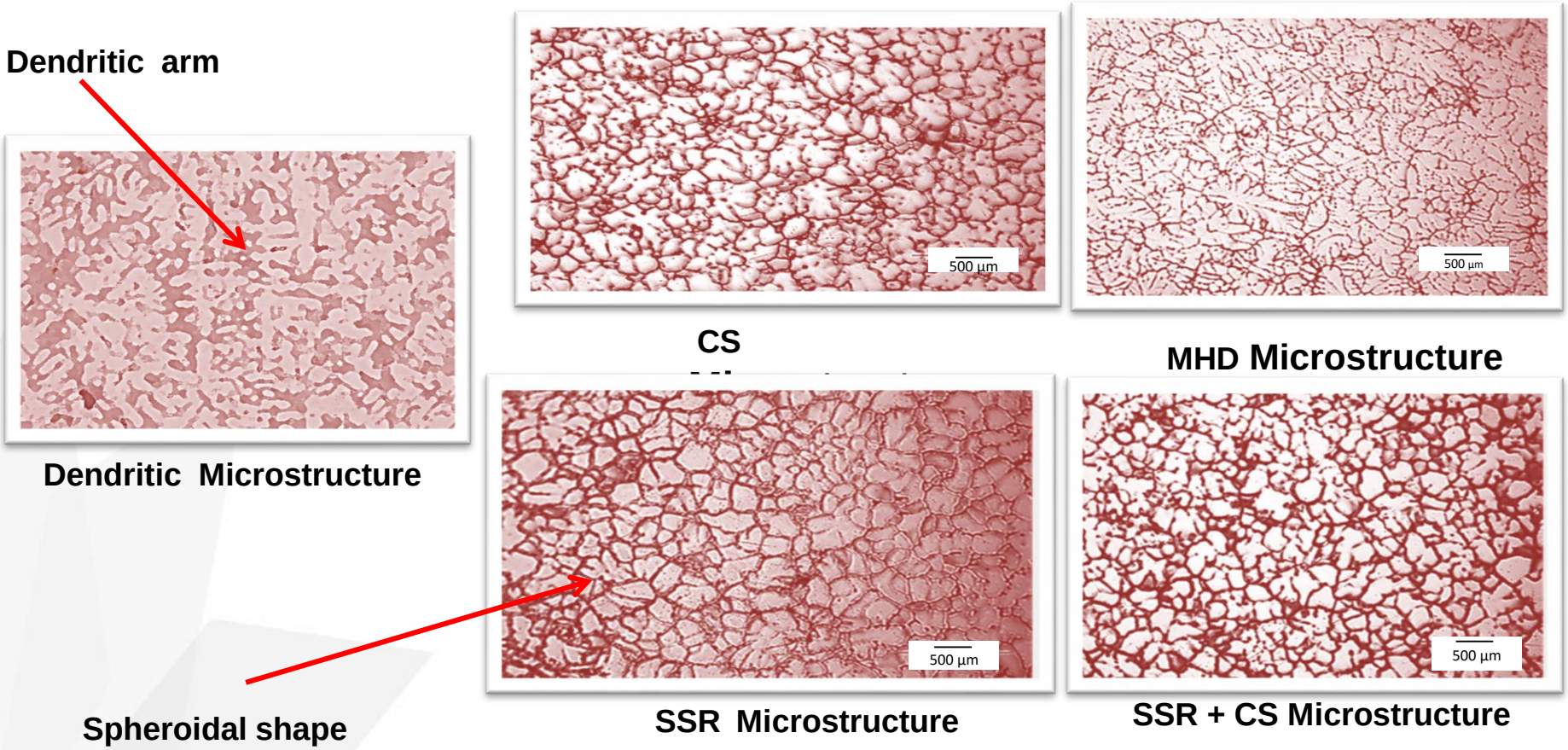


Figure 7. Microstructure of all Semi - Solid Methods

Previous work

Microstructure Results

Shape Factor (*Solid Fraction*) = $4\pi A / P^2$

P = the average perimeter.

A = the average area of the grains

S. F. = value should be between 0.6 and 1.0

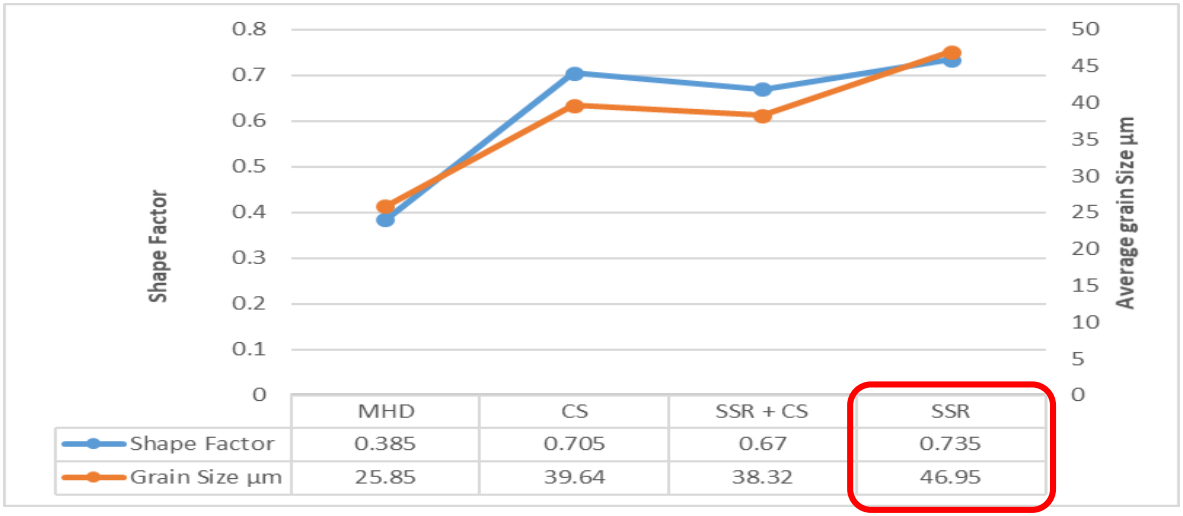


Figure 8. Shape Factor and Grain size of variance types of Alloy A201

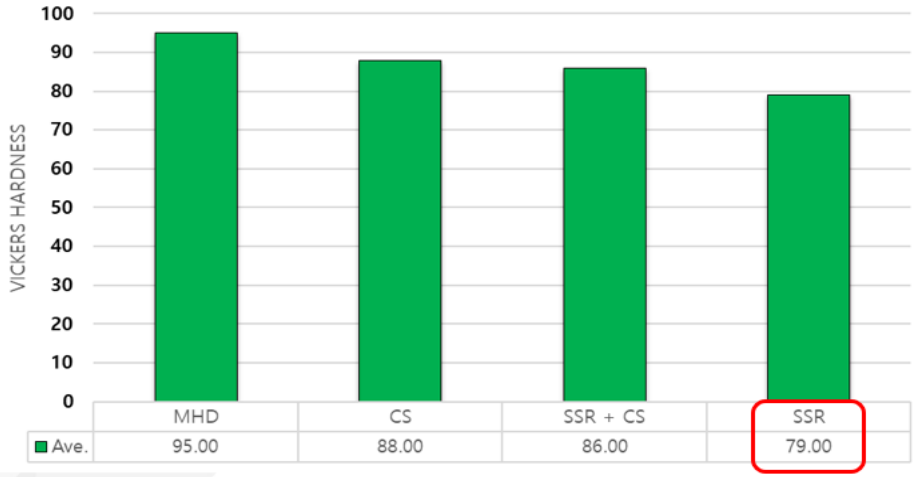


Figure 9. Vickers Hardness of all Methods

Previous work

- **Tensile test and Compression test**

Aluminum EN 6063-T6 Extrusions alloy

Aluminum type`	Yield Strength (σy) MPa	Ultimate Tensile Stress (UTS) MPa	% Strain
Aluminium Extrusions	215	241	0.080
Aluminium Rheocasting	290	340	0.110

Table 2. Results of the stress-strain curve of the two-sample alloy.

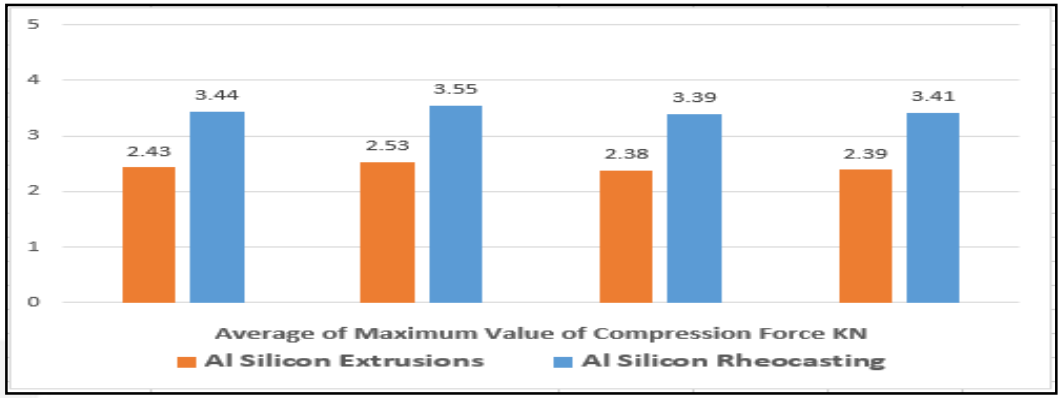


Figure 10. The Maximum Value of Rheocasting alloy and Extrusions alloy Compression Force

The average maximum force for Rheocasting sample was 3.44 KN when the average maximum force for Extrusions sample was 2.43 KN

Previous work

- **Brinell Hardness test**

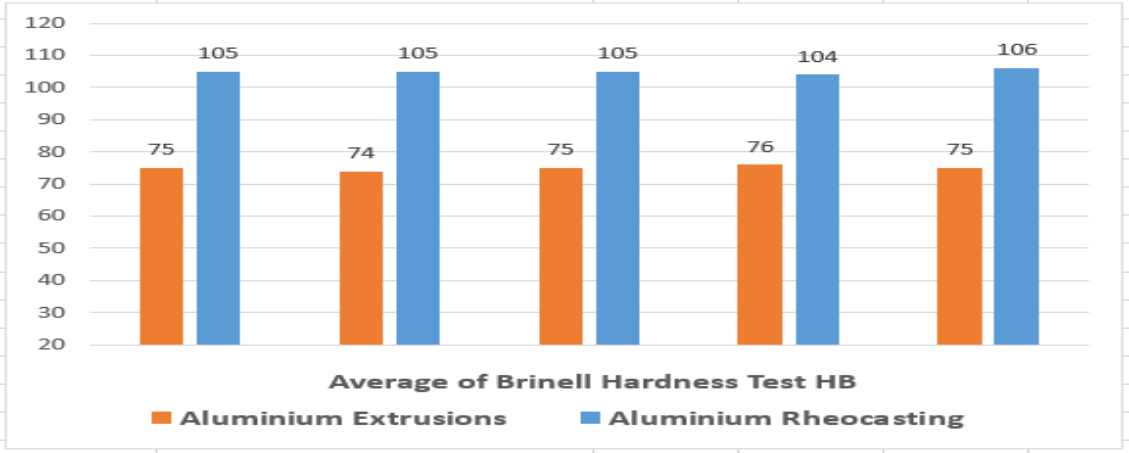
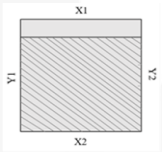


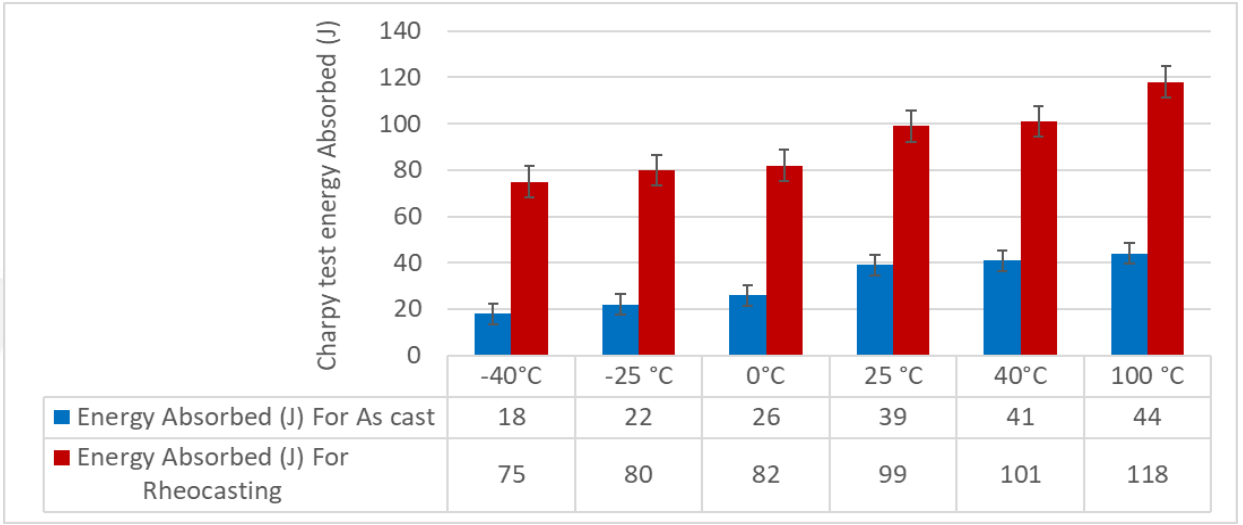
Figure 11. Hardness Brinell of Aluminium EN6063-T6 Extrusions and Rheocasting alloy

- **Impact test**

Aluminum EN AW 6082 alloy

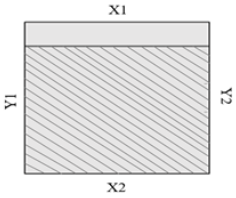


standard cross-section area of Charpy impact test



	-40°C	-25 °C	0°C	25 °C	40°C	100 °C
Energy Absorbed (J) For As cast	18	22	26	39	41	44
Energy Absorbed (J) For Rheocasting	75	80	82	99	101	118

Figure 12. the values energy absorbed in casting and rheocasting samples



Previous work

- Impact test

standard cross-section area of Charpy impact test

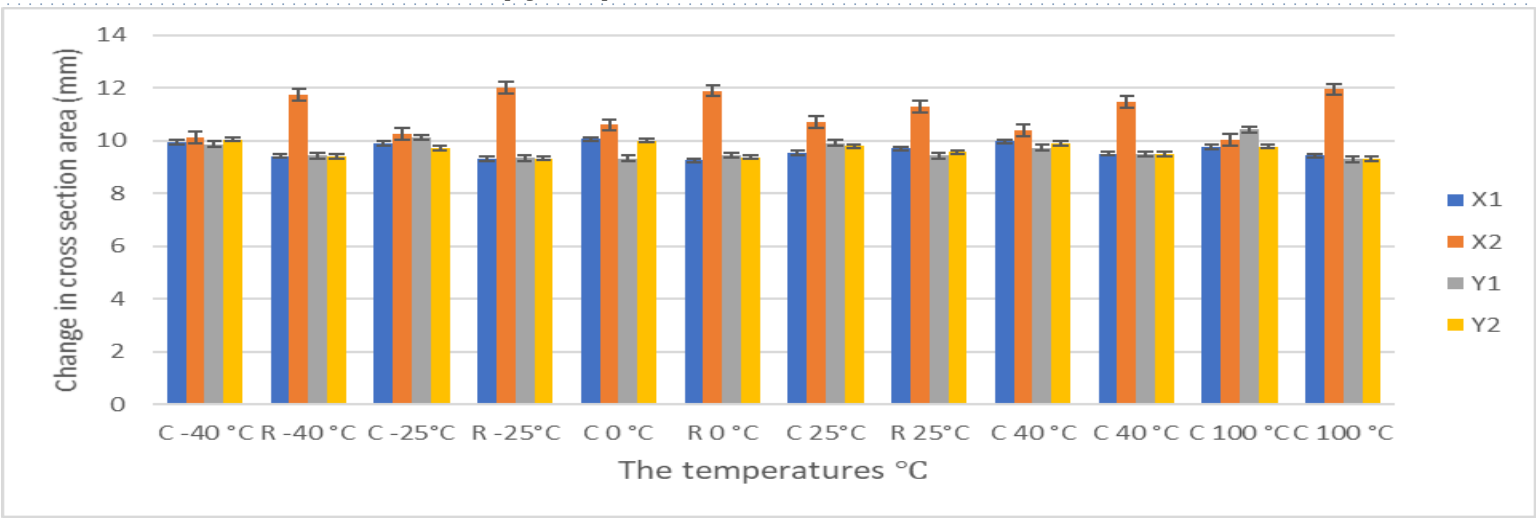


Figure 13. Calculate explosive edge in the Impact Test

- Hardness test

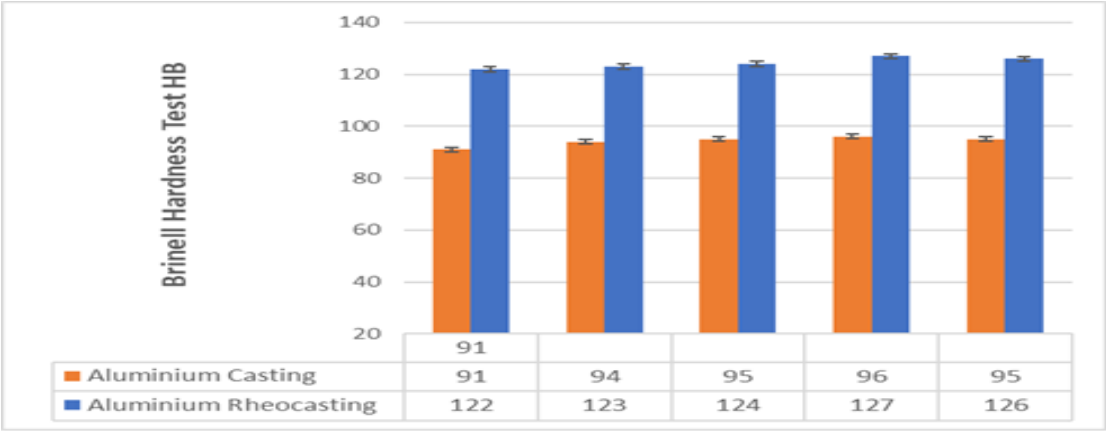


Figure 14. Average hardness Brinell of Aluminium EN AW 6082 and Rheocasting alloy

Previous work

Scanning Electron Microscope (SEM) for casting and rheocasting samples at room temperature

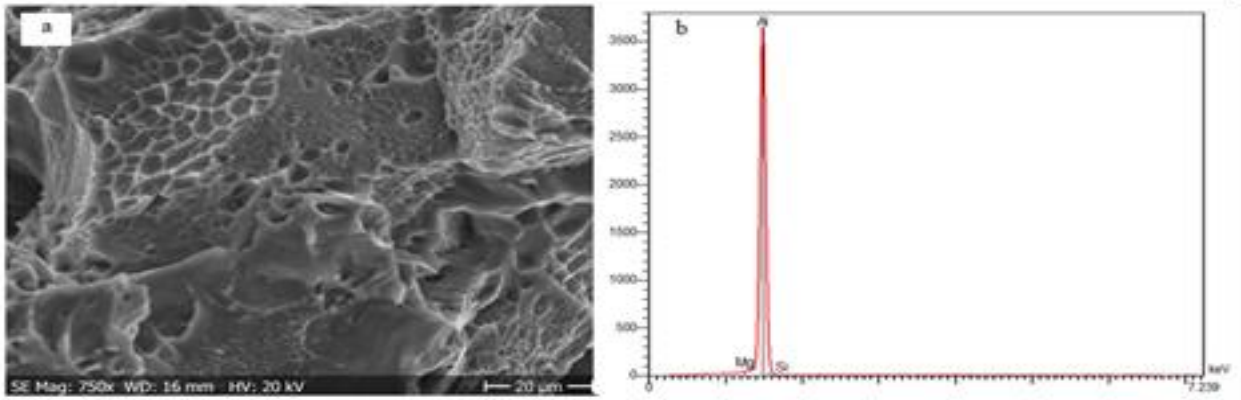


Figure 15. a. The SEM image of grain boundaries in the undeformed part of casting Specimen (39J) b. Energy-dispersive X-ray spectroscopy (EDS) spectrum revealing the precipitation of Mg_2Si of casting Specimen.

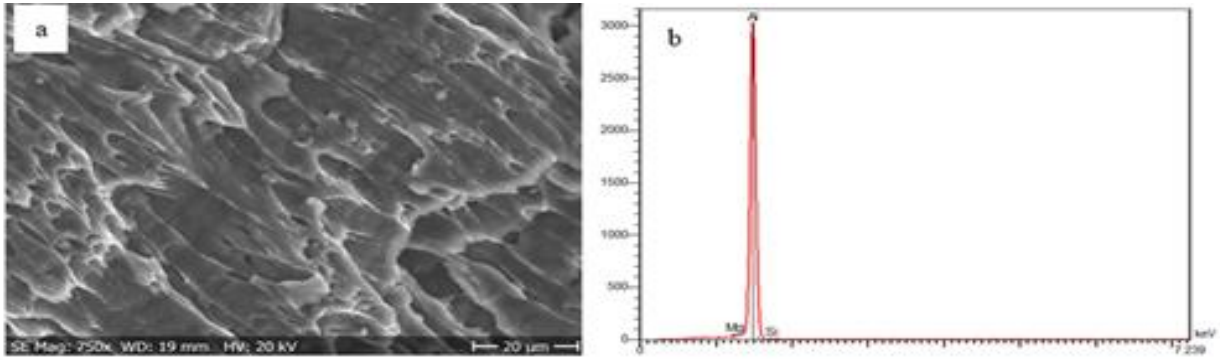


Figure 16. The SEM image of plastic deformation at the grain boundaries of rheocasting Specimen (99J) b. Energy-dispersive X-ray spectroscopy (EDS) spectrum revealing the precipitation of Mg_2Si of rheocasting Specimen.

Results and Conclusion

Characterization of Microstructure and Shrinkage Porosity of aluminium alloy EN AB 4244 Casting and Rheocasting Semi-Solid Alloy

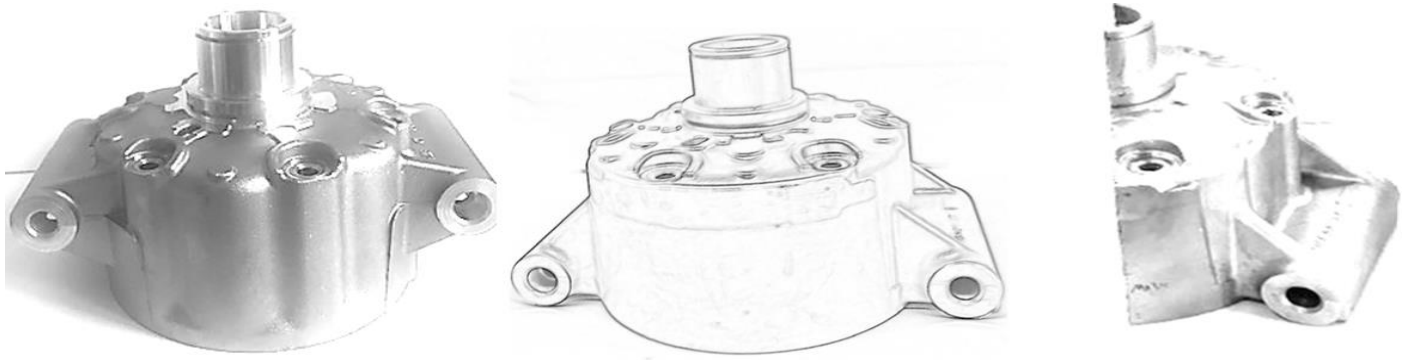
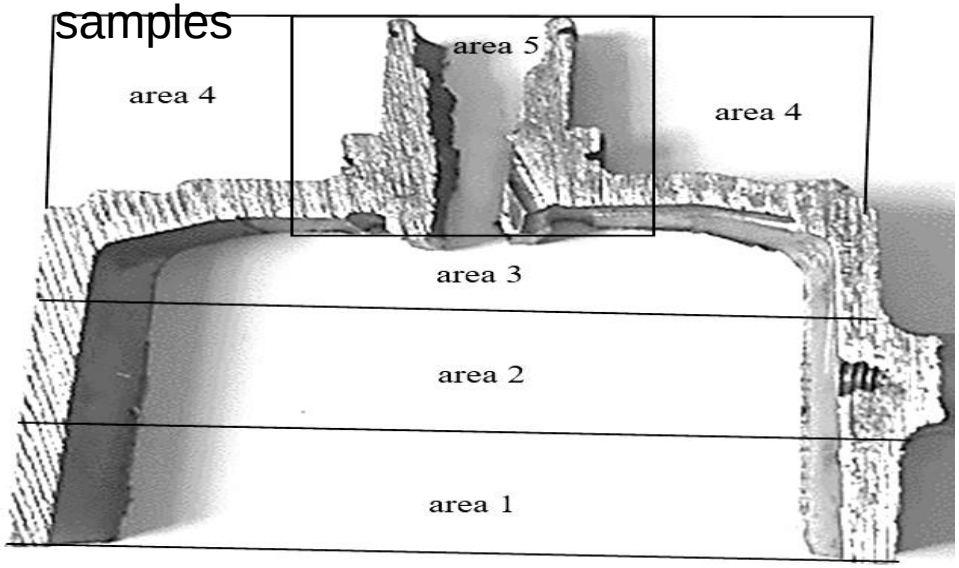


Figure 17 Casting and Rheocasting application samples

Casting sample



Rheocasting sample

Figure 18 The five-area macrostructure of Casting and Rheocasting application samples

Results and Conclusion

Figure 19 Casting and Rheocasting application mounting samples

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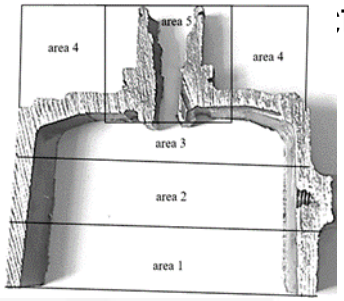


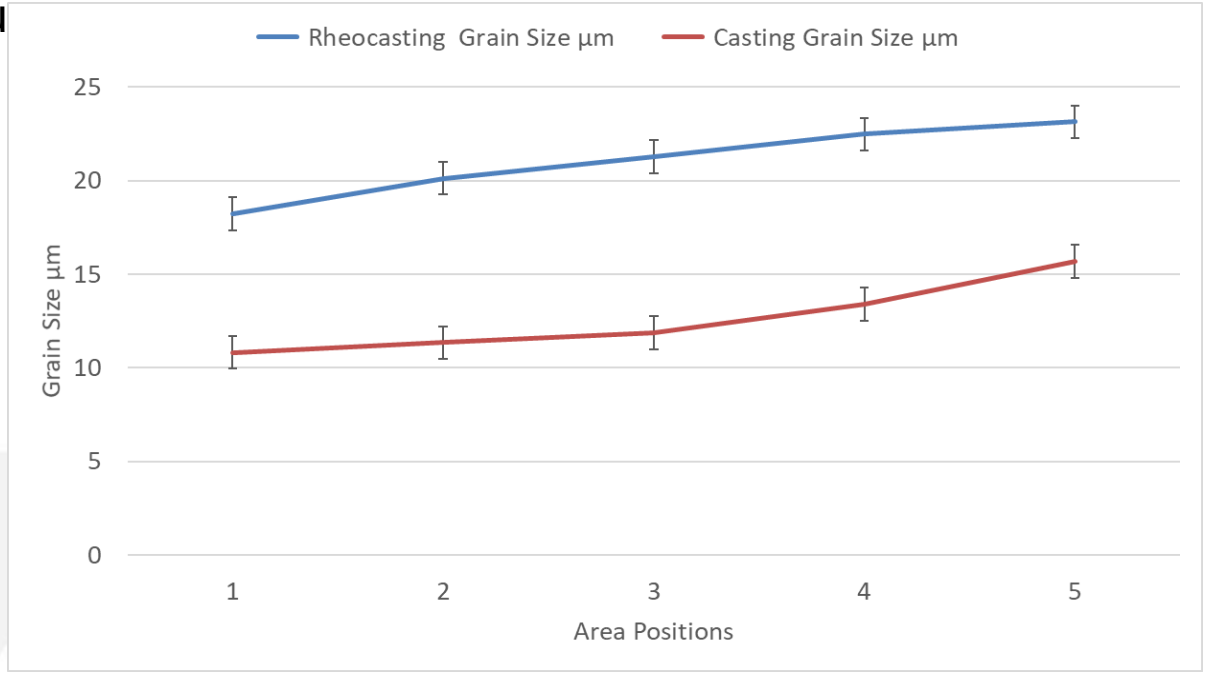
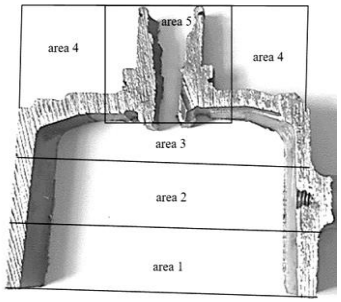


Figure 21 primary α grain size of Rheocasting and Casting application samples.

Results and Conclusion



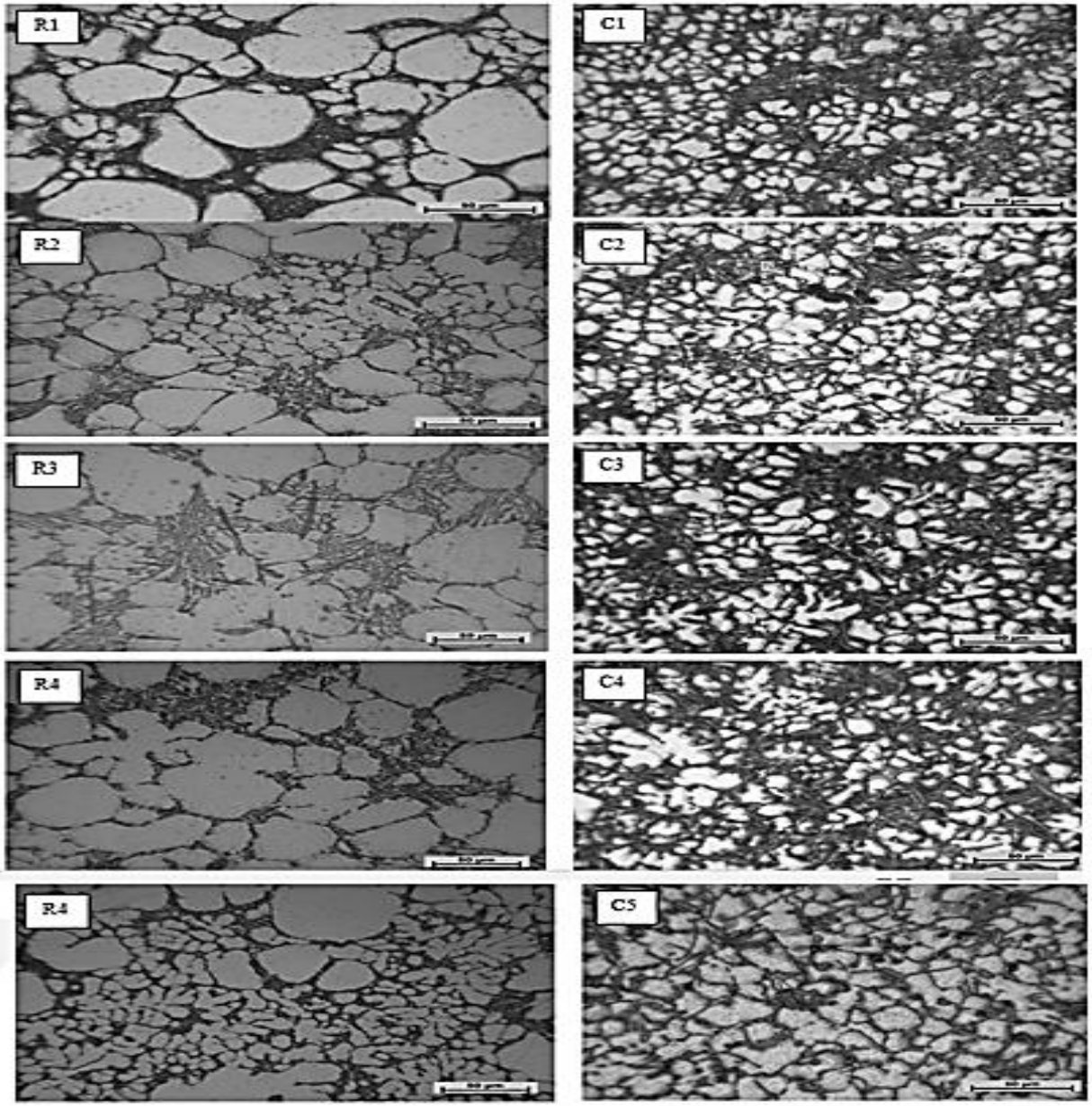


Figure 22 Representative microstructure of Casting and Rheocasting application samples

Results and Conclusion

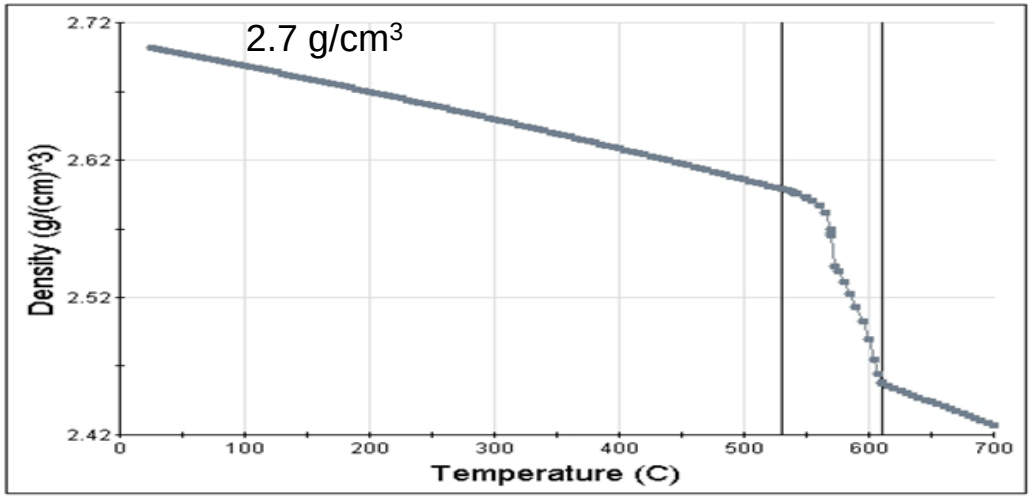
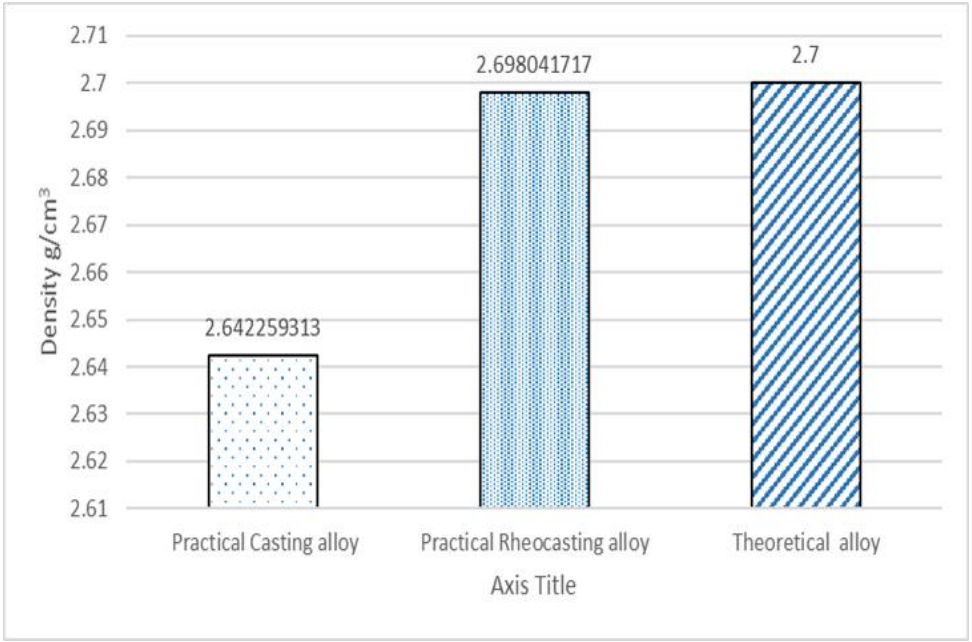


Figure 23 Using program (JMatPro) to find the density of each alloys theoretically

The Archimedes method



Theoretically

Figure 24 The theoretically and Practically densities of casting alloy and rheocasting sample

Results and Conclusion

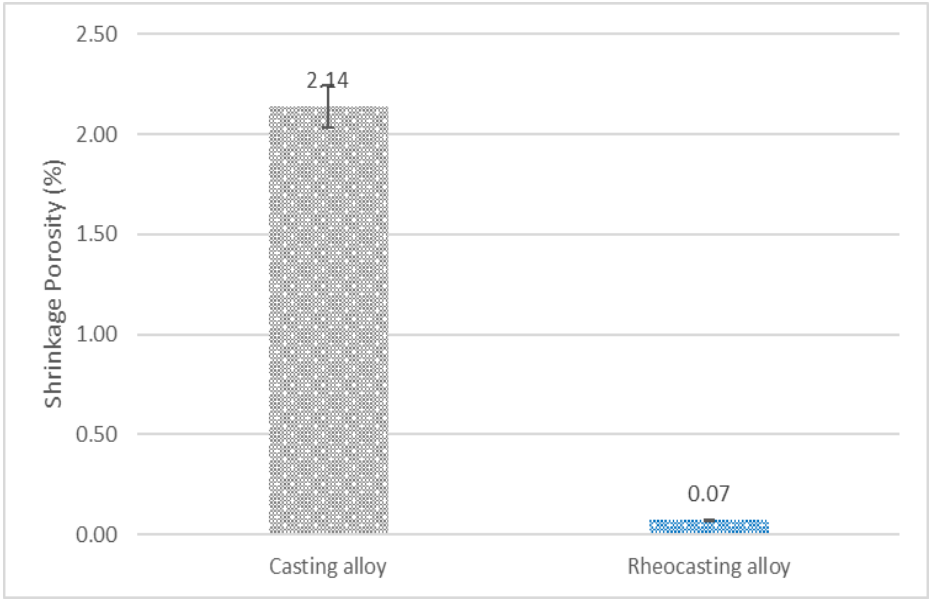


Figure 26 Shrinkage porosity of casting alloy and rheocasting sample

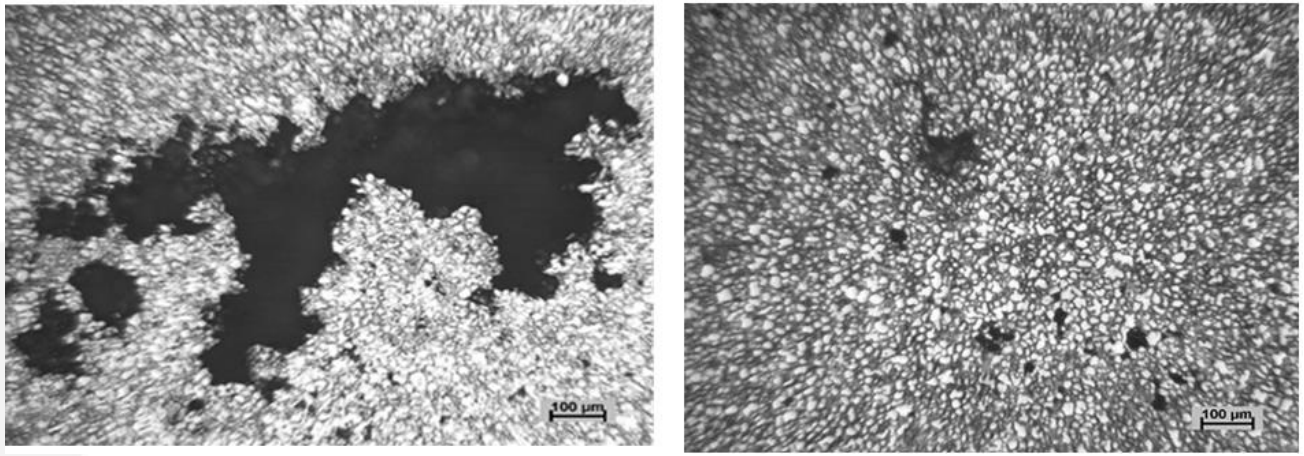


Figure 26 Big and small Porosity volume in five area Casting application sample

Activity in all Semesters

Publications

- Publishing paper in International Engineering Symposium at Bánki (IESB 2017) the topic was: (**Comparison of the techniques to produce non-dendritic feedstocks for thixoforming**) in (20.11.2017)

- Publishing paper in ***European Journal of Materials Science and Engineering (2019)*** the topic was: (**Comparison between the Non-Dendritic Methods of an EN AW 2011 Aluminum alloy Depending on Mechanical Properties and Microstructures**) in (02.10.2019)

- Publishing paper in 12th Engineering Symposium at Bánki (ESB 2021) the topic was (**Microstructures and Mechanical Properties of Aluminium EN 6063 - T6 Extrusions and Rheocasting alloys)** in (18.11.2021)

- Publishing paper in 12th Engineering Symposium at Bánki (ESB 2021) the topic was **(Impact toughness and microstructures behavior of the Aluminium EN AW 6082 rheocasting and casting alloys in different temperatures**) in (18.11.2021)

Activity in all Semesters

In Publishing

- Finished work on paper (**Characterization of Microstructure and Shrinkage Porosity of aluminium alloy EN AB 4244 Casting and Rheocasting Semi-Solid Alloy**)
- Finished work on paper (**Differential Scanning Calorimetry of aluminium alloy EN AB 4244 Rheocasting Semi-Solid in different stage heating rates**)

Conference Proceedings

- K.A. Abdulrahman, R. Mihály, G. Viktor, **Comparison of the techniques to produce non-dendritic feedstocks for thixoforming**, 9th International Engineering Symposium at Bánki (IESB) (27.11.2017), Budapest, Hungary.
- K.A. Abdulrahman, R. Mihály, G. Viktor, **Evaluation of microstructure and mechanical properties for non-dendritic feedstocks of an EN AW 2011 aluminium allo**y, Smart, Sustainable and Safe Cities Conference (SSSCC) (25.05.2018), Budapest, Hungary.
- K.A. Abdulrahman, R. Mihály, G. Viktor**, Finite Element Modeling Strategies for Semi-Solid Forming**, 10th International Engineering Symposium at Bánki (IESB) (21.11.2018), Budapest, Hungary

Conference Proceedings

- K.A. Abdulrahman, R. Mihály, G. Viktor**, Microstructures and Mechanical Properties of Aluminium EN 6063 - T6 Extrusions and Rheocasting alloys** , 12th Engineering Symposium at Bánki (ESB) (18.11.2021), Budapest, Hungary

- K.A. Abdulrahman, R. Mihály, G. Viktor**, Impact toughness and microstructures behavior of the Aluminium EN AW 6082 rheocasting and casting alloys in different temperatures**, 12th Engineering Symposium at Bánki (ESB) (18.11.2021), Budapest, Hungary

Future Research Plan

- **Plane to publishing the two finishing paper .**
- **Start work in my thesis.**

Thanks for your attention!