PhD notebook

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Contents

1 Administration

- ≻ Create tax card, need contract information as salary
- ≻ What pension config ? If not in the salary, can I bring it back to France in 3 years?

  ⇒ link is here and go to Forskudsopgørelse
- ≻ Webinar "moving to Denmark and PhD at DTU

  ⇒ take the session 2026/02/20 from 1pm to 2 pm
- ≻ Mandaroty introduction culture day

  ⇒ Chose the option 10 March from 10:45 am to 2 pm
- ≻ Introduction to responsible conduct of research and research data management for new employees

  ⇒ chose 6 April from 9am to 1 pm
- ≻ ____________

2 Teaching

2.1 Course preparation

3 Bibliography

3.1 Powder production processes

3.1.1 Free fall and confined gas atomization

The free fall and confined gas atomization are similar in the process description. The main difference is the distance between the bottom of the liquid metal nozzle and the gaz impact point. On the confined side, the gaz jet is hit the liquid metal stream just after it leaves the delivery tube, and the gaz jets direction are generally tangential to the liquid metal stream. On the free fall side, the metal stream is hit after a certain distance which can be more than 100 mm under the delivery tube [1].

- ≻ Why: gaz jets direction are generally tangential to the liquid metal stream

3.1.2 Water atomization

3.1.3 Centrifugal atomization

3.1.4 Plasma atomization

3.1.5 Mechanical attrition and alloying

3.1.6 Melt spinning

3.1.7 Rotating electrode process (REP)

3.1.8 Chemical processes

3.2 Factors influencing metallic powder size and quality during gas atomization

3.2.1 Feedstock melting

One of the melting processes is to use a crucible heated by induction. It allows different types of feedstock such as powder, scrap, wire, and can accept pure metal elements or pre-alloyed elements. All these parameters will impact the powder quality. For instance, the melted scraps can be heterogeneous and may contain oxides and impurities. In these cases, it is recommended to take a sample of the homogeneous melted material in order to analyze the chemistry [2].

Both open and closed melting systems are used in gas atomization. When the metal is molten in open air, the risk of oxidation and contamination is increased, even if the slag provides a natural protection that is very commonly used in pyro-metallurgical processes [3]. Open air induction heating system can accept a bigger volume of metal but it will give a less good powder quality.

In a context of process optimization, caracterizing different feedstocks with the on-site facilities would be a nice sanity check to align with the literature results. Eventually, once this first step is controlled, it would be nice to continue the parameters optimization with vacuum heating. In order to be able to analyze properly the results, only one parameter has to be change for each iteration. To decrease the results given by combined parameters and to be able to improve the powder quality, on way would be, when it is possible, to focus on one parameter, optimize it, and keeping it optimized while modifying the next parameter, one by one. Some of the parameters are known in the literature to be significant in the powder quality improvement as well as requiring complex or expensive investments such as helium environment or a high quality feedstock. These parameters should be punctually tested for the sanity test and kept in mind to be re-introduced in the process only when it is consistent.

3.2.2 Gaz environment

3.2.3 Nozzle geometry

CAUTION: when design different nozzle with different apex angle, the impact height can change if only the gaz nozzle angle are modified. To modify only one parameter (the angle), the location of the nozzle have to be adapted to keep the same impact height.

3.2.4 Thermal condition and properties of the molten metal

The temperature of the molten metal and its surface tension affect the process efficiency. When increasing both the gaz and liquid metal flow, the powder size distribution is reduced [2].

3.3 Powder caracterization

3.3.1 Ductility and hardness

3.3.2 Impurities and reactivity

3.3.3 Tap density, apparent density, compressibility, green strength, flow properties and compressibility

4 Experiment: title

4.1 Description

4.2 Tools / method / protocol

4.3 Results

4.4 Discussion

4.5 Next steps

TO-DO LIST

References

[1] Singh, Koria, and Dube. "Study of Free Fall Gas Atomisation of Liquid Metals to Produce Powder". In: *Powder Metallurgy* (2001). DOI: 10.1179/003258901666239. (Visited on 02/18/2026).

[2] Kazybek Kassym and Asma Perveen. "Atomization Processes of Metal Powders for 3D Printing". In: *Materials Today: Proceedings* 26 (2020), pp. 1727–1733. ISSN: 22147853. DOI: 10.1016/j.matpr.2020.02.364. (Visited on 01/06/2026).

[3] Holappa and Kaçar. "Slag Formation — Thermodynamic and Kinetic Aspects and Mechanisms". In: *Advances in Molten Slags, Fluxes, and Salts: Proceedings of the 10th International Conference on Molten Slags, Fluxes and Salts 2016* (2016). DOI: 10.1007/978-3-319-48769-4_108. (Visited on 02/14/2026).