

Master thesis proposal

Quantification of dendrite spacing in permanent magnet ribbons: a deep learning approach.

Keywords: Microstructure, deep learning, magnetic materials

SCIENTIFIC DESCRIPTION:

Permanent magnets are integrated in numerous modern technologies, including electric motors, generators, and magnetic sensors. The performance of magnets is significantly influenced by their microstructural properties, which can be optimized through precise control of the manufacturing process. Strip casting is a rapid solidification technique used to produce ribbons with fine and controlled microstructures, crucial for enhancing the magnetic properties of permanent magnets. The control and the optimization of these microstructures are vital for achieving superior magnetic performance.

Strip-cast ribbons exhibit a lamellar microstructure, consisting of lamellae of the magnetic phase separated by thin interdendritic phases. The thickness of the magnetic phase lamellae, which corresponds to the distance between adjacent interdendritic layers, is a key process parameter, commonly referred to as interdendritic spacing. This parameter governs the thickness, homogeneity, and microstructural characteristics of the resulting grains. Therefore, the quantification of the interdendritic spacing in the microstructures of strip-cast ribbons is of particular interest.

Traditional methods for quantifying microstructural parameters in permanent magnets often rely on manual analysis of images obtained through microscopy techniques along several directions ([1], [2]). These methods, while effective, can be time-consuming and prone to human error. Deep Learning offers the potential for more accurate and efficient quantification. Deep learning models have been successfully applied to analyse the solidification microstructures of Al alloys [3] or single crystal Ni-based superalloys [4].

The primary objective of this internship is to implement advanced deep learning techniques for the quantification of interdendritic spacing in the microstructures of strip-cast ribbons. The experimental data, including microstructural images, will have been acquired prior to the start of the internship.

The student will compare and evaluate different deep learning models, such as U-Net, VGG16, and ResNet, which are pre-trained on large datasets. The goal is to determine the most effective model for accurately quantifying the interdendritic spacing in the given microstructures while using the cross-section images in only one single direction of the ribbons that are commonly taken during the process flow, requiring much less time and effort than the multidirectional imaging.

Through this internship, the participant will gain valuable experience in deep learning, image analysis, and material science. The outcomes of this project will contribute to the advancement of permanent magnet technology by providing a more efficient and accurate method for microstructural quantification.

Techniques/methods in use: Convolutional Neural Network, image analysis, transfer learning are the principal numerical methods. SEM imaging and sample preparation will occur before the internship, although they can be part of the training for teaching purpose.

Budget description and use: Salary.

Applicant skills: Machine learning / deep learning methods, python programming, image analysis, basic skills in material science is a plus.

Industrial partnership: None



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Possibility for a Doctoral thesis: No

