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Development and Evaluation of the Powders Mix Low Alloyed Steel + SiC for Selective Laser Melting

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For this work, the evaluation of the S2 tool steel + Silicon carbide (SiC) powders was provided in terms of the microstructural characterization after a thermal cycle and of the rheological properties of the mixtures. SiC powder was added at 5%, 10%, 15% and 20% in volume to S2 Tool Steel.

The aim of this study is to forecast the microstructures that can be obtained in the Metal Matrix Composites printed through Selective Laser Melting (SLM) after heat treatments, and to determine the proper method to prepare the powders mixture for the feedstock of the SLM.

The microstructures were characterized after Differential Thermal Analysis (DTA) in different conditions. The rheological properties were evaluated on three batches of S2 + 15% (in volume) of SiC powder prepared with different mixing methods which include Ball Milling and Manual mixing. The amount of SiC influence the microstructure obtained, passing from a fully pearlitic matrix for the lowest amount to a fully ferritic matrix with several types of graphite increasing the SiC amount.

The characterization was provided using Optical Microscope (OM), Scanning Electron Microscope (SEM), and chemical analysis such as Energy Dispersive Spectroscopy (EDS) that allow the evaluation and comparison of morphology and composition of the different phases of the different microstructures. For the comparison between the mixing methods, the same tools were used in addition to the technologies for the evaluation of rheological properties such as tap density, cohesive index, granulometry thank to the collaboration with Granutools and Greenmat. This characterization revealed that the manual mixing of S2 powder with pre-milled SiC is the best mixing method between the tried ones.

The following figures have been used for the discussion of the most outcomes results obtained in this project.
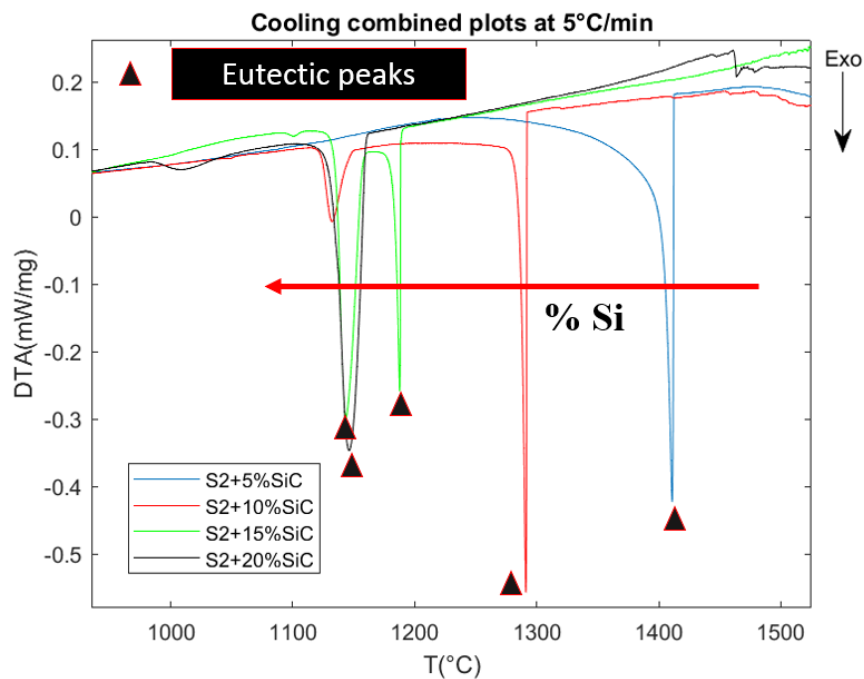

Figure 1: DTA cooling combined plots at 5°C/min of cooling rate in the range of temperature where solidification starts for each S2+X% SiC powders' mixtures
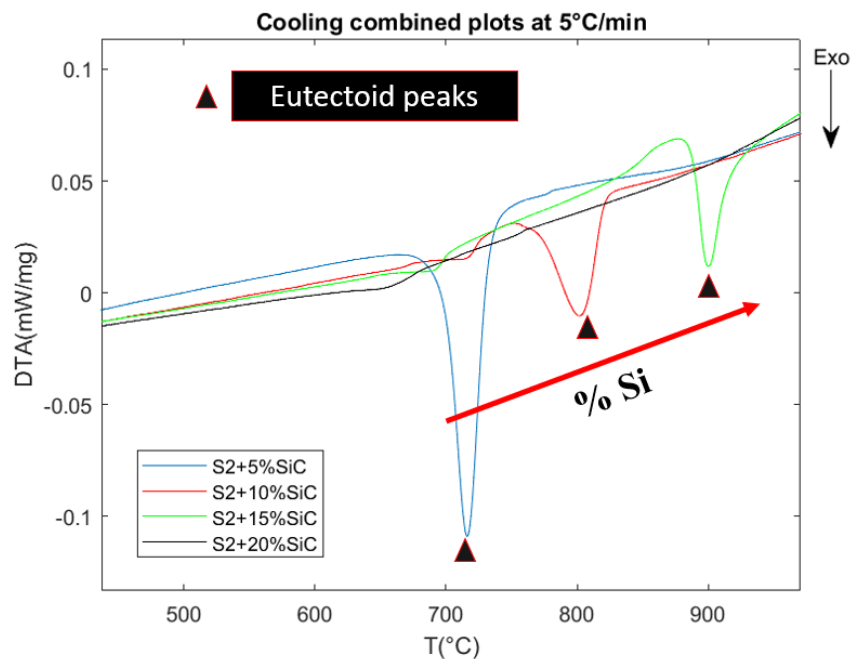

Figure 2: DTA cooling combined plots at 5°C/min of cooling rate in the range of temperature of eutectoid transformation for each S2+X% SiC powders' mixtures
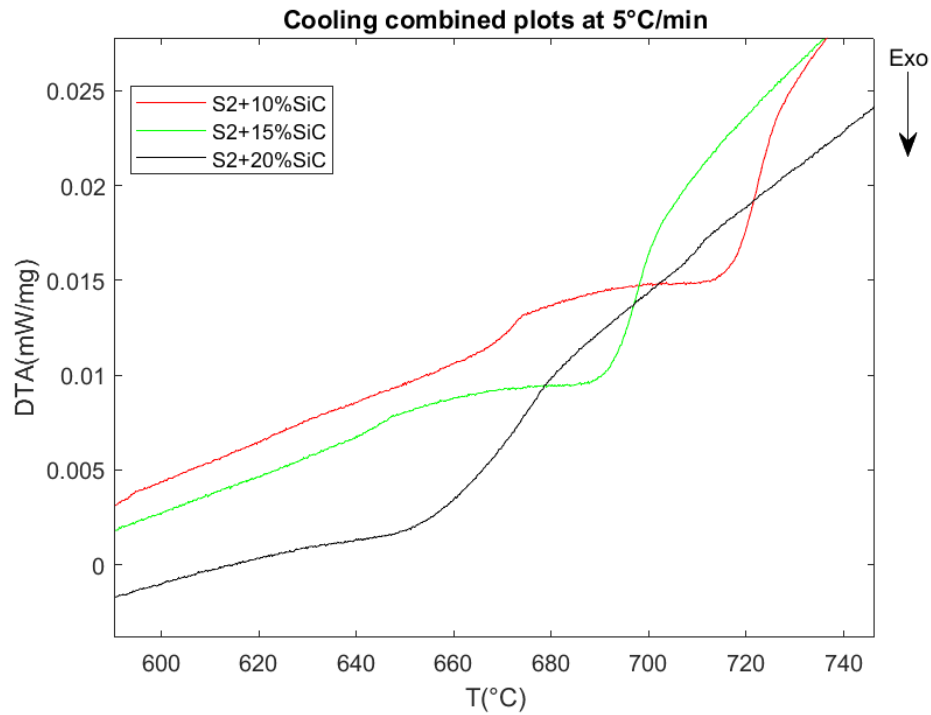
Figure 3: DTA cooling combined plots at 5°C/min of cooling rate in the range of temperature where magnetic Curie transition of ferrite for each S2+X% SiC powders' mixtures occurs
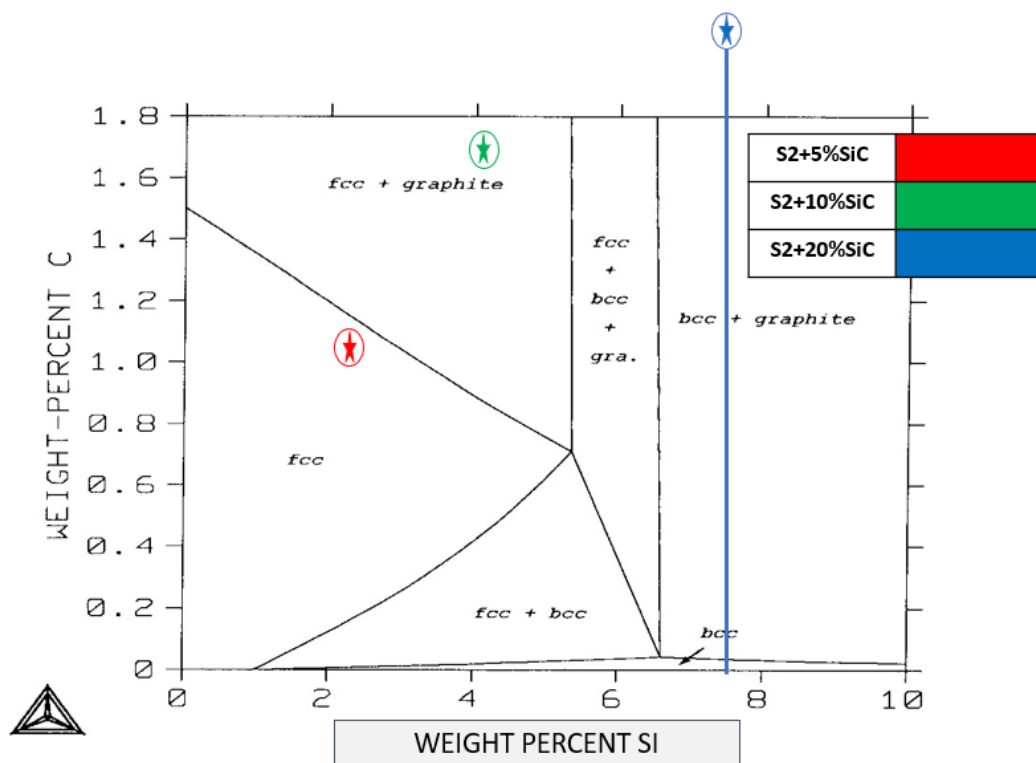

Figure 4: Calculated isothermal section (1000°C) of the iron-rich corner of the stable Fe-C-Si system
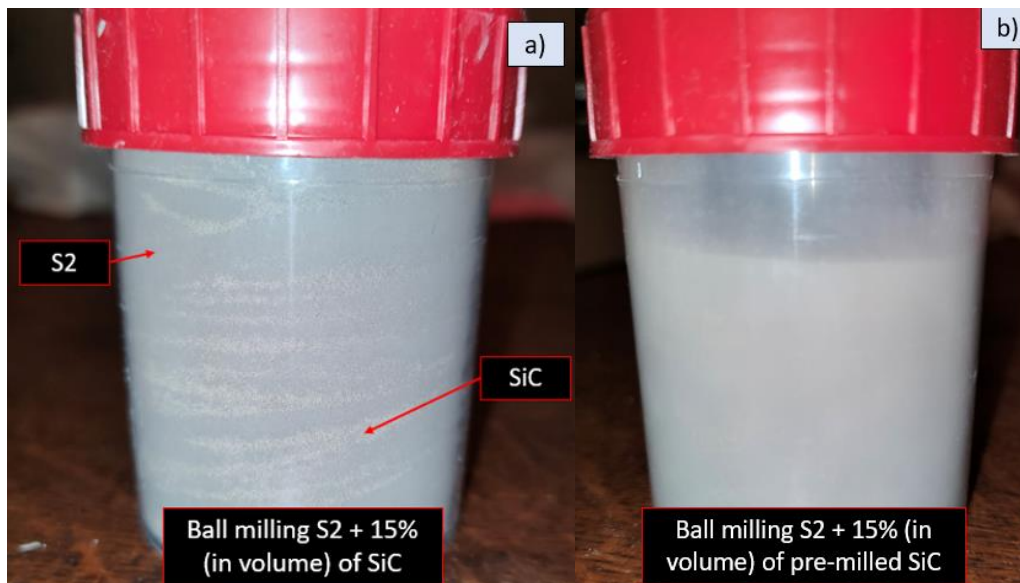
Figure 5: Batches for GranuPack and GranuDrum tests

Table 1: ap density results performed with GranuPack at Granutools on the S2 + 15% (in volume9 of SiC powder batches prepared with different mixing methods

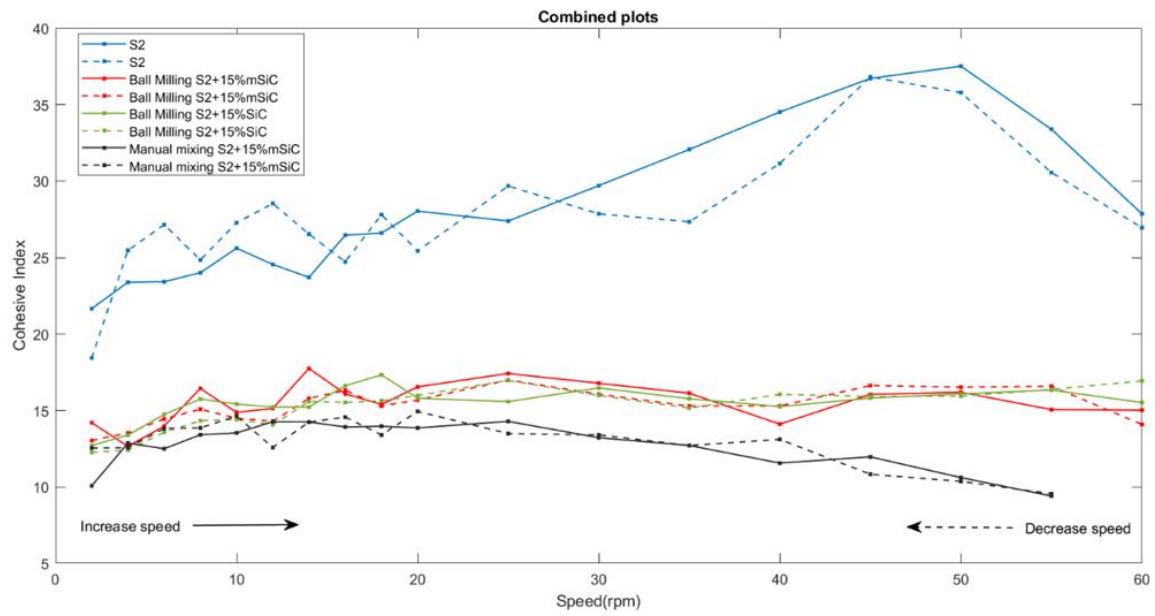| Name	Number of taps n	ρ(0) (g/ml)	ρ(n) (g/ml)	Hausner ratio	Carr's index	α (g/l)
S2	1000	3,959	4,743	1,20	16,51	32
BallMilling_S2+15% (in volume) of pre-milled SiC	1500	3,312	3,833	1,16	13,60	21,9
BallMilling_ S2+15% (in volume) of SiC	1500	3,481	4,032	1,16	13,67	22,7
ManualMixing_ S2+15% (in volume) of pre-milled SiC	1500	3,349	3,909	1,17	14,31	25,2

Figure 6: Cohesive index evaluation performed with GranuDrum at Granutools on the S2 + 15% (in volume9 of SiC powder batches prepared with different mixing methods