Posudek disertační práce

Title of Dissertation: Developing Trabecular Structure

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The topic of the work is very interesting and up-to-date. As additive manufacturing of metals is still rather a new technology, further research in this area is highly necessary and useful. The introduction containing the state of the art is thoroughly written and reflects well current state of this filed. Some important challenges in the additive manufacturing of metals were identified and this analysis is used to define the aims of the Dissertation. These aims were fulfilled within the submitted work.

The work presents an important contribution to the current state of knowledge in the field of additive manufacturing of metals, particularly with respect to biomedical applications. One of the important results is the summary of the cross-section effect on differences in mechanical properties in various printing directions. From a practical point of view, clearing loose powder particles while at the same time adjusting mechanical properties of surface-treated and HIP processed samples to the properties of a bone, is very important result. It should be also noted, that obtained results of mechanical tests could be used to increase the accuracy of computations and simulations of porous structures, replacing previously used data measured at bulk samples.

Generally, suitable methods were used in the experimental work and they were applied properly.

The description of the experimental program is rather confusing at the first reading. Experimental work would definitely benefit from a more conventional layout, starting with an overview of experimental materials, where a list of all used materials and their characteristics would be given. Chapter Methods does contain only a brief mention of pure titanium powder from Concept laser at the beginning. However, a few pages later, another pure titanium powder appears (TILOP) and still later, titanium alloy grade 23 is mentioned in the description of the experiments. There is no explanation why these materials were added and why they were used for a particular part of the experimental program. Introductory overview (or flowchart/table) of all the experiments carried out at each material would also improve the clarity of the work.

Considering the formal side of the work, there are various typos, mixture of singular and plural in the same sentence (for example “The sample were fabricated…” pg.18), verbs are occasionally missing. The frequency of these mistakes is not excessive, considering the length of the text. There seems to be more of them in Discussion than in other parts of the work.

Graphs and images are of the good quality, however really many figures are not mentioned in the text at all (for example Fig. 4.8., 4.9., 4.23, 4.29., 4.28., 4.30. ….) and also some tables are not mentioned in the text. Overall, there are many graphs and images in the work, which are accompanied with rather spare texts describing or commenting obtained results. The combination of these two issues could result also in obscuring the presented results, as in the following case:

Results obtained at samples with different cross-sections are very interesting, however the graphics, captions and descriptions of the fig. 5.5 -5.7. are quite confusing.
“Samples with high cross-section area” are mentioned in the text to be in Fig. 5.6. (pg. 53).

Yet, the graph is titled “Samples in section I”, while the caption below the graph (Fig. 5.6.) states, that it covers “Samples in section I and II S_0< 1,5mm$^{2"}$. So basically three completely different descriptions of the same results are given and only one of them could be correct. The fact, that following figure 5.7. is not mentioned in the text at all doesn’t help to clarify this passage.

I have following questions to the submitted Dissertation:

What does the statement “Columnar powder grains grow in building direction” mean (chapter 5.1., first paragraph)? Powder grains were globular and the powder does not grow during the AM process.

Cross-section area of porous samples from pure Ti was designed to be 36 mm^2. How would you explain the very different accuracy of the cross-section obtained for Concept Laser CP-Ti powder (average 40.4mm^2 – pg. 31) and for TILOP pure Ti powder (average 36.76 mm^2, pg. 36)? Can any of these two results be considered as “typical” and would you expect to obtain roughly the same results (or at least the same trend) if these two powders were additively manufactured with the same processing conditions again?

Why were three input materials used for different parts of the experimental program? Why wasn’t a complete set of the experiments (single strut testing, compression testis, surface treatment and HIP, dynamic response) carried out at one material?

How do you explain the results presented in Tab. 5.8. and 5.9. You mentioned, that “the impact force was not significantly changed with the testing environment” (pg. 74). Yet, this is hardly true for all the samples. H3 sample reached three times higher impact force in AIR than in BLM (tab. 5.8.) and B6 sample reached twice higher impact force in AIR than in BLM. Moreover, the trend of the differences in impact force obtained for surface treated samples and surface and HIP treated sample is not the same for 3 and 6 minutes of surface treatment (Air: B3<H3, but B6>H6). Why?

The postgraduate student proved to master appropriate skills and knowledge in his field of expertise and therefore **I recommend** submitted Dissertation for the defence.

In Pilsen,

8.1.2020 Ludmila Kučerová