A two-factor experimental study on the fatigue response of 15-5 PH stainless steel obtained by powder bed laser fusion

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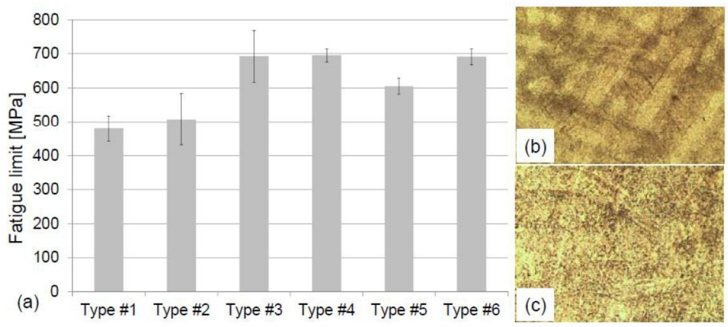
Nowadays, there is an increasing interest towards Additive Manufacturing (AM), which is expected to have a great impact on the future manufacturing industry. This novel technology makes it possible to take advantage from the possibility of building even complex parts, starting from a CAD file. Further advantages are related to the short working time, which makes this technology particularly suitable for the construction of both small- and large-sized component batches. The main drawbacks stand in the high cost of the process, in particular of the material powder to be used, which is partially compensated by the small amount of material being wasted during the process. Different acronyms for AM processes are available by different manufacturers. Direct Metal Laser Sintering (DMLS) by EOS and Selective Laser Melting (SLM) by MTT Technologies Group can be mentioned among the most widely applied. Further drawbacks of the process consist in the lack of data, especially regarding the fatigue response, and in possible anisotropy effects, arising from the stacking process. This study follows a previous one, dealing with the effect of the build orientation on the fatigue response of Maraging Steel MS1. Focus is here given to 15-5 PH stainless steel: its fatigue strength has been studied considering two factors: build orientation and allowance i.e. thickness to be removed by machining upon DMLS manufacturing. Issues of novelty arise from the performed experimental campaign that considers a combination of parameters, which has not been the subject of previous research.



Six sets of specimens have been manufactured according to ISO 1143 for fatigue tests under rotating bending. In particular, they have uniform section at gage and they have been loaded under four-point bending. The six sets can be regarded within a two-factor plan with six treatment combinations. The first factor, build orientation, has been considered over three levels (specimens built along horizontal, vertical and 45° inclined direction with respect to the base plate). For the second factor, two levels of allowance, 1mm and 3mm at gage have been considered. The test results have been processed by ISO 12107 and the Dixon method, for the determination of respectively the S-N curves and the fatigue limit, along with their confidence bands. The results in terms of the fatigue limits are resumed in Fig. 1(a). It can be observed that allowance generally has the effect of increasing the fatigue limit: removing a larger thickness seems to be able to remove surface irregularities that may trigger crack initiation. For greater allowance, the build orientation also has an effect: horizontally built parts behave better, as the build plane, where most imperfections are likely to be present, is aligned to load. The best results have been found for slanted samples, where neither the build plane, nor its perpendicular direction are aligned with load. Fractographies and micrographies have been used to get a better comprehension of the retrieved outcomes (Figs. 1 (b-c)).

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