# Fatigue behaviour analysis of AISI 316-L parts obtained by machining process and additive manufacturing

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## 1. Introduction

Additive manufacturing has suffered a great boom, reaching high precision and detail in the parts generated and being implemented in different industrial sectors [1]. The incorporation of materials of different nature is feasible thanks to the enormous development of the technique, like composite and metallic materials [2].

Even though 3D printing offers the possibility to manufacture complex geometry parts or even parts impossible to elaborate by any other manufacturing process, it presents clear disadvantages compared to those obtained through the traditional manufacturing processes mentioned.

The main objective is to compare the dimensional accuracy at a micro-geometric level (surface roughness), as well as comparing the mechanical behaviour (fatigue by rotating bending) obtained in metal parts manufactured by machining and additive manufacturing processes.

## 2. Methodology

Two different manufacturing methods have been used, additive manufacturing and dry turning process. For the additive manufacturing, two types of specimens have been considered depending on their manufacturing direction, vertical or horizontal. For the samples obtained by dry turning, an AISI 306-L steel bar was cut into 205 mm individual bars. Subsequently, they have been machined to the geometry shown in Figure 1, using a CNC lathe.

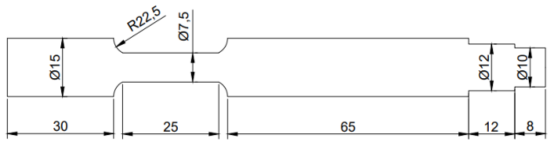


**Figure 1**. Tested samples geometry and

The tolerances and roughness (*Ra*) of all the specimens is analyzed. Also, for the fatigue test, an infinite life test type has been carried out. The specimen has been threaded into the part with the smallest section to be able to grab and hold the pendulum with the weight corresponding with which the test will be done (14,5 kg). Once the machinery is turned on and everything is ready, the test tube begins to rotate, thus subject to fluctuating forces, once the material reaches its limit and breaks, the machine stops and register the number of cycles.

## 3. Results and Discussion

An important fact when assessing fatigue behavior is the analysis of the crack growth. The best performance obtained in the mechanized specimens is mainly due to the fact that the crack growth is hindered by the orientation of the material grains, while in the 3D printed specimens, growth is favored due to the material deposition by layers. Also, the better Ra of the machined specimens compared to those of additive manufacturing delays the onset of microcracking on the surface, improving its fatigue behavior. Moreover, it can also be considered that the internal structure of the additive manufacturing specimens, in the period of solidification, trap small air pockets, helping the crack growth.

## 4. Conclusions

Due to the manufacturing process, the machined specimens have a better surface finish (Ra) than the ones obtained by STL. Thus, the mechanized specimens have a better fatigue behaviour than the additive manufacturing specimens. Due to the better surface finish, surface microcracks are less likely to appear and nucleate. Between both printed specimen types, the fatigue behaviour of vertical additive manufacturing samples is better than the horizontal ones, although the surface finish is better in the horizontal.

## 5. Acknowledgements

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## 6. References

[1] C. Culmone, G. Smit and P. Breedveld. *Additive manufacturing of medical instruments: A state-of-the-art review.* Additive Manufacturing. Elsevier B.V. 2019.

[2] N. Li et al. *Progress in additive manufacturing on new materials: A review*. Journal of Materials Science and Technology. Chinese Society of Metals. 2019.