The influence of manufacturing process parameters on low-cycle fatigue properties and fatigue crack propagation characteristics of 17-4 PH steel parts produced by the additive manufacturing Material Extrusion (3D printing) method.

Additive manufacturing, also known as 3D printing, is one of the newest and fastest evolving technologies. Unlike traditional manufacturing methods, additive manufacturing allows the creation of components layer by layer, facilitating the easy production of any structure and shape, thereby addressing issues inherent in conventional manufacturing techniques. Currently, there are numerous types of additive manufacturing techniques, with material extrusion (MEX) being the most prevalent. This technology has gained popularity due to its accessibility and low cost of both equipment and materials. Initially, only polymers were used for printing in this technology; however, in recent years, new materials have been introduced in the form of metal-polymer composites. Metal printing using the MEX technique can be an alternative to the currently most popular metal 3D printing techniques, such as Powder Bed Fusion (PBF), due to the lower cost of equipment and the simple operation that does not require high-power lasers or powder form materials.

Metal part printing using the MEX technique is performed on standard devices designed for material extrusion techniques. However, in the case of MEX printing, the metallic material takes the form of a composite consisting of highly densified metal powder and a polymer binder. To obtain fully metal parts, the printed elements, known as "green parts", must undergo catalytic debinding (also known as washing), which partially removes the primary polymer binder. This process results in what is known as a "brown part", composed of pure metal particles and a residual polymer binder (secondary binder). The final step is sintering at temperatures just below the metal's melting point, which ultimately removes the secondary binder from the brown part and causes the metal particles to fuse, forming a fully metal part.

17-4 PH steel, also known as martensitic stainless steel, is a material known for its high strength and corrosion resistance. It also exhibits good machinability and can be hardened through heat treatment processes, making it an ideal material for fatigue strength research in additive manufacturing technologies, including the MEX technique.

The primary objective of this project is to investigate the structural and strength properties of 17-4 PH steel, focussing on static tensile strength and low-cycle fatigue, supplemented by an analysis of fatigue crack propagation processes in elements manufactured using the MEX material extrusion method.

As part of the project, an analysis of the impact of additive manufacturing parameters will be conducted, including additional selected structural and strength tests. The goal of this analysis is to minimise potential defects in the additive manufacturing process, such as the occurrence of porosity between the deposited material paths. The range of variations in manufacturing parameters will involve the creation of a matrix with different values for each variable that influences the process.

The implementation of this project will not only provide insight into the impact of manufacturing parameters on structural and strength properties, but also establish fundamental characteristics regarding low-cycle fatigue. This will be complemented by descriptions of the fatigue cracking process based on analyses of fatigue fracture surfaces using electron-optical methods.