

Development of an Industry 4.0-Based Smart Monitoring System for 3D Printed Support Structure Removal

Mohammed A. Noman and Wadea Ameen

Industrial Engineering Department

College of Engineering

Al-Yamamah University, Riyadh 11512, Saudi Arabia

Abstract

Additive Manufacturing (AM), commonly known as 3D printing, is a manufacturing process used to create objects layer by layer from a digital three-dimensional model. AM includes a family of different technologies and processes that build up parts by adding materials in layer style. This technology has become widely used because of its ability to produce complex shapes, customized products, and functional components with reduced material waste compared to conventional manufacturing methods. Despite these advantages, many printed parts require support structures during the printing process, especially for overhanging features and complex geometries. Support structures are temporary elements that help stabilize the part and improve printing accuracy during fabrication. Once the printing process is completed, these supports are removed through post-processing operations to obtain the final product. However, the removal process can increase production time and effort and may sometimes affect the surface quality of the printed part. Various methods were used to remove metal support structures, depending on the material and geometry. Wire electrical discharge machining, saws, Dremel handheld power tools and pliers are popular methods and tools for removing the support structures from PBF parts. Sandpaper is a quick tool that is used to remove the witness marks leftover by the supports on the bottom surface. For metal supports, a wire electrical discharge machining (EDM) machine, milling equipment and handsaw may be required to remove the part support from the baseplate and then remove the supports from the part. Manual removal remains the most common and widely used method for removing support structures, where simple hand tools such as pliers are frequently used to detach the supports from the printed parts. The ease of removing support structures depends on several factors, including the geometry of the part, the type and design of the support structure, the material properties, the printing technology used, and the level of adhesion between the support and the main part. In addition, surface finish requirements and the tools used during post-processing can also influence how easily the support can be removed. Support structure removability in additive manufacturing refers to how easily temporary support structures, which are added during the 3D printing process to hold overhanging or complex features, can be removed after printing is completed. It describes the effort, time, and risk involved in separating these supports from the final printed part without causing damage or affecting surface quality. Good removability means the support can be detached smoothly, with minimal force, short post-processing time, and little or no damage to the part. Poor removability, on the other hand, may lead to surface scratches, part deformation, or high manual effort during cleaning. In most of the previous research evaluated the support structures though support structures removal time. In this study, the removability of support structures is evaluated using two main criteria: removal time and the force required to detach the supports. Removal time is used to measure the efficiency of the post-processing stage, while the applied force represents the mechanical effort needed to break and separate the support structures from the printed part. To ensure accurate and consistent measurement of these parameters, a dedicated device was designed and developed specifically for this purpose. This device enables controlled and repeatable testing conditions, allowing a more reliable assessment of support structure removability.

Keywords

Development, Industry 4.0, Smart Monitoring System, 3D Printed Support