Additive technologies are finding increasing application in many industries. Medical applications are attracting particular attention, in areas such as surgery (production of physical models of the patient's bones for pre-operative analysis and surgical assistance, as well as the production of implants), pharmaceuticals (drug delivery systems, including the production and dispensing of drugs), dentistry (production of fixed and removable dental implants), tissue engineering (construction of bone scaffolds), and orthopaedics (production of limb stabilisers, prostheses).

When it comes to the design of prostheses, 3D printing makes it possible to produce components that perfectly fit the patient's anatomy. Traditional prostheses often require multiple visits and adjustments before they are comfortable for the patient. With 3D printing, this process is greatly simplified and accelerated. Through reverse engineering, it is possible to accurately represent the patient's limb, producing a prosthesis that is both comfortable and functional. The materials used to print prostheses are often cheaper and the manufacturing process itself is faster than traditional methods. This is particularly important in developing countries where access to advanced medical care is limited. The ability to experiment with different materials and designs allows for the creation of prostheses that are more durable, lighter and better mimic the natural movements of the replaced limb (e.g. bionic prostheses that integrate sensors and motors). 3D printing technology is still developing and its potential in orthopaedics and prosthesis manufacturing is enormous.

When it comes to the functionality of prostheses, they are made of common polymeric materials, e.g. PLA (Polyactide) based, and have a lower coefficient of friction than elastomers, e.g. TPU (in friction pairing with steel), which can cause difficulties in lifting objects and daily functioning. Elastic coatings for such prostheses, which are crucial for user comfort and improved functionality, remain a challenge. Currently, silicone overlays for prostheses are used, but they have some disadvantages, such as limited durability, lack of easy modification and personalisation, insufficient adhesion to the prosthesis base and application only at the distal phalanx site. Therefore, there is a need to develop new methods of manufacturing elastomeric coatings integrated into the prosthesis, which can eliminate these disadvantages and provide better quality prostheses.

The prosthesis components (Figure 1) are irregularly shaped models (freeform geometry) and are therefore extremely difficult to simulate for known materials and almost impossible for 3D printing, hence the legitimacy of using basic research to determine strength properties with real, practical applicability to the medical industry. Both at national and international level.

The aim of this project is to evaluate the effectiveness of two multi-material fabrication methods (multi-material 3D printing and in-mould casting) that can be applied to the production of flexible coatings for hand prosthesis components manufactured with additive technologies. Additional research objectives are to evaluate the mechanical properties of thermoplastic-elastomer interfaces and to assess adhesion between thermoplastic and elastomer.

The project aims to provide a solution that can significantly improve the quality of life for people using hand prostheses by creating integrated flexible coatings with improved adhesion, durability and wear properties. Firstly, the analysis of the adhesion of flexible coatings to prostheses manufactured with additive technologies is a relatively unexplored area, which makes the study unique. Furthermore, the use of modern manufacturing methods such as 3D printing, combined with flexible materials, opens up new possibilities for the design and manufacture of coatings, which represents an innovation in the field of prosthetics. By developing new methods for producing flexible coatings with improved adhesion to the prosthesis substrate and higher durability, the study will improve the quality of prosthetic hands and increase user satisfaction. In addition, the new technologies and materials used in the project may also find applications in other areas of mechanical engineering, such as robotics.

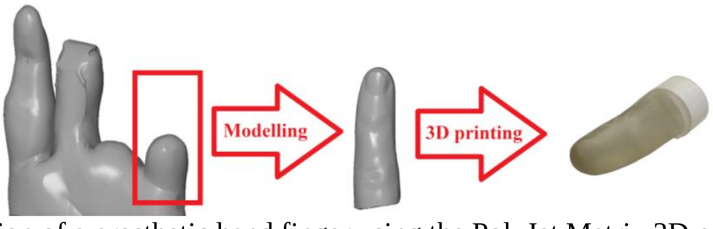

Fig. 1. Fabrication of a prosthetic hand finger using the PolyJet Matrix 3D printing method

Source: Szczygieł P. “Prototype of hand prosthesis components manufactured with biocompatible material using PolyJet Matrix technology”; Mechanik 2022;95:50–54; doi: 10.17814/mechanik.2022.7.10