The Summary of a Confidential Thesis

This bachelor thesis explores the potential and benefits of implementing a 3D metal printing learning factory within the framework of Industry 5.0. The primary objective was to design and develop a virtual model of such a learning factory, leveraging advanced 3D visualization and simulation tools. This initiative aims to bridge the gap between theoretical knowledge and practical application, providing students and professionals with a robust environment for hands-on training in advanced manufacturing technologies.

The thesis begins with an introduction to the concept of Industry 5.0, highlighting its emphasis on human-centric approaches and the integration of advanced technologies such as artificial intelligence (AI), robotics, and 3D printing. The background section details the critical need for skilled professionals in 3D manufacturing, particularly in Estonia, where digital innovation is progressing but advanced manufacturing still requires practical training facilities.

In the first chapter, the concept of learning factories is examined, focusing on their role in 3D manufacturing education. Various case studies of existing learning factories, such as those at Siemens, MIT, and Penn State University, are analyzed to identify best practices and their impact on education and industry.

The second chapter outlines the methodology for creating a virtual model of a 3D printing learning factory. This includes defining requirements, sourcing and collecting data, planning, digital modeling, and iterative testing and optimization. The chosen software for this task is Autodesk Revit, selected for its comprehensive Building Information Modeling (BIM) functionalities and advanced visualization tools.

The third chapter presents the conceptual design of the learning laboratory. Detailed requirements and specifications are provided, including the selection of 3D printers and the integration of collaborative robots (cobots) and autonomous mobile robots (AMRs) to enhance efficiency and safety. The importance of zoning, utilities, and safety compliance is also discussed.

In the fourth chapter, the process of creating the 3D visualization model in Revit software is detailed. This includes initial model planning, adjustments due to logistical and structural constraints, and the final implementation of the model. Screenshots and visuals from Revit illustrate the development stages, highlighting the practical challenges

and solutions encountered.

The thesis concludes with a results and conclusions chapter, summarizing the key findings and their implications for future research and practical applications. The developed virtual model provides a comprehensive and realistic simulation environment for training and innovation in digital manufacturing. It supports Estonia's goal of becoming a leader in high-value manufacturing by equipping the workforce with essential skills for Industry 5.0.

This research contributes valuable insights into optimizing learning environments and enhancing educational outcomes in smart manufacturing. The implementation of a 3D metal printing learning factory stands as a significant step towards bridging the theoretical-practical divide in advanced manufacturing education.