ASSESSING THE INNOVATION POTENTIAL USING THE TECHNOLOGICAL COMPETENCE LEVERAGING (TCL) METHOD

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Executive Summary

Project overview

High-Power Impulse Magnetron Sputtering (HiPIMS) is an advanced coating technology that is currently being further developed for manufacturing superconducting radiofrequency cavities of particle accelerators. Although this technology offers numerous benefits compared to common coating techniques, the number of industrial applications is today still low. This leads to slow adoption of the technology, further developments and high costs of HiPIMS coatings. The aim of this project, therefore, is to identify and analyse potential application fields for HiPIMS to ultimately increase industrial adoption of this technology.

Methodology

First, a technology description outlines the technological aspects of the project by giving an overview of HiPIMS and its important characteristics. 30 interviews with leading experts of HiPIMS and literature research are the sources of information.

The following part, on which this project focuses on, follows the methodology of Technology Competence Leveraging. This systematic four-step approach is an effective method to identify potential application fields for existing technologies without the need for technical in-depth knowledge. The objectives and sub-goals of the TCL method are (1) the identification of the core benefits of the technology, (2) discovering potential application fields with a need for these benefits, (3) analyzing the possible alternative industries and (4) the development of a profound exploitation strategy for the technology (Keinz and Prügl, 2010). Since the scope of this project focuses on the first three steps, the fourth step of the Technology Competence Leveraging method is not included. The theoretical methods and tools pyramiding, brainstorming, expert interviews and customer discovery interviews as well as the extensive knowledge of user communities are used to gather information.

Results

The expert and current user interviews conducted as part of the first step resulted in three core benefits of HiPIMS. They are used as the foundation for the next step, identifying potential application fields.

(1) Possibility to coat complex 3D-structures

(2) Thinner and more precise coatings

(3) Longer lasting and durable coatings

Based on these core benefits 9 industries comprising 28 potential application fields are identified by using individual and group brainstorming and utilizing specified user communities. The most promising application fields are evaluated by assessing the so-called Benefit relevance and Strategic fit, which combined result in an overall score that indicates the fit between HiPIMS, the needs and constraints of CERN and the respective application field. This analysis lead to four promising application fields.

(1) Ski equipment

The upper side of the ski is exposed to many different conditions. The current protection with a plastic foil is not satisfactory. Therefore, a coating with HiPIMS is a possibility to make the skis more resistant and therefore longer usable for the customer. It leads to a reputation increase for the ski manufacturer.

(2) Prostheses & Stents

HiPIMS could be used to coat sensitive medical devices such as prostheses and stents. Coatings with high wear off-resistance and a high degree of sterility, due to the dense coatings achieved with HiPIMS, could greatly increase the durability and functionality of those medical devices. Since the medical industry requires a high reliability of instruments, HiPIMS shows potential to set quality standards.

(3) Industrial stamping tools

Industrial stamping tools have to endure high degrees of mechanical stress and are required to have maximized service lives. The hard and wear off-resistant layers achieved with HiPIMS could therefore increase precision of industrial stamping tools while increasing the number of possible strokes at the same time. These tools are used in a variety of industries and are mostly used to manufacture components in high volumes, which underlines the need for highly sophisticated product characteristics.

(4) Food manufacturing machinery

The process of manufacturing food is bound to high quality standards. Especially, painted components of machines with no direct food contact and parts of these machines with direct food contact have a variety of deficits that bear risks. HiPIMS coatings could be used for these components to extend their lifetime, increase safety of food production and improve the level of hygiene of surfaces.

1 Project partner

The Conseil Européen pour la Recherche Nucléaire (CERN) is a world leading research organization focusing mainly on the field of understanding better the fundamental principles that govern our Universe. It was founded in 1954 with the main mission to deepen the knowledge about and the understanding of how particles interact with each other on an elementary level. The results of the organization's research are made available publicly free of charge (CERN, 2019).

The organization has today twenty-three member states, each of which has two official delegates to the CERN Council. Its facilities are run by about 2,500 technical, scientific and administrative staff members and over 12,000 associated external members that conduct research (CERN, 2019).

CERN operates the world's largest complex of particle accelerators. The most powerful scientific instrument is a particle accelerator called Large Hadron Collider (LHC). It has a length of 26.7 km and runs in a circular shaped underground tunnel. Using sophisticated technologies like superconducting magnets chilled to temperatures near absolute zero and radiofrequency cavities, particles are accelerated close to the speed of light. After the particles have reached their target speed, they collide with each other (CERN, 2019). This process is then tracked by detectors to gather data about the collision which is used to get a better understanding of the fundamental constituents of matter (ATLAS, 2019).

The LHC, however, is not the only instrument available for scientists at CERN. There are several other particle accelerators like the Low Energy Ion Ring (LEIR), the Proton Synchrotron (PS) and the Antiproton Decelerator.

Figure 1 - Scientific instruments at CERN (Hunter, 2017)

Since the Large Hadron Collider does not meet the needs of future research, CERN is currently planning to build a bigger "Future Circular Collider" (FCC). With a proposed length of about 100 km the FCC would be substantially larger than the existing LHC and thus, one of the major challenges will be the high demand for resources both, natural and financial (CERN, 2019).

2 Project description

Within the scope of EASITrain, a H2020 project funded by the EU, multiple projects have been conducted for the FCC project at Vienna University of Economics and Business. The focus of these previous efforts was on finding alternative applications for technologies needed in the manufacturing process of superconducting magnets and analyzing the most promising application fields. This project constitutes a follow-up project that aims to help CERN lower the costs for their planned Future Circular Collider, which is meant to take over from the LHC and extend its research. The following paragraphs define the scope, challenges and objectives of the project.

2.1 Problem definition

In order to conduct their experiments, scientists at CERN rely on sophisticated components like powerful superconducting magnets and radiofrequency cavities. Due to the size of the FCC, it requires considerable amounts of these parts. Therefore, the construction of the FCC needs concerted value-engineering of each component (CERNCOURIER, 2019).

This project focuses on the radiofrequency (RF) cavities, which are used to accelerate the particles. So far, these cavities are built using pure Niobium, which represents a substantial cost factor. To achieve significant savings in material costs CERN is planning to produce cavities using the High-Power Impulse Magnetron Sputtering (HiPIMS) technology to coat copper with a thin layer of superconducting material, which would result in lower costs. The problem is that High-Power Impulse Magnetron Sputtering is not commonly used in industrial manufacturing. This means low competition, too little experience and high prices for such coatings.

2.2 Objectives

The primary objective of this project is to identify and analyze new promising application fields for HiPIMS in various industries, making FCC an example of "Open Innovation", i.e. the dissemination of novel technologies with high societal value that are pioneered in the context of large-scale high-tech projects for fundamental science. The diffusion of this technology is meant to cause higher competition and increased experience in industry and therefore result in lower costs and constant quality for such coatings. One essential step to achieve this is to determine the core benefits it provides for its current users. Based on these findings, the subsequent objective is to identify potential application fields. All in all, this project will help to disseminate the knowledge about the benefits of HiPIMS technology in the society, which will benefit involved manufacturers and CERN alike and contribute to public welfare.

3 Methodology

The analytical section of this report is divided into four main parts – (1) a technology description, (2) the analysis of the core benefits, (3) the identification of potential application fields and (4) finally the in-depth analysis of the most promising application fields.

In order to gain information and analyze the gathered output we use a variety of methods. Therefore, the aim of this chapter is to give an outline of the used methods in order to provide an overview of the approach. The first part covers the description of the involved technologies. Afterwards, the Technology Competence Leveraging method is explained in detail to get an understanding of how results are derived.

3.1 Technology description

The technology description outlines fundamental components and technologies which are relevant for this project. It focuses on the radiofrequency cavities in general and HiPIMS, which is the technology used to coat them.

Data is collected in a two-step approach. First, extensive literature research is conducted to get a profound information base. Second, aspects mentioned during the interviews will be used to complement the secondary data. Therefore, both primary and secondary data is used to guarantee comprehensive information on HiPIMS.

3.2 Technology Competence Leveraging

The methodology used to find potential application fields for HiPIMS is the Technology Competence Leveraging (TCL) method. This systematic approach is used to efficiently determine potential application fields without the need to acquire in-depth technological knowledge. The method consists of four consecutive steps that have to be completed sequentially. The objectives and sub-goals of the TCL method are (1) the identification of the core benefits of a technology, (2) discovering potential application fields with a need for these benefits, (3) analyzing the possible alternative industries and (4) the development of a profound exploitation strategy for the technology (Keinz and Prügl, 2010). This project focuses mainly on the identification of the core benefits and the determination and analysis of new application fields.