PROJECT PERIODIC REPORT

Publishable Summary

Grant Agreement number: CP-TP 229099-2

Project acronym: MesMesh

Project title: *Ultra-thin conductive ceramic mesh to monitor stress and wear on a steel surface*

Funding Scheme: Small or Medium-scale focused research project (NMP)

Date of latest version of Annex I against which the assessment will be made:

Periodic report: **1st ■ 2nd □ 3rd □ 4th □**

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1. PUBLISHABLE SUMMARY

1.1 SUMMARY DESCRIPTION OF PROJECT CONTEXT AND OBJECTIVES

Today there are no adequate means of measuring the surface damage done to steel surfaces in industrial machinery like driveshaft's, gears, brake pads, flanges for fixed drilling and grinding machines, dyes for extrusion or moulds for injection moulding. This means that it is impossible or very difficult to determine when to change a part or perform maintenance. This results in enormous losses for the European community, due to machines breaking down and causing delays in production and delivery.

The aim of the project is the development of a pre-commercial prototype mould with built in continuous structural health monitoring. If the steel surface gets damaged or is worn down through use, the ceramic grid will crack or become thinner and have increased resistance. Using a number of transducers the surface damage can be quantified and allow for preventive maintenance.

For validating the technology proposed we have chosen to focus primarily on flanges and moulds for injection moulding due to relative ease of applying the proposed technology to these application areas.

The developed technology will be implemented and tested on high precision flanges used in machine construction and on moulds used for injection moulding, and hence these will work as proof of concept.

Our specific scientific objectives are centred on the development of new knowledge in field of mould modifications:

- development of predictive models for frequency dependent electrical properties of ceramic composites,
- understanding of microstructure-property relationships for the frequency dependent properties of conductor insulator ceramic composites.
- To carry out research work related to ultra-short laser ablation process at different radiation parameters such as wavelength, pulse energy density, repetition rate and spatial pulse shape.

Our detailed technological objectives for individual elements are as follows:

- electrical characterization of conductive ceramic composites,
- use of predictive tools for the design of optimum conductive ceramic for the waveguide sensor application,
- development and embedment of the conductive ceramic for the waveguide application into steel

- To find optimal process parameters for forming smooth walled and depth-controlled grooves in metal.

Our detailed integration performance objectives are:

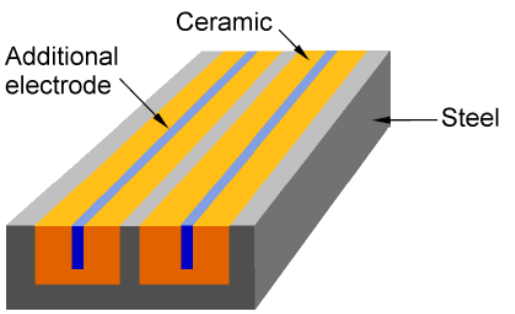
- To be able to produce moulds with a laser etched grove with a width of 80 micron with a deviation of no more than 5%.
- To produce a conductive ceramic with a cubic thermal expansion rate of 36ppm (36 x 10-6 1/°C) (same as steel) that can be bonded and/or sintered into the laser etched mesh.
- To have a software that can interpret the signal responses from the ceramic mesh to provide the end user with a tool to do real time monitoring of the structural health of a given steel surface.
- To ensure that the production costs of the developed technology when applied to a mould will not increase costs by more than 20%.This is considered acceptable as the life expectancy of the mould will be increased by no less than 20% and still give the end user benefits of reduced scrap and increased quality.

1.2 DESCRIPTION OF AND THE MAIN RESULTS ACHIEVED SO FAR

The MesMesh project aims to develop a cheap, innovative ultra-thin conductive ceramic mesh to monitor stress and wear on a steel surface. The technical progress of the MesMesh project is going according to schedule and promising results have been made within the various research areas.

Enhancement of Scientific Knowledge

The focus of the consortium at the initial stage was focused on making an analysis of existing literature within the various technological fields. This was necessary in order to acquire a deeper understanding about the processes and materials relevant to the further development and as part of the preparation for the upcoming work to be done.



Cutting edge laser technology

The research and development of laser technology has been carried out at the Laser Center at Vilnius University (VULRC). The primary goal is further development of laser micromachining with ultra-fast pulses. The progress that has been made is by means of selection, purchasing, integration and testing of suitable parts for the laser micromachining system. This includes the collection of the wavelength conversion module with appropriate optics, integration of galvanic-scanner for fast beam positioning as well as a study auto focussing/surface tracking possibility.

At the same time novel micromachining regime has been also tested by using a rotating mirror concept. The effect of laser pulse energy on the surface bottom roughness has been observed and it was demonstrated that pulse density tends to be essential parameter for micromachining quality.

Innovative ceramic development

The University of Bath is developing new ceramic materials suitable for a mesh network which will measure wear in steel components. Ceramic materials with appropriate electrical, mechanical and thermal properties for the sensor device are being currently investigated.

Materials previously identified at the initial stage, have been produced and detailed characterisation performed. It is indeed possible to develop conductive ceramic materials with tailored properties for the sensor element with a thermal expansion coefficient (8 to 9 x 10-6 K-1) suitable for their insertion into micro-grooved steel. Suitable insulator components to insert between the steel and the conductive element have also been identified. Among the sensing modes (microwave, low frequency AC or DC) considered, the most promising appears to be the resistive measurement approach.

It is all about bonding

The objective is also to develop a microstrip bonding mechanism along with the required control electronics such as pre-amplifiers and filters and ADC converters for high frequency signals. These will be tested with an algorithm designed to detect and determine the abrasion of the sensor mesh. This will be done using modeling data and mock up versions of the electronics to ensure stability. The electronics and algorithms will be tested rigorously both on simulation data and in the laboratory.

Work on transducer and DSP development has progressed with the most significant decision to eliminate high frequency microwave transducers. Resistive measurement using a DC signal is the most applicable technology and will allow measurements with a higher accuracy considering issues relating to signal frequency. The results obtained so far show that the objectives can be achieved using several methods. The most optimal solution will be chosen taking into account technical and economic aspects.

1.3 EXPECTED FINAL RESULTS AND THEIR POTENTIAL IMPACT AND USE

The final result of the project is the creation of a cheap, innovative ultra-thin conductive ceramic mesh to monitor stress and wear on a steel surface, using novel technologies like laser etching, conductive ceramics and advanced algorithms capable of detecting wear and tear or damage done to a metal surface.

Recent statistics show that injection moulding machines are only running at 60.2% utilization rate and have as much as 20% downtime. In order to increase their profitability and to be able to compete on the global market the utilization rate has to be increased.

Due to the nature of the proposed technology, it will be capable of doing non-invasive real time measurements during production, giving OEM sub-suppliers the possibility of ensuring high quality parts, reducing the amount of produced scrap and increasing machine utilization in a cost effective and easy way.

End users such as large production injection moulders will be able to monitor the structural health of a mould to determine when a mould is worn out or damaged ensuring they can order a new mould before production breaks down. It will also allow the end user to stop production as soon as the mould surface is damaged instead of waiting several hours before a quality assurance system detects the damage.

The technology could potentially also be used for real time health measurements on dyes for extrusion, in the automotive industry. In addition, the technology can be applied to driveshafts, gears, brake pads and a number of other areas where steel surfaces are subjected to continuous friction.

1.4 PROJECT WEBSITE

The MesMesh project website, www.mesmesh.eu, was launched in November 2010 and contains the project description, contact information, and publishable research results achieved so far. It will also include details of dissemination activities when we are further along.

For contacting the MesMesh consortium, please write to;

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