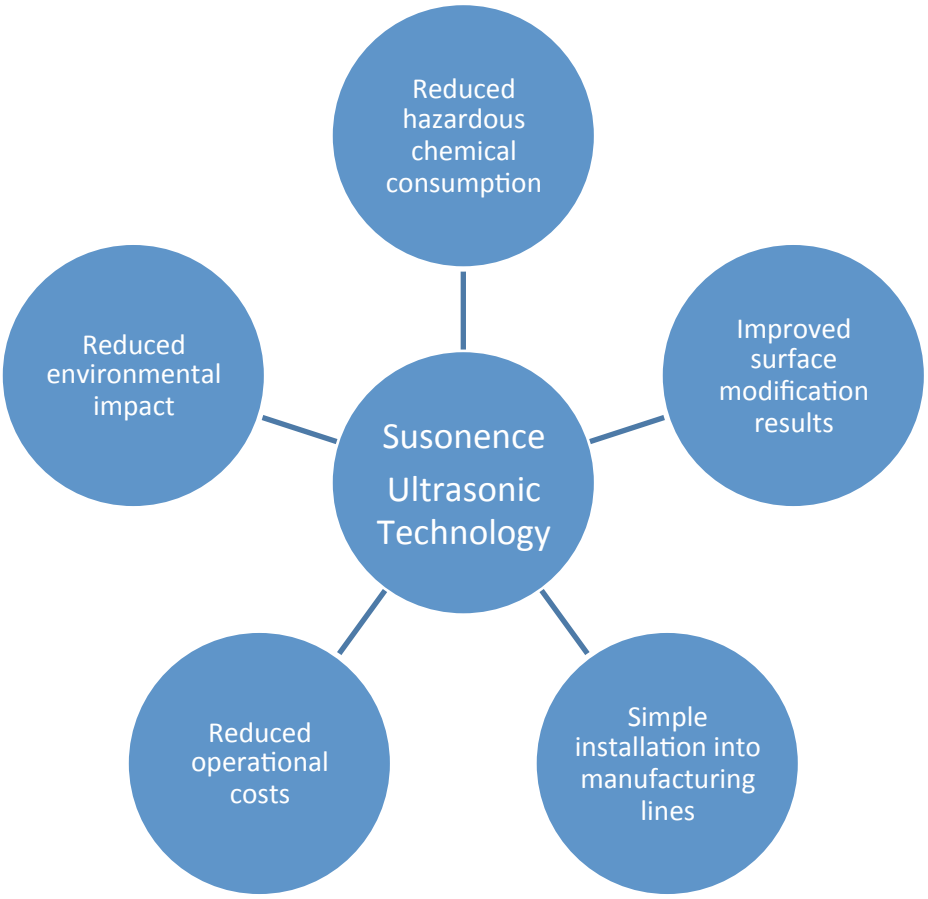
Susonence

Sustainable Ultrasonically Enhanced Chemical Processes

An Eco-Innovation Project to decrease chemical consumption and environmental impact within the surface engineering and allied sectors



A project sponsored by EASME (Executive Agency for Small and Medium-sized Enterprises) under the Eco-Innovation Initiative

eco-innovation

Background and Overview

Many chemical processes used in the Printed Circuit Board (PCB) and Metal Finishing sectors represent a non-sustainable use of finite resources. They typically consume significant quantities of chemicals and water and also lead to the generation of large volumes of effluent that are difficult and expensive to treat, while also wasting valuable materials. They also often operate at relatively high temperatures. There is a need to improve these processes via the use of new technologies that can enhance the overall efficiency and sustainability of these important sectors and that also offer a competitive edge over increasingly strong competition that is typically based in the Far East.

Susonence employs novel combinations of advanced ultrasonics and more benign, dilute solution chemistries as the basis of new processes that use less water, materials and energy in operation and which produce reduced quantities of waste. The project has built on earlier R&D work that has already clearly demonstrated the potential efficiency and environmental benefits of using ultrasonics in PCB and metal finishing processes. The Susonence project has been carried out to target key specific process combinations and to move this novel, highly innovative technology from the laboratory towards a production scale.

The project has resulted in the first installations of pilot plants at a partner SME site in France – Promet. Promet operates a variety of finishing processes within the surface engineering sector and has a client base embracing the aerospace and nuclear engineering industries. In common with many companies in the surface engineering sector, Promet wishes to move towards more environmentally friendly and cost-effective process solutions. Additional installation activity has taken place in the printed circuit board-manufacturing sector at Merlin Circuits in the UK.

The project has been coordinated by Env-Aqua Solutions Ltd (UK) and the project partners are:

C-Tech Innovation Ltd, UK;
Coalesce Solutions Ltd, UK;
Protection des Metaux SAS, France;
Pragoboard s.r.o, Czech Republic;
EIPC Services B.V., Netherlands
International Project Management, Plating and Materials, France
Coventry University, UK

Project

Technology

Surface modification processes are employed as an integral part of a large number of surface finishing processes. Wet chemical processes are used to change the chemistry and surface morphologies of a wide range of metal, polymer and ceramic substrates.

This is done so that the subsequently applied coatings are well adhered to the surface by a mixture of chemical and physical bonds. Wet chemical processes have traditionally been employed for surface modification in the metal finishing industry, since they can be easily integrated into a chemical plating line.
These traditional wet chemical processes tend to be characterised by the use of hazardous chemistries. The solutions are frequently either strongly acidic or alkaline and thus highly corrosive. Oxidising agents are also regularly applied, e.g. chromic acid, which has recently been upgraded from toxic to highly toxic and is classified as a carcinogen with its usage subject to ever-stricter legislation. In addition, not only are neutralizers often required but also copious rinsing, which increases water usage and produces highly contaminated wastewater requiring subsequent effluent treatment.

Sonochemical surface modification involves acoustic cavitation, where unstable bubbles form and undergo violent collapse creating locally high temperatures and pressures with the breakdown of chemicals in the cavitation bubble, e.g. the sonochemical decomposition of water can produce short-lived highly reactive species such as hydroxyl radicals (Mason T J, Lorimer J P, Applied Sonochemistry, Wiley VCH (2002) ISBN 3-527-30205-0).

Acoustic cavitation in a liquid near a surface causes asymmetrical collapse resulting in the production of a powerful microjet of liquid towards the surface. This can produce surface activation and surface cleaning through both chemical and mechanical attack, as well as improved heat and mass transfer. Extremely localised high temperatures and pressures can be generated which can alter the surface chemistry of the material by generating free radical species.

The application of this technology is capable of enabling surface modifications at a level more normally achievable by the deployment of, in many instances, concentrated hazardous chemistries operating at elevated temperatures, by dilute benign chemistries operating at near ambient temperatures. The impact of such has considerable reduced raw material, waste, energy and environmental demand.

Acoustic Cavitation Reactor (ACR) with sides removed to show the ultrasound generators

Results

The system has been demonstrated in pilot plant format for distinct applications within surface finishing and printed circuit board manufacturing facilities.

At Promet SA, our surface finishing partner plant in France, the system has been successfully installed to operate full-time on a production basis for tin/ lead barrel plating and plating on plastics pre-treatment applications.

Deployed on tin/lead barrel plating, the Susonence technology has demonstrated enhanced quality over conventional processing in that the tin/ lead ratio is maintained at an optimum 60/40-alloy value and has eliminated all problems in the control of alloy composition. This was a serious issue because compositional variations in the plated alloys caused significant changes in alloy melting points and product solderability. Other significant benefits are cost and environmental related in that the use of Susonence technology has demonstrated a 20% reduction in surfactant additions and a 50% reduction in organic brightener additions for the tin/ lead plating chemistry.

The plating on plastics deployment of Susonence is of greater significance in that results at Promet have demonstrated that more benign chemistries may be deployed in obtaining equivalent pre-treatment to that obtained conventionally with hot, concentrated chrome/ sulphuric acid solutions. Whilst Promet does not undertake large volume plating on plastics operations, for a dedicated manufacturer of plated on plastics products the cost, health and safety, legislative and environmental benefits are considered significant.

A video of these installations may be seen on You-Tube at the following web-address:

www.youtube.com/watch?v=dR6oQT3Q2ME

The printed circuit board manufacturing applications were demonstrated at Merlin Circuits Ltd in the UK via deployment on desmear and micro-etch applications.

In desmear operations, one is seeking to remove resin smearing within through-holes, which has occurred during drilling operations and which would otherwise inhibit the subsequent adhesion of electrodeposited metal through the holes forming conducting cross-layer interconnects. Desmearing is traditionally carried out using hot, concentrated potassium permanganate solution. With Susonence technology deployed, an equivalent level of desmear was obtained using a 17% reduction in temperature, a 50% reduction in chemical concentration and a 75% reduction in immersion dwell times. Together these benefits accrue into productivity, cost, health and safety and environmental gains.

In micro-etching operations, whilst no significant gains appeared to be attainable by the deployment of Susonence within a standard etch process, what was demonstrated as significant was the ability of Susonence to achieve comparable etching at low chemical compositions.

What can be clearly seen from the deployment results are the potential benefits of Susonence technology across a variety of chemical process treatments in respect of all tenets of sustainability, viz environmental, economic and societal.

The Market

The manufacturing processes to which the new technology could be applied play a critical role in industries of strategic importance to the EU, for example, civil and military aerospace, maritime, electronics, engine manufacture, automotive manufacture, chemicals and general engineering. The broad SME base within the metal finishing and surface engineering sectors represent key elements of the supply chain to these industries. The top industries served by electroplating SMEs are: Automotive (34%); Heavy Industrial (30%); Aerospace (27%) and others 5%. The products incorporating surface engineering are also widely used in the production of a large number of items for domestic and commercial use. The function of coatings produced in the sector is split between corrosion (42%), decorative (31%), abrasion resistance (22%) and others 5%.

It is considered that the market barriers across Europe have a synergy in that there are few regional issues distorting the legislative drivers, which are European, and the cost drivers, which are global. Within such a scenario it is felt that the deployment of Susonence to a variety of chemical processes not only enables significant reductions in environmental impact to be realised but does so in a manner that will offer tangible benefits in reducing costs and hazards within the targeted sectors. This is in itself considered to be a real contributory factor in enhancing competitiveness within these sectors of the European economy.

Further Information

For further information on this project please contact Dr Rod Kellner.

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