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CASE REPORT

SusCryMac – Innovative Cryogenic Machining by a Novel System and Method for Delivery of Liquid Cryogenic Fluid

This project is implemented through the CENTRAL EUROPE Programme co-financed by the ERDF.

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SUSCRYMAC

Summary

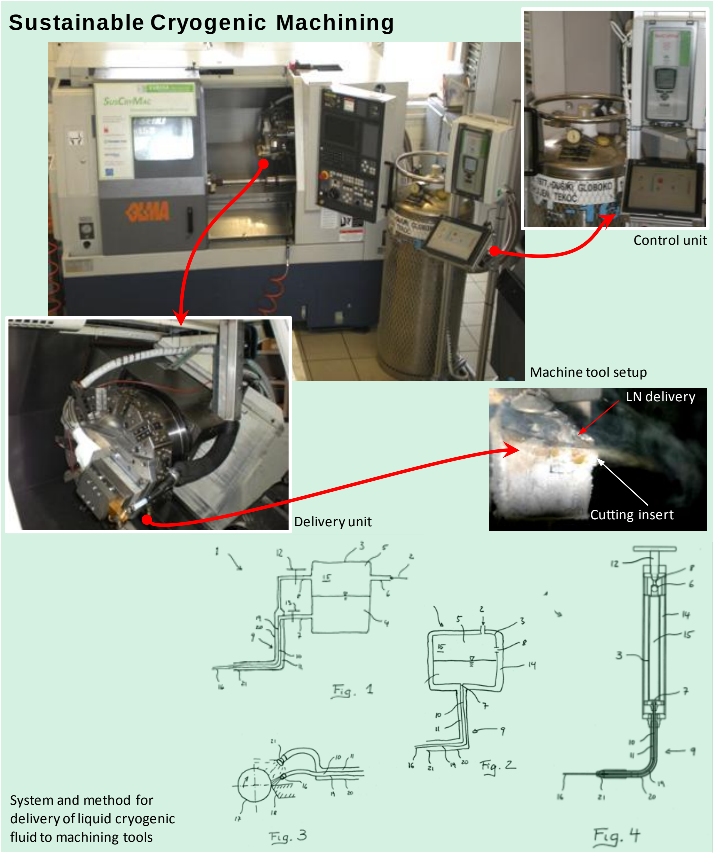
University of Ljubljana, Faculty of Mechanical Engineering, has developed a system and method for the **delivery of liquid cryogenic fluid to the machining tool / process** (patent pending). The invention is in the field of sustainable alternative to conventional machining – **cryogenic machining process**.

In particular, the invention relates to system and methods for delivering cryogenic fluid in liquid form / phase to the machining tools, preferably to a cutting zone of the machining tool to enhance the overall machining process performances. The solution can be useful for the companies that deal with the machining processes and the companies dealing with technical and cryogenic fluids.

Technology

In the machining processes, due to the nature of the process, there are beside **mechanical** also huge **thermal loads applied on the cutting tools**. For contradicting those loads, oil-based emulsions are usually used, even though they are known to be environmentally unfriendly, health hazardous and relatively costly. As **an alternative to oil-based emulsions** (from the sustainability aspect of view), a **nitrogen** that has evaporation point at -196°C and is in 78% present in the air that we breath, can be used **as a cooling lubrication fluid**.

The cooling mechanisms are obvious, however lubrication are more complicated. The problem that is faced when talking about cryogenic machining is in **delivery**. Due to the heat transfer and nonsufficient piping insulation, the delivered cryogenic fluid is usually in gas phase. With this, the lubrication as well as cooling properties are affected. Based on this invention, **a new system for the delivery of cryogenic fluid** has been developed that **assures the delivery of nitrogen to the cutting zone in the liquid phase**, and so improves lubrication as well as cooling conditions. Innovation is related to the continuous liquid phase cryogenic fluid delivery, with developed phase separation that delivers the liquid phase to the cutting zone, while eliminated gas phase is used as an insulation of liquid phase and establishing of inert atmosphere in the local cutting zone. The innovation at that stage improves cooling as well as lubrication performances, and nevertheless improves the overall performances of the cutting process/machined surface integrity.



Picture 1: Sustainable Cryogenic Machining

Development stage

Patent has been filed (EPO no. 10000782.2 and EPO no. 10001232.7). The university is interested in license or commercial agreement with technical assistance, as well as technical consultancy and/or joint further development.

The prototype unit, including the invention, runs at the Faculty of Mechanical Engineering, University of Ljubljana – Slovenia, and is available for demonstration and/or field test.

Market/Opportunity

SUSCRYMAC technology has a high potential in automotive and aerospace industry. When this technology will be specifically designed and adapted to different applications, such a manufacturing system will have a high potential to overtake a part of oil-based CL used in the industry nowadays and to become a sustainable high-performance alternative.

Surveys indicate that few companies have accurate information regarding CL costs. Available data in the EU automotive industry show that manufacturing costs incurred in connection with the deployment of CL are at 15-20%. CL are made from concentrates. On average about 4% concentrate are included in the water miscible CL. Single machines contain up to 5 m3 of CL, while large central CL systems may have up to 100 m3 and more. Common time intervals between replacements range from 4 weeks (single machines) to 1 years (central CL systems). A medium size automotive parts manufacturer uses 100.000 litres of oil-based CL that has to be changed every year. This change can cost up to 40.000 €. In addition 15.000 € are used for chemical treatment of oil-based CL, 15.000 € for waste water treatment and 6.000 € for cleaning of pipes and installation.

The market overview for CL usage in the EU is the following:

Substance group	Germany sales (t/year)	Total sales for EU (t/year)
All lubricants	1.146.844	5,2 mio
Of those, CL	78.877	360.000
Non-water miscible CL	48.170	220.000
Water miscible CL (concentrate)	30.707	140.000
Emulsions and solutions created from water-miscible CL	~770.000	~3,5 mio
Total amount of CL used	~820.000	~3,7 mio

It should be noted, that these statistic do not cover mineral oil free CL. Those mineral oil free lubricants have a market share of approximately 20% of total amount of water miscible CL produced.

This data are showing big market on one side, while on the other side are showing frightening affect on the environment pollution and health hazards. Both of them are putting high potential on the proposed innovative & sustainable cryogenic machining system with corresponding technology.

There are three different markets where SUSCRYMAC has a high potential of applicability:

- The individual industrial branches drive the specific demands for new innovations using the differing engineering materials. In particular in the automotive and the aerospace sectors that are SUSCRYMAC’s prime targets, the use of light weight, energy saving materials play a vital role for structural components, housings and drive system components. The continuing generation of new material types feeds the demand for low-density materials with high strength and easy manufacturability. The cutting of these materials is difficult due to the low thermal conductivity, the brittle nature of the material and the high chemical affinity to all known cutting tool materials. The economic efficiency of automotive and aerospace facilities is still a central issue for cutting technology. In-plant, adding of value to products and workpieces only takes place during essential operating time. Conventional processes such as grinding and turning have come under close scrutiny from a productivity perspective. The trend in recent years has been towards advanced cutting. For example, by replacing grinding with hard turning, process steps can be eliminated. The requirements for advanced cutting such as SUSCRYMAC place new and demanding challenges on the design and technology of the cutting processes. Apart from its economic importance, SUSCRYMAC research will enhance environmental sustainability through the proposed innovative sustainable machining system/technology, with cleaner, safer, cheaper machining with comparable quality. Additionally, environmentally sustainable production process gives more space for negotiation of the market price since the actual cost of production is lower and no additional costs are needed for oil-based CL usage, cleaning of parts, machine tool, etc. When all producers in the branch conquer new sustainable production technology (eventually, they will be forced to do so), costs will decrease. In general, this is good also for the EU economy.

- The second market is the one for the new cryogenic delivery system itself, which is not yet readily available in the EU market. As the system promises a high potential of applicability in hard cutting, most manufacturers in automotive and aerospace industry will need it, since the machining and product performances under cryogenic cooling can be drastically improved.
- The third market is covering high-tech industry, that is producing the parts were it is not allowed to used any CL at all, while this highly affect the functionality of the final product (for example tungsten dispenser cathodes are emitting the electrons under the chemical reaction which is immediately affected with the presence of just tiny amount of oils). Therefore, they are forced to use alternative machining that does not leave any residues on the workpiece, and keep machining performances as high as possible.

IP

The patent has been filed (EPO no. 10000782.2). The innovative cutting tool holder arrangement for sustainable cryogenic machining technology has also been patented (EPO 10001232.7). The university is interested in license or commercial agreement with technical assistance, as well as technical consultancy and/or joint further development.

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