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CONSIDERATIONS REGARDING CHIPS PROCESSING EQUIPMENT COMPONENT OF A SUSTAINABLE METALWORKING PROCESS

BY

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Abstract. Metalworking results in parts of different sizes and shapes, but also in metal waste that must be disposed according to the environmental protection requirements and, at the same time, reducing the costs for the company by scrap metal recycling and re-use of coolant in the process. Using a debris processing system „locally” can raise the value of scrap metal going to the recycler, reduce material handling and maintenance concerns, filter coolants for reuse in machine tools and help the manufacturer achieve environmental compliance. Based on the current direction in the field of Ecodesign a series of guideline have been proposed for the design, construction and operation of the new hybrid equipment for shredding / briquetting - compacting metal chips with coolant separating-collecting system from machine-tool.

Keywords: metal debris; coolant filtering; recycling.

1. Introduction

Metalworking represents an important part of the manufacturing industry as it results in parts with sizes and shapes from the simplest to the most

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complex, high quality of the processed surfaces, high productivity and relatively low costs, with application in automotive, naval, aeronautical, food, chemical, medical industry and so on. Common metals that are cut or machined include steel, stainless steel, cast iron, non-ferrous (aluminum, brass, cooper, magnesium, etc.), heat resistant super-alloys, titanium and hardened steel.

Cutting process refers to the removal of the material surplus from the workpiece in order to obtain the finished part having the dimensions, shape and technical conditions imposed by the technical project (design). The material surplus is removed in form of chips. The cutting process results in high cutting forces, friction and heat leading to high energy consumption and early wear of the cutting tools. To reduce these inconveniences in the cutting process, cooling-lubrication fluids are used, either in flooded form or in the form of a minimum quantity (MQL) accurately directed in the cutting area. Thus the cutting process of metals will result in finished parts and debris in the form of chips and used cooling-lubrication liquid. Frequently, the two elements adhere to each other.

Regardless the size of the metalworking facility, they all are facing the necessity to dispose these wastes while meeting the requirements imposed by the environmental legislation. Waste disposal means recycling the chips and coolant. In fact, each company can earn both by producing parts and by partially recovering the raw material costs and reusing the coolant. Recycling companies specialized in metal debris collection and processing offer a better price as scrap metals are dried, without coolant that adhere to chips.

Traditionally, within the metalworking facilities, the dirty coolant that contains the metal chips is discharged from the machine to be later processed, by a chip discharge system, whereby only the chips contained in the dirty coolant are separated from the coolant and collected. The chip discharge conveyor system typically includes a belt conveyor designed to remove only chips from the dirty coolant discharged from the machine tool and then discharge these chips out of a treatment tank. The clean coolant is filtered through a filter drum and discharged into another tank or recipient. It results in yet wet debris to be recycled. Equipment for debris processing at the workstation could be a solution.

2. Research Background on Chips and Coolant Processing Equipments

The literature review in the field resulted in three types of debris processing equipments: chips shredding/breaking, coolant separation and filtration and debris compacting. These equipments are used separately or in large systems including two or all of the three. The chips shredding equipments include shredding tools, usually consisting of several circular cutters in order to provide uniform, small sized chips from different sizes obtained in the cutting

process (Zhanjun, 2014; Areaux and Dudley, 1983; Rota, 2005). The tools have a rotating motion due to their location on shafts driven by an engine. There may be one or more shafts in the shredding equipment and other cutting edges on the casing walls, also having a crushing role (Nemedi, 2007). Most chips shredding equipments are composed of two shafts which rotate in opposite directions to retrieve easily the volume of chips. There are also equipments provided with devices for reversing the shafts rotation for the situation of blocking with large parts of the workpiece (Areaux and Dudley, 1983). The feed of chips volume is provided, in most cases, from the upper side of the equipment, but there are solutions in which the feed is made by one side (Areaux and Dudley, 1983).

The equipments for fragmentation waste are very complex equipment that can be used for shredding / crushing of metal, non-metallic, vegetable, animal waste, which usually consists of several cutting tools made of circular knives with the role of bringing the initial size waste to small and relatively uniform size parts. Another different equipment is used for compacting / pressing / baling the of waste is also known as waist presses.

There are also equipments for coolant separation and collection in order to be re-used (Fangpu, 2014; Mahas *et al*., 2010; Beek *et al*., 2004). These equipments consist of elements that involve the use of the magnetic field (Fangpu, 2014), centrifugal force in the upright (Cope, 1999; Dudley, 2001) or inclined position (www.arp-mb.de; www.prab.com; www.erdwich.com) and less frequently, of the air flow (Forlong, 2014). These equipments are used individually or in systems involving also the chips breaking. There are also chips compacting equipments consisting of hydraulic actuators (Thompson, 2002; Ralicki, 2008; Danielsson, 2013), ball screw actuators (Bendzick *et al*., 2002) and less frequently, pneumatic actuation. These equipments are also used individually or within systems including chips shredding devices.

The solutions found in the field have the disadvantage that they do not perform complete metal debris processing or have a complex structure, which means high resources consumption or high processing costs.

3. Considerations Regarding a Chips Processing „On the Spot" Equipment

The proposed equipment can be used to process the chips taken directly from the machine's conveyor belt and provides chips shredding, separating and collecting in two stages the coolant used during the machining process and chips compacting (Bocăneț *et al*., 2017). The solution presented in Fig. 1 has a compact construction that allows location in the proximity of machine-tools, with the possibility of simultaneous serving of several machines and performs chips processing „on the spot" (locally), without the need for additional debris handling operations.

The equipment consists of two main parts: a subassembly for chips shredding (mechanical subsystem) and a chips compacting subassembly (hydraulic subsystem). In both subsystems elements for separating and collecting the lubrication-cooling liquid are found. The shredding unit consists of a tank *1* with inclined walls to contain the chips, two sets of rotating cutters *2* with the purpose to reduce the size of chips, two sets of air nozzles *3* to guide the chips and partially separate the cooling-lubrication liquid, an inclined tank *4* provided at the bottom with a metal net that allows the coolant-lubricant adhering to the chip to separate and be collected.

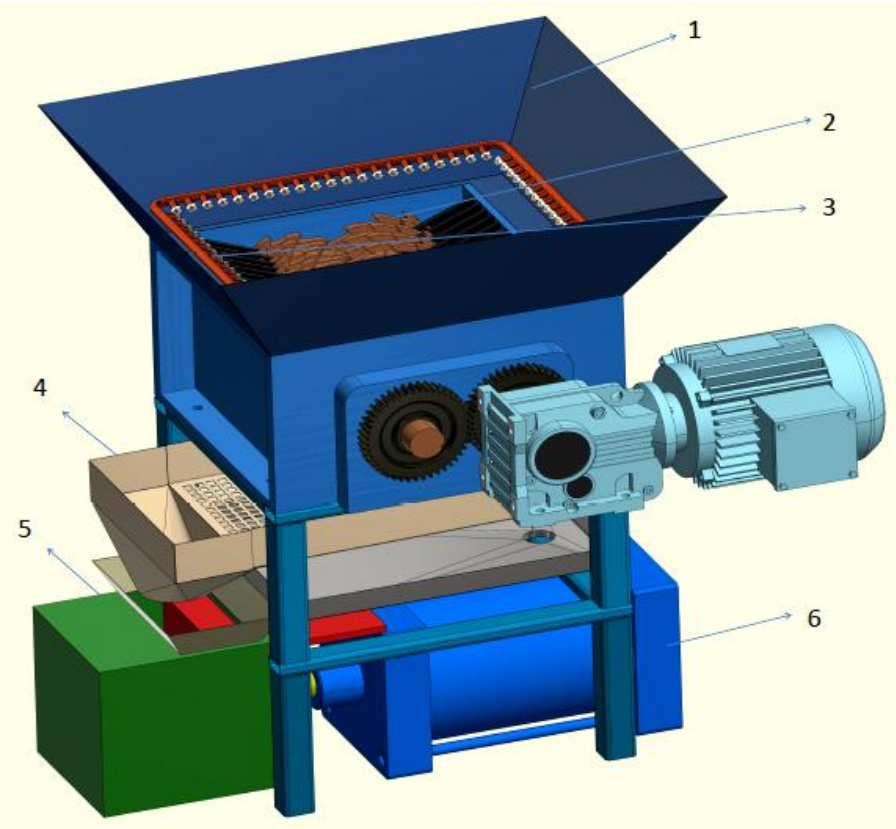

Fig. 1 – Proposed solution for new hybrid equipment for shredding / briquetting - compacting metal chips with coolant separating-collecting system from machine-tool (Bocăneț *et al.*, 2017).

The chips compacting assembly consists of a chamber *5* where a compaction plate driven by a pneumatic cylinder *6* will compact the chips into a solid block that will be discharged by opening a hatch/door mounted on the chamber.

The equipment can be industrially exploited in order to facilitate the recycling of chips within the company, being used at the workstation, for a large flow of metal waste, or separately in specially intended spaces.

Some advantages could be drawn from installing chip processing and coolant separation equipment, such as:

– The metalworking facility could process/recycle metal debris at the workstation with low resource consumption (electricity, compressed air);

– Recovering coolant by separation from the chips is beneficial for the company both in terms of new coolant costs and in terms of compliance with environmental legislation, mitigating its environmental impact;

– Any manufacturer could raise the value of its debris as dried and reduced size scrap metal could be sold to recyclers at higher prices;

– The result of chips processing is in the form of compact blocks that are easy to handle and stored;

– The chip blocks obtained from the processing are dried as a result of the separation of the liquid, occupying less space than the uncompacted chips and therefore could be stored for a higher period time.

4. Design Guide Lines for Chips Processing Equipment

In order to design the mechanical and hydraulic subsystems new hybrid equipment for shredding / briquetting - compacting metal chips with coolant separating-collecting system from machine-tool Eco-design principles and requirements must be used. Eco-design refers to the aim of optimizing the environmental performance of the products while maintaining the functional quality, in accordance with Ecodesign Directive 2009/125/EC for the setting of ecodesign requirements for energy-related products repealed the original Directive 2005/32/EC.

Thus, for the phases of the product life cycle, beginning in design, for the manufactures, a series of ecological design parameters are indicated: (a) the selection and use of raw materials; (b) manufacture; (c) packaging, transport and distribution; (d) installation and maintenance; (e) use; (f) end of life cycle, that is, the condition of a product which has reached the end of its first use until its final disposal.

From the analysis of the literature in the field of metal cutting/ metal working, machine manufacturing , the field of hydraulic drives/ fluid power a number of areas that can be approached and significantly improved, in the construction of new hybrid equipment for shredding / briquetting of metal chips, namely:

– the geometry of the fragmentation knives, the material used;

– the types of motors used especially in the case of hydraulic drive;

– technological optimization of individual components from the construction;

– introduction of the components for the recovery of the cooling-lubricating liquid from the chips resulting from the mechanical processing.

For the hydraulic systems, the relevant ecological design parameters are: weight and volume of the product; noise reduction; reducing energy consumption; extending service life and reducing hydraulic oil losses / leaks.

Ecological design involves the use of the best available technologies. The analysis carried out by BAT (Best Available Technologies), indicates for hydraulic operation, the following actions that can be followed (Fraunhofer, 2011; Bendzick *et al*., 2002; Findeisen, 2006; Handroos, 2017; Paoluzzi, 2008):

– optimal choice of auxiliary devices, pump system and engine size,
– adapting the pressure to the required level of system operation,
– use of optimized valves,
– use of hydraulic accumulators.

5. Conclusions

Metal waste processing is an important part of the activity of any metalworking facility, both in terms of environmental protection and recycling costs. The paper presents a chips processing solution that can be used at the workstation and has some advantages, such as processing of the chips „on the spot" using the resources that can be found at the workstation, easy handling of the scrap metal and so reducing the risk of injury of the operators and reducing the costs with new coolant. Based on the current direction in the field of Ecodesign a series of guideline have been proposed for the design, construction and operation of the new hybrid equipment for shredding / briquetting - compacting metal chips with coolant separating-collecting system from machine-tool for the mechanical and hydraulic subsystem.

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CONSIDERAȚII PRIVIND PROCESAREA AȘCHIILOR ÎN SCOPUL RECICLĂRII - COMPONENTĂ A UNUI PROCES DE PRELUCRARE PRIN AȘCHIERE SUSTENABIL

(Rezumat)

Prelucrarea deșeurilor metalice reprezintă o parte importantă a activității fiecărei întreprinderi având ca obiect de activitate prelucrarea metalelor, atat din punct de vedere al protecției mediului înconjurator, cât si din punctul de vedere al costurilor cu reciclarea. În lucrare se prezintă o solutie de procesare a așchiilor la postul de lucru. Echipamentul propus este avantajos deoarece procesarea aschiilor se realizează „local" utilizându-se resursele prezente la postul de lucru (electricitate, aer comprimat) și astfel nu apar costuri suplimentare cu aducerea altor tipuri de resurse, manevrarea deșeurilor metalice devine mai facilă, iar riscurile de accidentare ale operatorilor sunt reduse și prin separarea și colectarea lichidului de răcire-ungere se reduc costurile cu noi lichide.

Pe baza direcției actuale în domeniul proiectării ecologice, au fost propuse o serie de principii pentru proiectarea, construcția și funcționarea unui nou echipament hibrid pentru mărunțire / brichetare - compactarea chipsurilor metalice cu sistemul de separare-colectare a lichidului de răcire din mașină-unealtă.