Treatment and disposal of coolant in machining operations

Uzdatnianie i utylizacja chłodziwa w obróbce skrawaniem

HALINA PODSIADŁO
TOMASZ SZMURŁO*

DOI: https://doi.org/10.17814/mechanik.2017.8-9.106

Coolant plays a very important role in machining operations. Over time, coolants become worn out and, as such, they would be corruptive for the ecosystem. For economic reasons, it is worthwhile to treat them for reuse. Then for the environment protection reasons they should be properly disposed of. These issues are closing the subject of the article.
KEYWORDS: cooling liquids, machining, coolant conditioning, utilization, economics, ecology

Cooling fluids play a key role in machining. Without them, such processes as drilling, tapping or grinding, would be difficult to do. The tasks of machining fluids include:

- lowering the temperature of the tool and the workpiece, which favorably influences the dimensional accuracy of the workpiece produced and the blade life,
- reduction of friction between the tool and the workpiece and chips, which reduces the force and cutting power, thus reducing the amount of heat produced and improving the quality of the treated surface,
- ease of removal of chip from the cutting zone,
- counteracting the growth,
- corrosion protection of the workpiece and machine.

In order to meet the basic functional requirements, the working fluid should:

- well drain the heat, which corresponds to water responsibility,
- have good lubricating properties, which in turn is made by oil.

Machining fluids can be divided into oil emulsions and clean oils. **Oil emulsions** are oil mixtures, usually mineral, with water (in a ratio of 1:10 to 1:60) with the addition of emulsifiers, corrosion inhibitors and bactericides. They have better cooling properties than water and much higher lubricant capacity. They improve the lubricating properties that can be obtained by adding vegetable or animal oils. They are supplied in the form of concentrates, which should be mixed with water, usually with special mixers (fig. 1).

As **oils**, vegetable and animal fats, mineral or mixed can be used. Mineral oils are often used as the cheapest and most effective. Compared to emulsions, oils have:

- significantly weaker cooling properties,
- improved corrosion and lubricity properties thanks to active additives or admixtures of fatty oils.

Liquids based on fatty oils are very effective, also in terms of cooling properties, and are easily biodegradable [10].

* Prof. dr hab. inż. Halina Podsiadło (h.podsiadlo@onet.pl), inż. Tomasz Szmurło (szmurlotomasz@gmail.com) – WIP, IMiP, Politechnika Warszawska

Fig. 1. Mixer for dispensing oil concentrate with water [1]

In addition to oil emulsions and oils, synthetic fluids are used. These are aqueous solutions such as glycol without oil. They exhibit properties similar to oil emulsions, and their transparency makes it easier to observe the treatment zone [8].

Recovering the coolant on a single business scale

Coolant recovery is one way of reducing costs and demonstrating the care for the environment. The use of a closed system is most commonly used, which allows multiple uses of the same coolant. The process is that the coolant fed into the cutting zone flows down the workpiece and workpiece with the chips to the drawer or chip conveyor (fig. 2). The conveyor/drawer has two functions: remove chips from the machine space and separate the coolant from the residue after machining. From this point on, the coolant recovery process begins. It flows through sieves, where thicker chip fractions are deposited, and then pumped to the main tank [11]. But before it gets

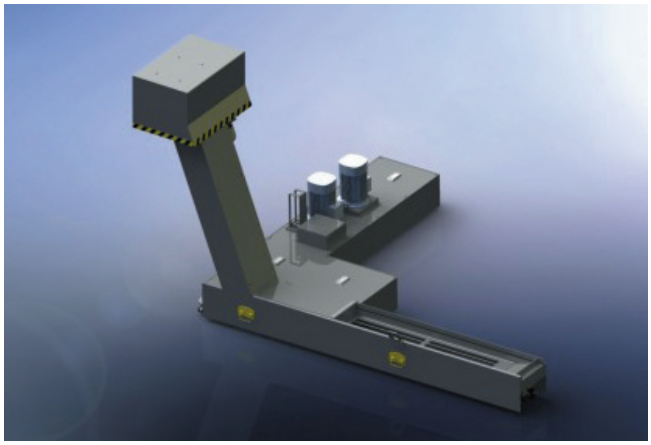

Fig. 2. Chip conveyor [2]

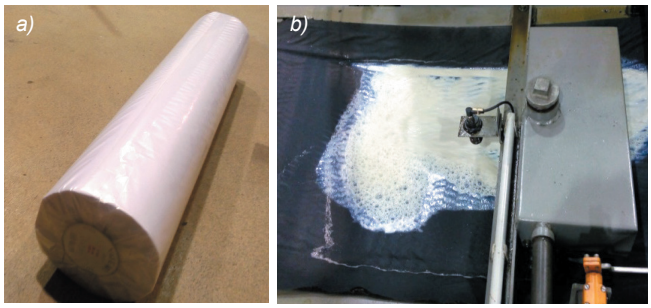

Fig. 3. Spare filter roll [1] (a); process of filtration of coolant using fleece with active carbon [1] (b)

there, it is filtered by a special material (fig. 3a and fig. 3b). Vesicles are found in two types: plain white and black, containing active carbon, which prevents the development of mold in natural emulsions. Soaking through the material, the coolant leaves on it fine chips. sludge (fig. 3b).

Purification of the coolant from the fine metallic suspension is very important due to the prolongation of the service life of the high pressure pumps and the patency of the fluid delivery tubing directly into the cutting zone. Filtration coolant is successfully used in the cutting process, in closed loop. The wasted slurry is collected into the container and then disposed of (fig. 4).

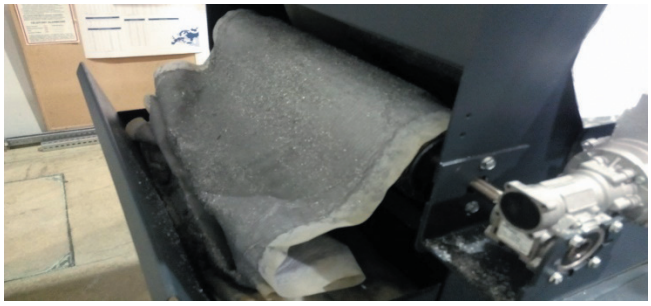

Fig. 4. Used fleece [1]

Purification of cooling-lubricating liquid

Another process to restore the coolant properties is to collect the oil that accumulates on the liquid surface. The oil distributed through the central lubrication system of the machine is delivered to all its moving parts under load.

Excess oil flows into the machine working area, where it is mixed with the cooling liquid. By using a rugged tape rotated on rolls, the accumulated oil is collected from the surface of the cooling emulsion (Fig. 5). An aluminum sump is pressed against the tape, which removes the oil, then the oil flows through the hose into a separate container.

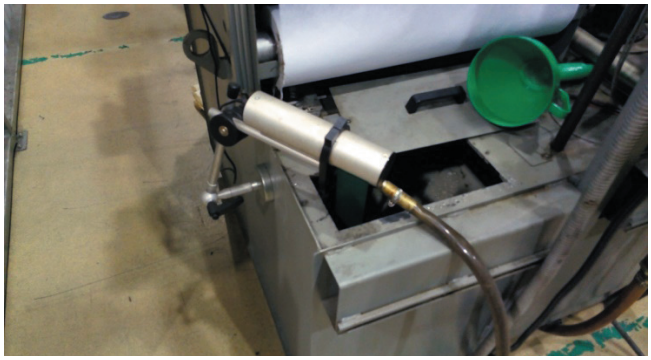

Fig. 5. Oil separation device [1]

In industry, larger oil separators (fig. 6) are also used, which are more efficient, used in larger tanks.

Fig. 6. Industrial oil separator [3]

Coolant cleaning and regeneration systems for the needs of a company

In response to ever-more restrictive environmental standards and market-saving policies, modern refrigerant purification and regeneration equipment is emerging (fig. 7a). Such machines can be installed on each machine (fig. 7b) using an oil cooling system. Oil and other floating substances are separated from the coolant so that the coolant is reusable.

Coolant treatment equipment:

- clean and regenerate the coolant,
- filter impurities (0.4 mm filter),
- disinfect and deodorize (remove odors),
- separate and recover oil,
- are environmentally friendly,
- are self-cleaning,
- they offer high efficiency and low maintenance costs,
- reduce the risk of skin irritation of the worker,
- have PLCs supervising the work,
- can measure the pH value (additional option),
- allow to combine several machines (machine tools) into one system.

These types of systems allow to significantly reduce the expenses for new coolant and disposal of an old one. Separated oil is collected in larger tanks and collected by specialized companies, then is re-processed and serves as a base for further products.

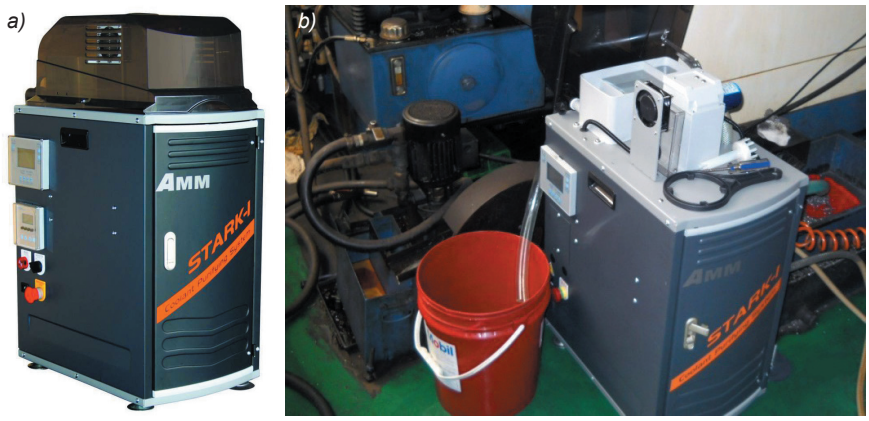

Fig. 7. Sample cooling unit [3] (a), machine combined with cooling system [1] (b)

Oil mist, or coolant in aerosol form

When machining with high parameters from the coolant, an aerosol is generated which escapes from the machining space of the machine. The cloud is rising above the machine and mixed with air. It is inhaled by the operators, settles on the equipment of the workshop, exits outside the building through open windows or ventilation (fig. 8).

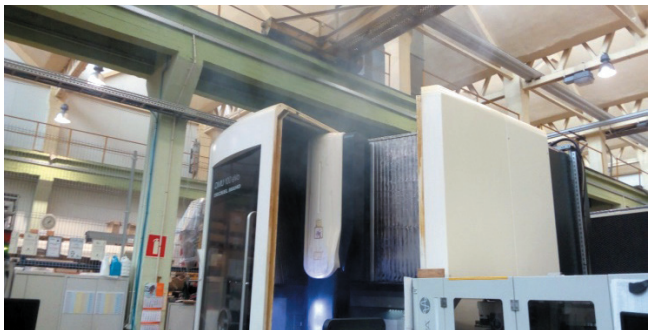

Fig. 8. A cloud of the coolant aerosol floating above machine [1]

In order to prevent such phenomena, companies should supply oil mist, smoke and vapor separators resulting from mechanical treatment using full or emulsified coolants. An example of such a solution may be a filter for central systems (fig. 9). It was designed for larger machines. It can also be used as a central mini-system to combine several machines to provide optimum performance and easier control.

Such a device:

- has filtration systems suitable especially for machine park,
- can filter large quantities of air from large machine tools,
- universal – it can be connected to different machines and attach another,
- is equipped with high-performance modules that allow the purified air to be returned to the room, leading to a reduction in heating costs.

Another example may be a CMC type separator, a combination of a self-cleaning centrifuge system and a mechanical filter system with an enlarged filter surface. The separator is equipped with an integrated pre-filter, recommended under severe conditions, with high dust and chips or where the suction space is close to the spindle (fig. 10).

Fig. 9. UF-type filter for central systems [4]

With the additional filter module – POST-FILTER type P – you can achieve efficiency up to 99.98% H 13 Hepa-Filter (according to DIN 53438, EN 1822) [6]. The initial concentration of impurities is of the order of ≤0.1 mg/m^3. Separators can be used for such pollutants as oil mist, smoke and micro-scrap from tool machines, machining centers, lathes, regenerative devices, lasers, drills, milling machines, screw drivers, grinders, spark processing machines, forging equipment, industrial washing machines and transfer machines [6].

Fig. 10. CMC type separator [4]

Utilization of coolant by distillation

One of the methods of coolant disposal is vacuum distillation. Oil wastewater such as used coolants, emulsions used in foundry or rinsing water can be treated. Hydrocarbons and oils penetrating into the distillate are very problematic. So far, these pollutants had to be separated by additional methods. Due to the low oil content in the distillate it can be reused, thus providing a workshop-free operation or can be disposed of in the sewer. Such solutions are provided by VACUDEST®, which produces ClearCat devices (fig. 11) [5].

Vacuum distillation (fig. 12) gives a crystal clear distillate, removal of heavy metals and salts and sterility due to vapor temperatures above 120 °C. The ClearCat machine with an innovative vacuum distillation system produces a crystal clear distillate, practically free of oils [9]. In addition, it has a self-cleaning heat exchanger (fig. 13), which greatly improves the efficiency of the process.

The effects of the exchanger are:

- improved heat exchange – which results in higher distillation efficiency and lower electricity demand,
- clean surface of heat exchanger – which contributes to reducing cleaning costs, longer maintenance time, higher media concentration and reduced foaming.

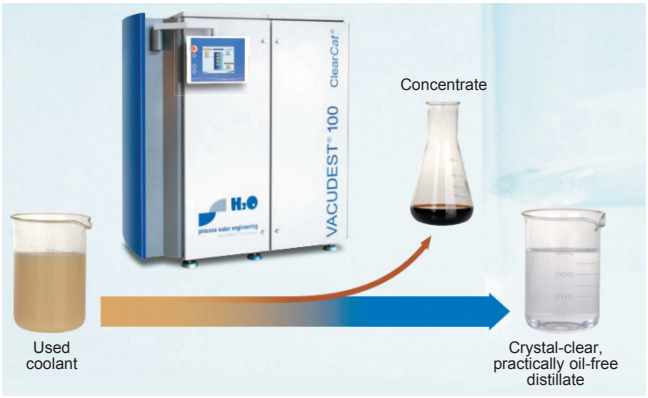

Fig. 11. Vacuum distillation device [5]

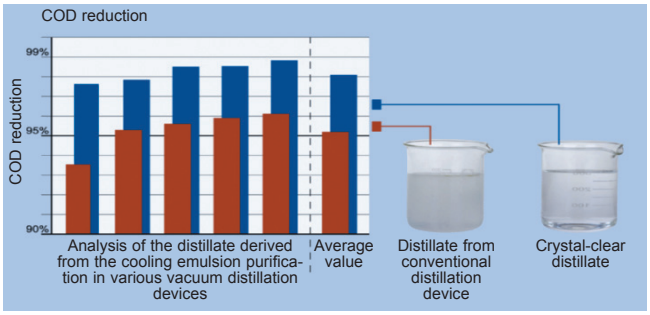

Fig. 12. Comparison of the distillation in vacuum with conventional distillation [5]

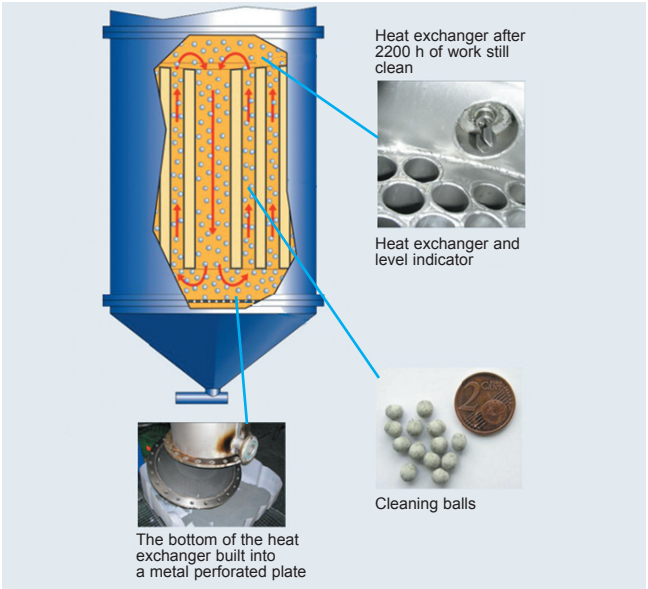

Fig. 13. Heat exchanger [5]

Conclusions

The negative impact of petroleum substances on the environment is a problem that the plants have been fighting for years. More stringent regulations are required to enforce proper conduct in this area. The ecological awareness of the whole society is growing.

Under the name of used oils is often referred to as waste oils derived from automotive: used engine oils, gear oils and hydraulic oils. Industrial waste oils are mainly contaminated hydraulic, gear, machine, turbine, compressor, transformer and heating oils. Among them are waste oils derived from recovered oils used in metalworking – including emulsifying and non-emulsifying oils, process oils, protective oils used to prevent corrosion and other applications. Such oils are also obtained by de-oiling, e.g. in separators. In industrial plants there are also oil-contaminated wastes, such as sludge from oil separators and settlers, metal working sludge containing oil, used oil filters, oily spent sorbents, sawdust, and oil packages. Oil waste is divided into: waste oils, water-oil emulsions, sludge containing oils and other oil waste. Please note that in accordance with the Waste Act (Journal of Laws of 2001, No. 62, item 628, as amended), art. 11 and 39 sec. 5 [7], oil waste should be collected selectively. In Poland, this is a big problem, as it is very common to pollute waste oils with other wastes.

Savings in the plant can be obtained by looking for companies that recycle used oils, ready to pay for the waste that is the raw material for them. Oil recovery brings savings to many parties. The customer, selling the used material, benefits financially by deducting these amounts from the original purchase amount, i.e. buying them cheaper. In the case of transformer oils, for example, this often amounts to considerable amounts. The recipient also resells the waste, and the receiving refinery earns again, for the first time – by selling fresh oil, the second time – when it is used as a component for the production of lower quality oils, but also at a low price.

REFERENCES

1. Materiały własne.
2. www.google.pl/search?q=transporter+do+wi%C3%B3r%C3%imgrc=s_uwWKbL
3. odolejacze.com/tag/destylacja-cleaning/
4. www.technika.pl
5. Materiały firmy VACUDEST®.
6. www.tripleairtechnology.co.uk/downloads/The-new-series-of-BS--EN-1822.pdf
7. isap.sejm.gov.pl/DetailsServlet?id=WDU20010620628
8. portalnarzedzi.pl/artykul/prawidlowe-wykorzystanie-chlodziw/
9. produkty.totalpolska.pl/wiedza/rozdzial%2012.pdf
10. www.abplanalp.pl/wiedza/dobor-chlodziwa-i-jego-wplyw-na-produktywnosc/
11. www.utrzymanieruchu.pl/menu-gorne/artykul/article/utylizacja-zuzytego-chlodziwa-do-obrabiarek/
12. public.sds.tiktalik.com/patenty/pdf/171402.pdf