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The minimum quantity lubrication production method is setting an entirely new standard for process air purification in the metalworking sector.

Minimum quantity lubrication, or MQL, is a production method whose popularity has been growing significantly in particular in the automotive and aviation sectors. We will try to describe the process in general and how it affects the working environment and process air purification in particular. In some publications, this method is also referred to as Near Dry Machining.

Background

Minimum quantity lubrication is a solution to the problem of using large volumes of oil and water in the metalworking process.

As the rate of production and metal-working has risen, the use of cutting agent and lubrication known as coolant has increased. Naturally, the need for maintaining the coolant, which in many cases can be very costly, has risen accordingly.

Minimum quantity lubrication can be used to identify major cost savings and decrease environmental impacts by reducing the general consumption of oil and water. This is partly because the cost of both oil and clean water over time has been rising, along with the fact that water is a scarce commodity in many regions. It is also generally more expensive taking care of contaminated water and waste oil, due to local regulations and laws. Another advantage would be that a much smaller amount of oil leaves the process with the air stream as a result of process air purification.

In other words, a reduction in the use of coolant will of course leverage significant cost savings and environmental benefits.

What is minimum quantity lubrication / MQL?

Rather than providing cooling and lubrication by soaking your work piece and tool in coolant, known as "flooding", the process of minimum quantity lubrication involves atomising the oil before injecting it into a compressed air stream which is then directed on to your tool

and work piece. Put another way, they are cooled with air, while oil is used to lubricate/reduce the friction.
This method has been around in various applications for at least 15 years. The method was tested in machine tools designed for "flooding" of coolants early in this development phase in which there was no major need for any special design of the machine's internal surfaces.
When using the "traditional flooding" method, chips and other metalworking residues are flushed out from fully horizontal surfaces thanks to the large amount of coolant that is continuously being supplied to the process. When introducing minimum quantity lubrication for this type of machine tools sedimentation and transport of the metalworking residues are significant problems and a major limitation. In modern machinery adapted for minimum quantity lubrication, the aim is to minimise or entirely eliminate the type of surface where sedimentation and build up can occur.
Moreover, equipment for minimum quantity lubrication in this early stage is built on existing machinery, a process we now call external coolant supply (air and coolant). Modern machine tools that are designed and adapted for minimum quantity lubrication almost always has internal coolant supply. For internal coolant supply, air and coolant are fed internally in channels through the machine, the tool holder and ultimately into the tool. As this means you can more accurately control the cooling and lubrication to take place, you can further reduce the amount of the fluid supplied and eliminate the risk of "shadows" as the tool and tool holder prevent the air and coolant from reaching the key areas of the process.

Current status and future

From a purely intuitive angle, it is fairly easy to understand the benefits that minimum quantity lubrication offer in the form of reduced oil and water consumption, less spent coolant waste and cleaner metalworking residues for recycling/reuse.
However, a number of issues remain such as the problem of removal of metalworking residues, application difficulties and inadequate cooling in certain processes (such as deep drilling operations), restrictions for metalworking that cause high temperatures (grinding), difficult to process material (such as Ti and Ni alloys) as well as special operations (honing and drilling of small holes). The need for cleaning the machines also increases, as sedimented and small solid metal oxide particles are bound by oil, and often form thick and hard coatings that are difficult to remove. You are frequently forced to ensure a more regular and significantly more comprehensive machine maintenance routines. Minimum quantity lubrication can also cause increased wear to tools and bearings in the machinery.

The rate of change of course varies between different industries, but it is clear that the aviation, and especially the automotive industry, is a strong driving force and there is no doubt that minimum quantity lubrication is becoming steadily more popular, while problems are being mitigated afterwards and becoming less important. The manufacturing industry along with machine and tool manufacturers and producers of coolants are continuously driving this development forwards as a way of increasing productivity, safety and availability.

Traditional process air purification

An important element in creating safe systems for the machine tools is the management of the process air.
Normally it is a case of fully enclosed processes where the machine enclosure prevents the contaminated air from spreading through your facility.
This enclosure always has some open space and temporary openings for tool change, moving work pieces, service, maintenance, etc. In order to prevent the contaminated air from leaking out from these openings, the machine enclosure is normally provided with negative pressure through forced air transport away from the process. This air must be cleaned of impurities before it is returned to the facility or released to the atmosphere, known as process air filtration.
The process air from machining processes contains contamination levels typically in the order of mg/m3, which is why filters in these systems must be self-cleaning/draining in order to ensure an adequate service life in continuous operation.
Safety, availability and cost of ownership are key parameters in the selection of a process air purification system.
Historically, the need for two types of process air filtration systems has in principle been ascertained, one for wet (oil mist separators, scrubbers, etc.) and one for dry machining (dust collectors, scrubbers, etc.). Mixed processes can certainly occur, but this is mostly the result of dry and wet processes being accidentally mixed due to carelessness in the design of the process air filtration ducting system or extraction points. It is simply a case of mixing dry and wet emissions in the same extraction system.
Small amounts of wet constituents can of course occur in what is defined as dry processes, such as from a light oil coating of, or residual oil on the work pieces in dry machining, as well as the presence of solid particles in wet processes, such as metalworking residues.
This has led to a range of solutions for dealing with these cases with the marginal involvement of wet particles in dry emissions and vice versa.

For example, dust separators are provided with a continuous injection of lime, or other absorbent material, in order to bind the wet constituents, while the oil mist is fitted with a pre-filter or inertial separator to remove as many solid particles as possible and to keep the recycled oil as pure as possible.

How does minimum quantity lubrication affect the requirements for process air purification?

Minimum quantity lubrication is adding an entirely new dimension to process air purification. The emissions are no longer wet or dry but consist instead of varying degrees of both wet and dry components. It is not the mixing processes that arise due to a fault or that viscose particles for some reason have managed to infiltrate into a dry process or solid particles in a wet process, but it is rather a question of a mix of dry and wet which is the normal condition for minimum quantity lubrication. As emissions change, entirely new needs and requirements arise for process air filtration. Traditional equipment for wet and dry must be modified or replaced with a new method in order to cope with the demands for filtration efficiency and service life. Nevertheless, demands remain for productivity, safety, and availability with the user, which is why equipment for process air filtration that has been specifically designed for minimum quantity lubrication is required. For example, using a dust collector with lime feed to absorb the relatively high viscous ingredients is completely unreasonable. It is true, you can get it to work fairly well but you will then be producing huge amounts of contaminated lime that must be managed and disposed of. You have to adapt the technology to meet the new requirements.
One difficulty when designing a filtration system for the handling of airborne emissions from minimum quantity lubrication, is to characterise the contaminants. What is the ratio between wet and dry? What is the particle ratio in terms of size in wet and dry components? How is measuring to be undertaken and what equipment is suitable to use? How do you clean the filter? Variations overtime in the production cycle?

What does Nederman Filtac do?

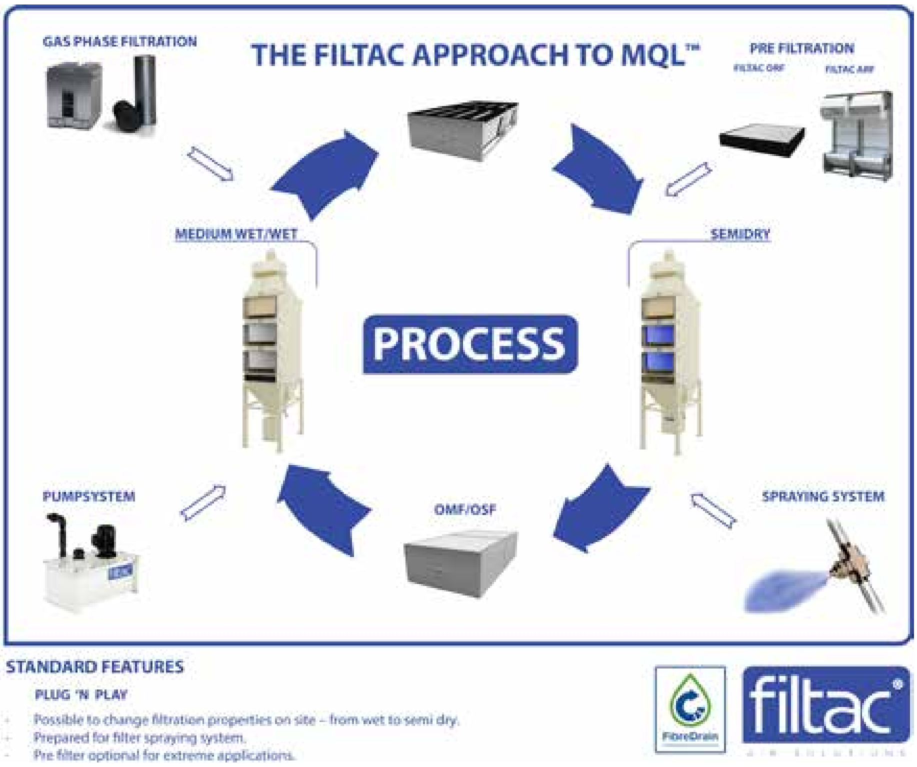
Following an extensive mapping of process and test installations for the new minimum lubrication processes, we at Nederman Filtac, as a part of our FibreDrain technology, have developed a method for defining processes and producing input data for the parameters that govern the selection of filter. To make a rough characterisation, we have chosen to use the traditional filtration methods wet and dry and between them define new issues that are typical for minimum quantity lubrication. In the absence of any agreed terminology, we have chosen to call these Semi-Dry and Medium Wet as defined by the ratio of the wet and dry ingredients.
It is no good trying to use traditional methods and Filtac Nederman has developed new filtration systems to ensure satisfactory operability.
The characterisation is best described by this image:

Besides the fact that minimum quantity lubrication requires special, newly developed filters to meet the set requirements, there is a high rate of change concerning modifications to a specific process, and partly for modifications between the traditional process air purification and minimum quantity lubrication, which is one reason for developing flexible process filtration systems. For example, a powertrain plant does not have homogeneous emissions. Normally, there is a mix of dry, wet and minimum lubrication processes. As each year that passes, the automotive industry is experiencing increasingly high rates of change as new products replace old ones at an ever growing pace, and it is a major benefit for the user if it is possible to move easily between the different application areas and maintain high flexibility over time. It is simply an advantage of being able to adapt a delivered system to fit everything from minimum quantity lubrication to traditional "flooding" (oil mist separation). Nederman Filtac has a patent-pending solution for achieving this flexibility known as Filtac MQL, which means that once the system is installed, it is possible that you can only adapt the process filtration equipment, largely freely, between the different application areas of Semi Dry <-> Wet <-> Medium Wet by basically changing the filter and handling systems for waste.

We have tried to illustrate this flexibility in the image on the right.
In other words, you can use the same filtration unit for a large number of applications, which ensures high flexibility and a low cost of ownership.

What is what?

Medium Wet and Semi Dry are defined by the contaminants caused by the process. The survey revealed many expected and unexpected results. For example, a minimum lubrication process for aluminium processing is normally "wetter" (Medium Wet) than the equivalent steel processing (Semi-Dry).
You might easily draw the logical conclusion that the relationship should be reversed as steel is a harder and more difficult material. Despite this, more coolant is required in the minimum lubrication of aluminium due to the fact that the soft aluminium otherwise has a tendency to adhere to the tool which makes the handling and transportation of the metalworking residues tricky.



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Conclusions

Process air filtration in the metalworking sector is evolving. Processes are changing at an increasing rate and new application fields with new emission characteristics are growing increasingly stronger. The emissions are becoming more diversified which calls for a more flexible filtration process.
For the new emissions, new filtration equipment will need to be developed to avoid compromising user requirements for safety, availability and cost of ownership.
You can be absolutely certain that process air filtration is undergoing fundamental change, and old truths are being replaced with new facts and practices.
Minimum quantity lubrication will set an entirely new standard for process air purification in the metalworking sector.

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