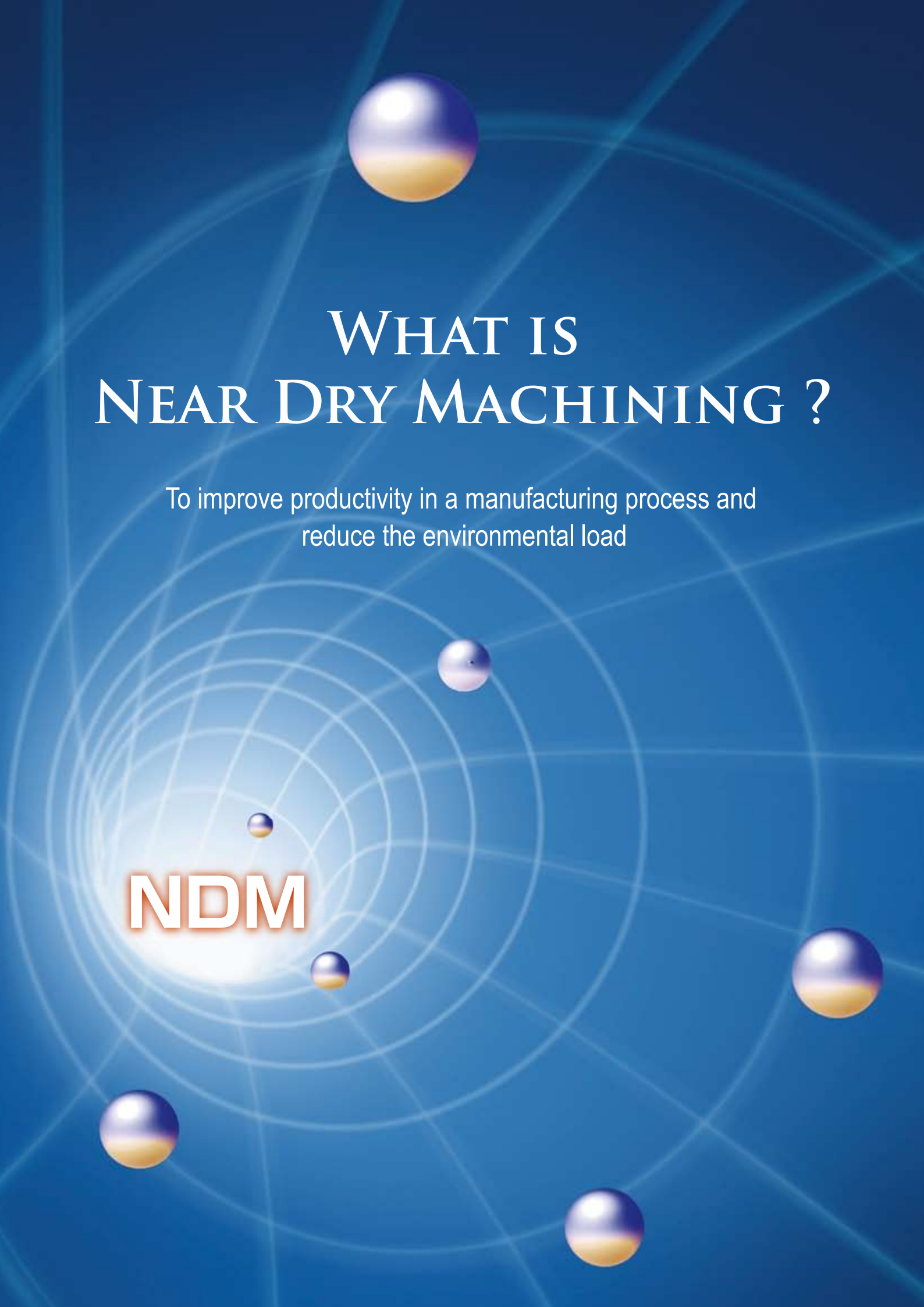
What is Near Dry Machining ?

To improve productivity in a manufacturing process and reduce the environmental load



General Description

Great potentiality of Near Dry Machining

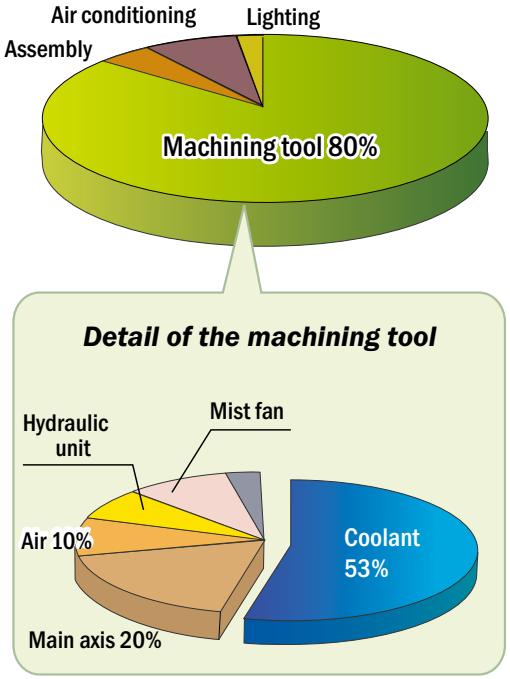
Masayuki INOUE, Study group of MQL

Study group of Minimum Quantity Lubrication: this study group was established to promote and spread the use of Near Dry Machining and its main activity is to provide technical information to users.
For further information, visit *http://www.MQL.jp*.

◆ History of lubricants

It has been known that applying a small amount of oil or water to the cutting point facilitates the machining process since metalworking started. Before HSS tools and NC machine tools were introduced, many machines did not have any splashguards and a small amount of oil was applied to the cutting point only or oil was applied to the cutting edge using a brush.
After use of NC machine tools was spread in 1960 through 1980 following introduction of cemented carbide tools, the process was sped up and the amount of chips produced per hour was increased significantly. Cemented carbide tools, which highly heat resistant, have changed the required quality of lubricant from lubricating the cutting point to cooling a large amount of heat generated. In addition, it became important to flush a large volume of chips produced in a stable manner. As a result, a lubricant tank and a circulation motor have upsized and a large amount of lubricant is now put onto it with high pressure to cover the entire cutting point. Meanwhile, water-soluble lubricants have become more popular than oil-based lubricants. Because no danger of fire during automatic operation of NC machine tools became a requirement.

There has been a growing interest to the environment issue since late 1990s, particularly to reduction of the environmental load resulting from the product as well as the production process. An increasing number of companies have been introducing the environmental management system (ISO14000) and working on strengthening control of energy saving and hazardous substances in the factory. In the metal work factory, it was found that lubricant played a large part of the environmental load.



Percentages of Energy Use at Machine Factory of Toyota Motor Corporation

Data source: Igawa,et al., TOYOTA Motor Corporation

◆ Problems with lubricants

The Kyoto Protocol that defines each industrialized country's goal for reduction of global warming gases came into force in 2005. The Japanese Government formed the project "Team minus 6" to call for public attention to energy saving. In Japan, about fifty percent of the total energy consumption is consumed by industry and cutback of the energy use and reduction of the environmental load are urged along. In particular, reduction of the energy consumption by machine tools is a significant issue since about 700,000 machine tools are operating currently (note 1). As shown in the graph on the right, 53% of the energy consumed by a machine tool comes from lubricants (coolants) according to the report by automobile manufacturer (note 2). Especially reduction of lubricant used in the factory is considered as an important issue.

Since lubricants ultimately become sludge containing metal powder and are disposed as industrial waste, the quantity of lubricants used needs to be reduced, also in terms of reduction of industrial waste. Lubricant consumption is 130,000 tons per year and the oil waste generated is reported to be 420,000 tons per year (including after dilution). (Note 1)

Chemical substances have been controlled more tightly with regulations such as Pollutant Release and Transfer Register (PRTR), Law Concerning Special Measures against Dioxins, Soil Contamination Countermeasures Law, and most recently, Restriction of Hazardous Substances (RoHS) imposed by EU.

In 1997, a high level of dioxin was found from the incinerator of a factory in Osaka, which became a serious social problem. Investigation revealed that such a high level of dioxin was caused by incineration of waste soaked with the chlorine-based lubricant and this incident pushed use of non-chlorine lubricants further. JIS standard was also revised to withdraw lubricants with chlorine additives. Currently only a part of additives used in the lubricants are hazardous and the lubricant manufacturers are making an effort to develop the lubricants with less environmental load. However, chemical substances require measures that consider future regulations and restrictions as well as strict and exact control to avoid any leakage. Unfortunately, it is true that lubricants leak from the part basket and the floors are wet in many factories. Therefore, it is important to avoid using any hazardous substances, if possible, to prevent any risks from occurring.

Taking risk control into account, use of biodegradable oil is more preferable since the environmental load is much lower even if the oil leaks and flows out to the ground, the river, and the ocean. Typical biodegradable oil includes vegetable oil and biodegradable ester of vegetable oil origin. However, using such oils for a large amount of conventional lubricants has been refrained because of the high cost. As a result, they have been mixed into a mineral oil for performance gain.

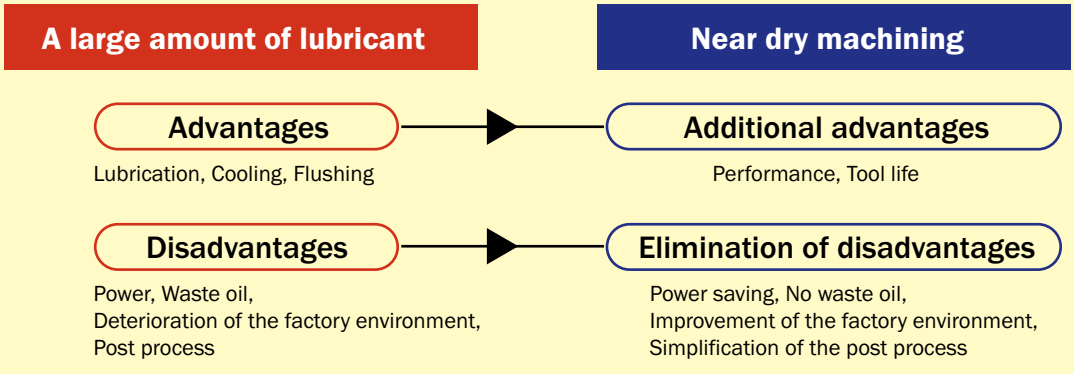
◆ Advantages and disadvantages of a large quantity of lubricant

A large quantity of lubricant has many advantages. The advantages include (1) lubrication, (2) cooling, (3) eliminating chips created by hole drilling, (4) removing chips (flushing) from the area processed and the table surface. For micromachining process, lubricants are used to cool the work material and to prevent change caused by heat as well as prevent change of the machine itself caused by heat.

As many people have already known, if lubricants are not used, the tool life will become shorter. In case of aluminum, the tool may be damaged resulting in poor precision and roughness. You will recognize the difficulty of dry machining if you stop using lubricants.

Lubricants also have many disadvantages including the environmental issue. As described above, power consumption for the circulation motor and the process for waste oil disposal are required. The floor gets dirty and a bad odor is emitted, which results in deterioration of the environment in the factory. As a result, a cleaning and

Reasons for introduction of Near Dry Machining



degreasing process is needed after the lubricant is used. In case of nonferrous metal that usually cost more, chips are usually collected and remelted, but they need to be dried if they are wet with the lubricant.
However, is it actually necessary to use such a large quantity of lubricant? Not all cutting processes require a large quantity of lubricant. Shown below is a summary of oil type used by work material according to the investigation by Study Group of Lubricant Technology. (Note 3)

Lathe
Steel dry 24%, insoluble 18%, soluble 58%
Casting dry 42%, insoluble 4%, soluble 54%
Aluminum alloy dry 10%, insoluble 20%, soluble 70%

Machining center
Steel dry 5%, insoluble 36%, soluble 59%
Casting dry 23%, insoluble 14%, soluble 63%
Aluminum alloy dry 3%, insoluble 17%, soluble 80%

According to the summary, lubricants have different effects on work materials. Casting is processed well with dry machining and lubricants seem to work better with aluminum alloy. The effect is also different from process to process. Dry machining is easily adapted to intermittent cutting such as milling and end milling while use of lubricants facilitates hole machining such as drilling, tapping and reaming. Lathe process is between two types above and requires cooling if the continuous processing time is long because the cutting edge is always in the work. The point is that a large quantity of lubricant should not be used from habit. Instead, a minimum quantity of lubricant should be applied to the appropriate process as needed.

◆ Reduction and replacement of lubricants

Now, how lubricants with such advantages and disadvantages can be reduced and replaced? To eliminate the power consumption issue, it would be a good idea to use the lubricants with appropriate quantity and pressure. Generally, the lubricant pump is provided based on the idea “the bigger, the better” and it is important to know the quantity and the pressure appropriate to the process type. However, this solution may reduce the power consumption but other disadvantages such as waste oil disposal remain.
Therefore, application of dry machining that uses no lubricants and near dry machining that uses the extremely small amount of lubricants is being considered as a way to clear all problems lubricants may cause. Near dry machining is also called as Minimum Quantity Lubrication (MQL) and has already been put into practice in many factories. Near dry machining is a method to mist high-efficiency vegetable oil based lubricant or biodegradable synthetic ester of vegetable oil origin in minute amounts of 2-30 ml per hour to the cutting point only.
Dry machining that does not use any lubricants has also been studied. Cool-air machining, which sprays cool air of minas 30 degrees centigrade to the cutting point, became predominant in the late 1990s. It was reportedly effective mostly to grinding but an energy efficiency issue and a workability issue such as frosting remained to be solved. One of the other machining was that applies nitrogen gas to the cutting point to prevent oxidation of the tools. This was not significantly effective and oxygen deficiency caused by use of deoxidized nitrogen was indicated as a problem. Currently it is expected to be effective to process the magnesium that has a high risk of fire. In addition, a variety of dry machining technology, including a method using powdered dry ice, has been studied at the university level.

◆ Examples where near dry machining improved productivity

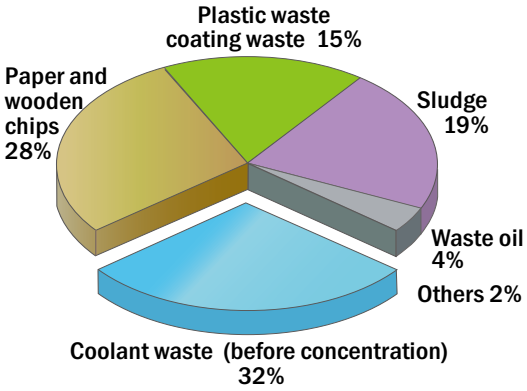
The reason for adoption of near dry machining is roughly classified to two types. One reason is that the longer tool life and the better workability are expected compared to the use of water-soluble lubricants (1). The other is that eliminating the disadvantages such as power for the circulation motor, waste oil disposal, deterioration of the work environment, and post-processes of degreasing, cleaning, and drying improves productivity and reduces the cost (2).

The example of (1) is as follows. The aluminum building material industry first adopted near dry machining on a major scale in the beginning of the 1990s. Switching the extensive use of water-soluble lubricant mist to the near dry machining with oil mist together with use of high-efficiency vegetable oil have improved the life of a cutting saw. Aluminum building materials usually need lubricant to be processed but if possible, less lubricant is appreciated for aesthetic purpose. Adoption of near dry machining decreased a number of man-hour required for the degreasing process, which the grease was removed manually one by one, to a quarter of the conventional way.
In the late 1990s, a mold cutting method changed along with speeding up of the machining center. The fast cutting method with low cutting inhibited heat generation and enabled to make a high-precision mold. Mist cutting was recognized to be effective to this type of cutting method and was adopted by many mold manufacturing factories. Especially it was easy to mist small plastic molds, which boosted the number of adoption.
In the 2000s, a carbide drill for small deep hole processing was developed. Only a gun drill and a high-speed drill could drill a hole with a diameter of 4-8 mm and the length of 20 times longer than the diameter, but a carbide drill allowed the process with the efficiency five times better than the conventional way. In addition, this type of process is more compatible with near dry machining compared with other types of oil. It was found that the near dry machining crushed chips finer and discharge them efficiently from the deep hole created. Thus, it is

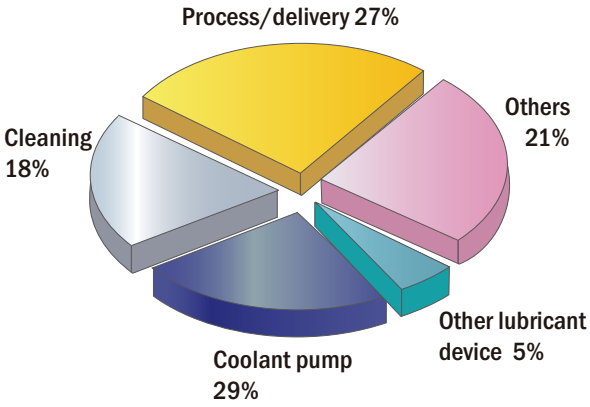
still a part of machining only but the near dry machining has contributed greatly to improvement of productivity through selecting a good combination of the process method and the tool.

◆ Contribution to the environmental issue in the manufacturing process

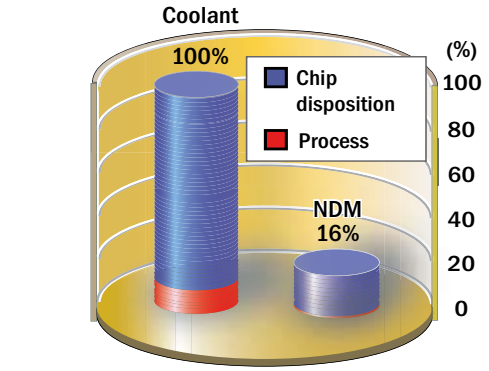
Now described below is the example of (2), which the better productivity and the lower cost were realized though eliminating the disadvantages of power consumption, waste oil disposal, deterioration of the work environment, and the post-process of degreasing, cleaning and drying.
One of the typical examples of introduction of near dry machining to reduce the environmental load in the manufacturing process is a process line of the aluminum engine cylinder block at Mazda Motor Corporation. In Mazda, they analyzed their machining process lines



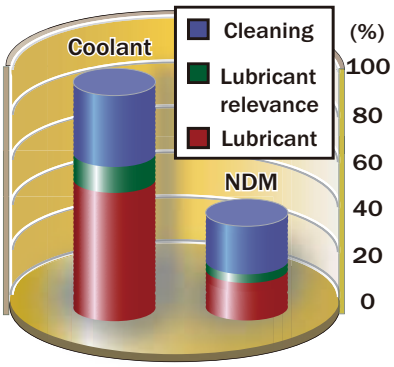
Breakdown of incinerated waste from engine process line at Mazda



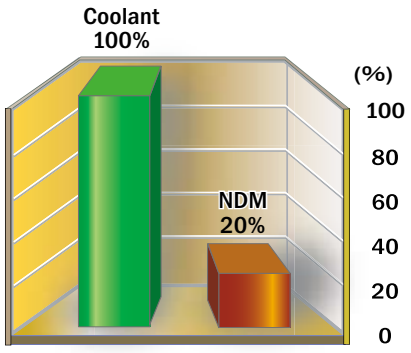
Breakdown of power consumed at engine process line at Mazda



Reduction of coolant used at Mazda



Reduction of power consumption at Mazda



Reduction of waste (waste oil) at Mazda

and found that the coolant pump (lubricant circulation pump) consumed the power the most. In addition, it was determined that the lubricant had a major impact on the global and the work environment because of the incineration of the waste oil and the foul smell/mist. Consequently the project was implemented to reduce the lubricant used. After detail analysis of the current situation, identification of the problems and repeated discussion on the countermeasures, they decided to introduce the near dry machining in full scale and realized energy saving, resource saving, and waste reduction. Their effort was awarded as the Prize of Minister of Economy, Trade and Industry at the Energy Saving Conference organized by The Energy Conservation Center in 2002. (Note 4)

◆ Impact on post-process

Near dry machining has influenced to post-process. A representative example is drying of chips. For expensive metals such as copper and aluminum, chips are collected and remelted. However, chips soaked with oil or water are hard to be remelted and it is preferred to keep chips as dry as possible for collection. In particular, it gives a great advantage to metal material factories and foundries where are equipped with a melting furnace and remelting is available on site. In addition, near dry machining may simplify the cleaning process in the degreasing/cleaning process usually required for part machining. These advantages contribute the total productivity and often lead to solve the environmental problems caused by the lubricant.

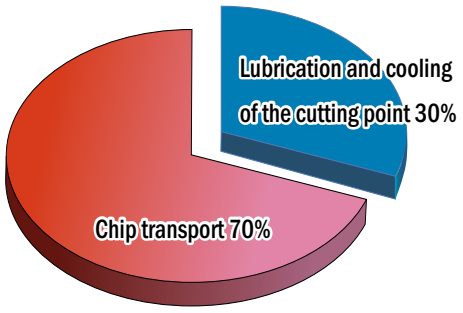
◆ Contribution to the work environment

It is the work environment that is an important and urgent problem to be solved regarding to use of the lubricant. In case of a middle- or small-size factory, it is evident whether the factory has a dry or wet environment once you step in it. The lubricant may drip or change to floating mist which settles down on the floor making it wet or sticky. In some factory, the water-soluble lubricant decays causing acidic or nasty smell during summer. In the heavy industry such as ships, aircrafts, power, and construction machinery, large machines such as a gate type machining center and a floor-type horizontal boring machine are used and many machines are not equipped with a splashguard, which makes control, setup, and cleaning of the lubricant more troublesome. Such cases would benefit from near dry machining greatly. It is important for medium- and small-size companies to improve the factory environment to recruit young people and part-time workers. It is also said that introduction of near dry machining has made the factory environment including the floor dry and that has resulted in better workability. Improvement of the work environment is hard to show in numerical terms since it gives only a subjective and sensory effect to people like 5S activity (note 4). Therefore, it is necessary to convert it to numbers through the inquiry to the workers. It is also a good idea to ask the external party to audit the work environment through ISO14000 certification.

◆ Problems of near dry machining

Conventionally the lubrication effect and the cooling effect of the lubricant was emphasized. However, the base material and coating technique for a tool have been improved, which made the tool more heat resistant. Therefore, the need of a lubricant is getting lower relatively. As a result, a main effect of the lubricant required has changed from lubrication and cooling to delivery of chips produced. Consideration needs to be given to delivery of chips from the designing stage of a machine tool. Because it is not easy to apply near dry machining to the machines designed based on use of a large amount of lubricant.
Mazda, where applied near dry machining successfully to the engine process line in 2002, uses near dry machining for machining but applies a unique flushing method for discharge of chips. This method discharges the anti-corrosive cleaning solution intermittently between the end of the process and the delivery of the processed item to flush the chips and is called "Energy-saving chip collection technology". (Note 5)
Denso Corporation has adopted a gravity drop method as a way to discharge chips of the current machines at a low cost. This is the method to keep down the energy consumption by making a slant part with a big inclination angle with a stainless plate. They tested and evaluated the angle of which the chip actually drops and concluded that the angle of 35 degrees or more (45 degrees to ensure safety) would be necessary. (Note 6)

According to the above, it is indispensable for machine tool manufacturers to consider application of near dry machining at the development stage of the tool. The manufacturers also need to examine how to discharge the chips to apply near dry machining to the existing tools.



Percentage of lubricant applications

Data source: Kondo,Toyota Motor Corporation,1998

◆ Engineering

A front line of the production site is always in search of the appropriate conditions, which is close to the limit, to improve the cycle time, the cutting condition, the tool life, accuracy, the plane roughness, and the cost. A mass production site such as automobile part processing is always searching the fastest boundary condition.
If the item that has been used extensively is replaced to less energy and less resource under that boundary condition, the process itself needs to be subtle and unstable inevitably. Consequently finding the boundary area, which is the minimum amount of lubricant require effort, time and patience.
In addition, there are extremely various conditions to apply near dry machining to some machining. For example, process content, work material, tool material, shape of a tool, a cutting speed, slash, feeding, machine stiffness. In addition, a type of lubricant that has been used conventionally, additives, concentration of a water-soluble lubricant, a discharge pressure, a discharge amount; there are too many of them.
Therefore, it is important to collect necessary data to promote reduction of the lubricant and application of near dry machining. Engineering that can provide the work solution is essential. Meanwhile, schemes and means at site are necessary to apply near dry machining to the existing equipment. They include those decided by checking the actual equipment such as a device to remove chips or installation of a nozzle.
If you are planning to introduce near dry machining at your factory, you are recommended to consult a machine tool manufacturer and a mist device manufacturer with a rich experience in near dry machining. Especially, Fuji BC Engineering (Bluebe) has opened a MQL trial center where a machining center and a NC lathe are installed for user. Use of such a facility helps you to understand and introduce near dry machining.

[Reference]
(Note 1) NEDO “Energy Usage Rationalization Technology Strategic Project” Basic Plan 1999
(Note 2) Toyota Motor Corporation, IGAWA, IWATSUBO and MIYAZAKI, Mechanical Engineering May, 1999
(Note 3) Hiroki SAKURAI, TOOL ENGINEER, Jan., 1998
(Note 4) 5S activity = One of Japanese movement of productivity improvement. Cleaning up and arrenging a manufacturing space and factory for productivity.
(Note 5) Energy Saving Conference, 2002, from ECCJ web site
(Note 6) NAGATA and MORITA, Denso Corporation, Monthly Toribology, Feb., 2004

Use of less coolant and application dry machining are becoming a standard in machining process. As if they have foreseen this trend, Fuji BC Engineering (Mizuhoku, Nagoya) started import of Bluebe near dry machining system by ITW (U.S.A.) in 1989, and then, the license production in Japan in 1993. Many managements are very concerned about grease and stain left on the floor by use of lubricants. KURODA PRECISION MANUFACTURING Co., LTD., one of the customer of Fuji BC Engineering, is also concerned the said problem. We asked how application of "Bluebe" has improved the work environment. (Hiroya WAKABAYASHI, SEISANZAI (Production Equipment) MARKETING Magazine)

KURODA PRECISION MFG is a machine-part manufacturer, whose main products are automobile parts, in particular, brake parts, engine parts, ABS (antilock brake system) parts. The head office is located in Nagoya and the production sites are in Yoro-cho and Kaizu-cho in Gifu. We visited Yoro Plant for this interview. This plant consists of an old and a new factory buildings and Bluebe is applied to the NC lathe in operation at a new plant built in 2003.

◆ Concern over the dirty floor

It was a top priority to take some measures for grease on the floor. Their environment management was promoted according to this priority and they obtained ISO14001 certification in 2002, which became a good reason for introduction of <<Bluebe Near Dry Machining System>> (hereinafter called "Bluebe"). Previously sawdust was used to absorb the oil, but there was a concern over the subsequent process since dioxin was generated when the sawdust absorbed the oil was burnt for disposal.

Mr. NOMURA, Production Engineering Group Manager (left) and Mr. TERAMURA, Manufacturing Leader at Yoro Plant

Bluebe applicator installed at a NC lathe

First, they tried Bluebe with a NC single-purpose lathe followed by a NC lathe for aluminum processing at full scale in April 2003. "The air has been purified and the factory is much cleaner." The result of the system introduction was obvious. However, they have not finished a full review on the cost issue and plan to "compare Bluebe with the conventional way taking into account the sawdust disposition and the measures for cleanliness maintenance in the work site".

It is said that the power consumption for processing accounts for 60 - 70 % of the total power consumption. It is assumed that the power cost was considerably high before introduction of Bluebe because heat generated by

A product is delivered on the clean conveyor without oil stain, which is not expected with oil-based lubricants.

a coolant pump increased the room temperature and the room needed to be cooled down. Meanwhile, Bluebe does not require a coolant pump so that cooling is not necessary resulting in reduction of the power cost. The comment "the factory is cooler." proves reduction of heat generation by the machines.

◆ Improvement of cutting tools for near dry machining

KURODA PRECISION MFG manufactures and devices the cutting tools for near dry machining. They have devised a part of tools for near dry machining at this time but are planning to apply near dry machining successively after they become more familiar with processing with the near dry machining tools.

It is generally known that near dry machining has a disadvantage on cooling compared to the conventional lubricants. The load on the cutting tool is also large. These are the reasons why they have been improving and manufacturing the cutting tools in the company. Bluebe lubricant has a good lubricating property but they "would like to improve performance of the cutting tools so that the product quality will stabilize." (Kimio TERAMURA).

◆ "More improvement is needed for the work environment"

Most of the machines used by KURODA PRECISION MFG still use oil-based lubricants. According to Mr. Naohiro NOMURA, they also use water-soluble lubricants

The floor is cleaner without oil stain because of introduction of Bluebe

but some problems remain to be solved such as prevention of the lubricant from entering in the chuck. Bluebe, in that respect, is a very attractive alternative since it has high lubricating property and uses a minimum amount of oil. In fact, there is a strong demand to apply Bluebe in the production site.

"To establish the safe and comfortable workplace and improve the production efficiency, it is indispensable to solve the environmental contamination caused by the conventional lubricants." It is also assumed that Bluebe contributes greatly to the work environment. It reduces the burden of control, cleaning, and disposal of the oil agent. Furthermore, it consists primarily of vegetable oil and is harmless to the human body. They think that "there is still room for improvement of the work environment". This shows their strong determination to improve the environmental problem for their employees, the society, and the company future.

Yoro Plant is located near a tributary of the Ibi River where sticklebacks are swimming. Sticklebacks, a protected species, live only in a limpid stream that needs to be protected by all means. Therefore, an oil-water separator is installed in the plant to dispose rainwater and wastewater and collect the oil content before discharging the water to the stream.

Oil-water separator. It purifies rainwater and wastewater and discharges them to the rivers.

KURODA PRECISION MANUFACTURING Co, LTD.
Capital 70,000,000 JPN
Founded in 1925.
President Toshihiro KURODA
Obtained ISO9002 certification in 2000.
Obtained ISO14001 certification in 2002.
Main products: piston wheel cylinders, piston master cylinders, piston clutch release cylinders, ABS parts, oil pumps shafts, oil pump valves, hydraulic parts, etc.

Die machining case

Die machining by near dry machining

TOOL ENGINEER (Kogyo Chosakai Publishing Co, Ltd.) Reprinted from the September issue in 2006.

◆ Characteristics of near dry machining

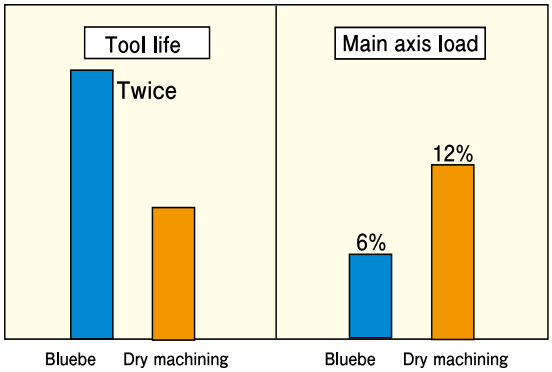
Near dry machining is compatible with die machining. To know why, it is necessary to be familiar with characteristics of the near dry machining.

Near dry machining is a method to spray a very small amount of a high-performance lubricant precisely onto the cutting edge and process the work material. Therefore, it is especially effective to the process requiring lubrication of the cutting edge. In this process the work material is not cooled as well as when a large amount of a water-soluble lubricant since it is cooled by the air for mist. That is, it is more effective for the cutting tool with less heat generation and the process with a small contact area with the work. In other words, near dry machining fit to the finishing process with small cuts better than rough carving and heavy cutting.

◆ Impact on die machining

Die machining has had a large increase in speed of machining recently and high rotation, shallow cut, and fast feeding have become predominant. Such a machining method keeps heat generation down as well as lets heat out to chips to prevent deteriorating accuracy of the product caused by mutation by heat. This method, which inhibits heat generation, goes well with near dry machining.

Figure 1 shows the data comparing Bluebe near dry machining to dry machining (air blow only) for ball-end milling. In this example, the die factory using an initial type of a high-speed linear machining center introduced Bluebe to reduce the main axis load. Compared to the dry machining using the air blow only, use of Bluebe reduced the main axis load to half while it extended the tool life of a ball end mill twice longer than before. In addition, possibly because the tool life was extended, the finishing surface was improved aesthetically so that polishing might be unnecessary.

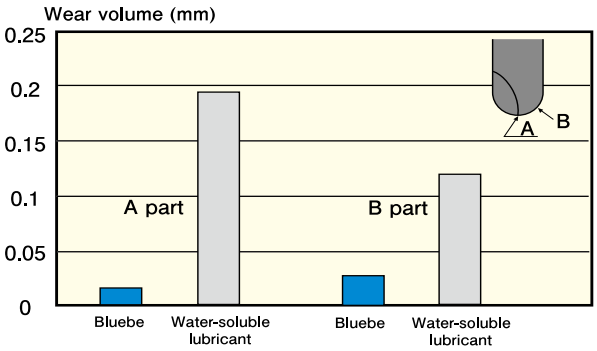


[Fig. 1]Tool life and main axis load for ball-end milling

Carbide ball-end milling, Down cut, Vc=125m/min., f=300mmm/min., a=0.1mm, SKD61 (HRC40), Carbide ball-end mill R5, Applicator: Bluebe JK2/lubricant: Bluebe LB-1

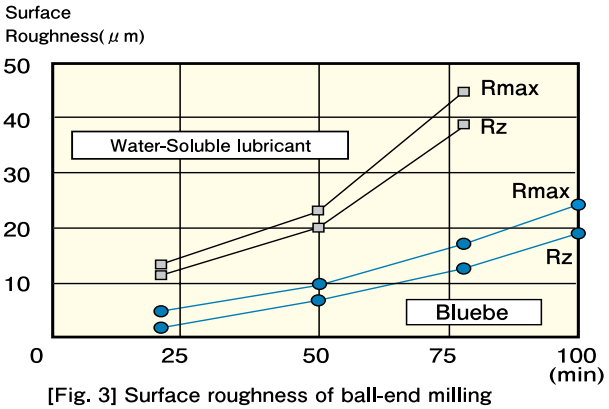
Figure 2 shows the comparison of an amount of mechanical abrasion when the same die is ball-end milled using Bluebe and a water-soluble lubricant. Mechanical abrasion was measured at the ball part (B part) and the tip (A part). The result shows that the abrasion was much less when Bluebe was used. Especially the tip was less wearing. Generally, a cutting speed of a ball end mill does not increase at the tip and is usually slower than the appropriate speed of a carbide tool. Therefore, the tip tends to wear faster. It is assumed that abrasion was prevented by continuous application of a high-lubricating oil agent at the tip.

Figure 3 compares the cutting surface roughness between a water-soluble lubricant and Bluebe. According to the graph, Bluebe keeps the roughness better than the water-soluble lubricant. The roughness worsened in proportion to the machining time and it is assumed in this view that the roughness is proportional to the abrasion of the ball end mill. The abrasion-inhibiting effect that Bluebe has, as



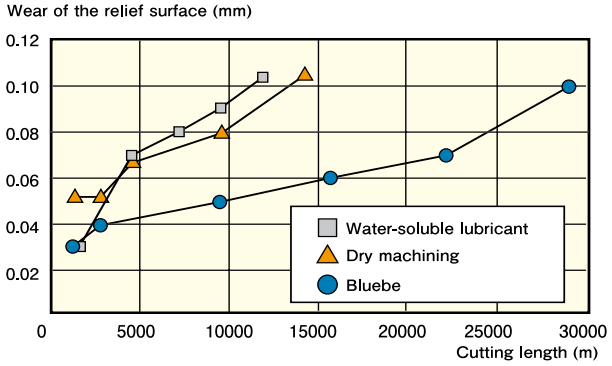
[Fig. 2] Wear volume of ball-end milling

Carbide ball-end mill R3X6, Work material HPM1
N=10000min-1, F=2000mm/min, AD=1.0mm, RD=0.5mm



[Fig. 3] Surface roughness of ball-end milling

Carbide ball-end mill φ12, Work material SCM440 or the equivalent
Hardness 29-30HRC, a=0.2mm



[Fig. 4] End milling and wear of the relief surface for a hardened steel

Side end milling, Down cut, Vc=30m/min., f=214mm/min.,
SKD11 (HRC 62.5), Carbide end mill φ10, Six blades,
Life judgment VB=0.1mm

[Pic. 1] From the left, an internal application EcoBooster, Bluebe oil, an external applicator

shown in Figure 2, may affect directly on the roughness.
Figure 4 is an example of the direct carving process of hardened steel with HRC 62.5. It shows that Bluebe extended the tool life compared to the water-soluble lubricant and dry machining. Especially Bluebe is effective to end milling for high-hardness steel so that it is being used more.
As described above, Bluebe has a great advantage to extending a tool life used for die machining and improving the surface roughness. The data shown here are only field data and not completed. However, a study conducted by a researcher has been published for ball end milling using near dry machining and it is reported that near dry machining is superior to dry machining and a water-soluble lubricant in terms of tool abrasion. (Note 1)

◆ How to use Bluebe

Bluebe near dry machining system spray a minute amount of vegetable-based oil to a cutting point. The system has two types of an internal applicator and an external applicator. The internal applicator supplies the mist though the spindle and applies it to an end mill from a collet with a gap while the external applicator applies the lubricant to the cutting edge using an external nozzle. (Pic. 1)
The internal applicator is better with a large die because an external nozzle cannot be set around the tools if the tools with significantly different diameters and lengths are replaced by ATC. For a small die like a size of a mobile phone, since the tools use have the similar diameters and lengths, the cutting point is at the same position, which it is available to mist by an external nozzle. A mist device is operated by turning the air on and off once the quantity of the oil and the air is appropriately set and the air can be supplied by the M signal or the air blow of the machining center. The external applicator with a nozzle may be easier to adopt because it can be retrofitted to a machining center. In addition, a simplified external applicator BK type is also available as a trial device. You can use it at an appropriate price of 100,000 yen on a trial base. (Pic. 2)
Many reports have been made on superiority of near dry machining for die machining but many factories seem to be slow to introduce the system. It may be difficult to have complete control of the tool life in quantitative terms unlike in the case of mass-produced items. But once you try it, you will understand the advantage and the effect of the system.

(Note 1) Katsuyoshi KANOU, Cutting technology for the next generation based on the data, 2000, THE NIKKAN KOGYO SHIMBUN,LTD

[Pic. 2] Simplified mist application BK type

Aluminum cutting

Near dry machining application for aluminum gate cutting

TOOL ENGINEER
(Kogyo Chosakai Publishing Co., Ltd.)
Reprinted from
the August issue in 2006.

Yashima metal Co.,ltd. (Saku-shi, Nagano) is a cast manufacturer for aluminum engine pistons as a group company of Art metal Co.ltd., which manufactures engine pistons. They have applied near dry machining to the process to cut the unnecessary part called a gate from the cased piston, which has shown successful results.

The reason they decided to introduce the near dry machining is that they decided to review their work when their factory was rebuilt. They cast 500,000 aluminum engine pistons monthly. They used up to nine different aluminums in the past but now put them together to five types. They handle 200 different models of a piston every month and the total models reaches 800. The minimum lot is one and the average lot number is about 2,000. Before it took a long time for tooling change when the type to be casted was changed. In case of a small lot, too much time was spent for tooling change and it was difficult to make an expected profit. Consequently, the work was reviewed to a large extent aiming to reduce the tooling change time "from 90 minutes to 10 minutes" (Mr. Haruhiko HASHIZUME , President). In that process, "gate cutting" is also reviewed and reexamined. They reviewed the cutting tool, which was the same as that used in the parent company, and designed and developed their unique cutting tool that is more suitable to their situation.

From the left, Mr. Haruhiko HASHIZUME , President of Yashima metal Co.ltd.
Mr. Hiroyuki BABA , Factory director
Mr. Yoshinori KURUMISAWA , Sales Engineering, Tatekita Engineering Co., Ltd.

An aluminum piston and the gate. The gate is relatively large compared to the piston itself.

Different from cast iron, aluminum cast iron shrinks the molded article and changes the volume significantly. To compensate that, it is necessary to have a large peripheral part commonly known as "a gate riser". This is a part attached to the both sides of the article like ears. This part is unnecessary for the post process so that needs to be cut after casting. A gate-cutting machine is used for that.

In most cases, a water-soluble lubricant is applied and a carbide chip saw is rotated at high speeds to cut aluminum. Yashima metal Co.,ltd. . used this method

conventionally. They used a carbide chip saw (cold saw) and cut aluminum at the cutting speed of 960m/min and 0.01 mm/blade and with feeding of 720 mm/min. High-speed cutting provides a good cutting surface and accuracy but has a disadvantage of spreading the water-soluble lubricant in the factory as mist, which wet the floor with the oil. The water-soluble lubricant also decays in the high-temperature environment causing an odor. In addition, the fast-rotating tool generated terrible noise. One of other disadvantages was a low yield because the chips created are thin and the air inside acts as insulation during remelting.

In general, a cast factory has been dealt with a heating problem for a long time. Therefore, they "wanted to eliminate either of the heat problem and the noise problem." (Mr. HASHIZUME) Furthermore, they aimed to eliminate water since water causes to the defect inside the cast as well as the water intrusion raises the risk of phreatic explosion.

◆ Significant improvement by adoption of low speed cutting (low rotation, high feeding)

"Low speed cutting", which rotates the tool at low speed and cuts with a large feeding, was first tried as a replacement of the conventional high-speed cutting. After much trial and error, a new cutting mechanism using a water-soluble lubricant was completed. This mechanism rotates a tool (a disc saw) at low speed and cuts into the work material on a large scale with fast feeding. When the commonly used aluminum AC8A is cut, a high-speed metal saw is used with the condition of the cutting speed of 94m/min, the feeding per blade of 0.1 mm, and the feeding of 900 mm/min. The machine is compatible to different work sizes so that it can be used for various kinds and a small lot. In addition, many measures are tried to enhance rigidity of the machine as well as the clamp. Since the process efficiency is high, a motor with the smaller capacity was selected compared to the conventional cutting tools.

Mr. Yoshinori KURUMISAWA (currently at Tatekita Engineering Co., Ltd.) who was in charge of development of the machine learned about near dry machining at that point and decided to introduce Bluebe near dry machining system (manufactured by Fuji BC Engineering). Because it was common to apply a large quantity of water-soluble lubricant to eliminate the heat generated by machining, he was doubtful about the effect. But application of near dry machining brought an unexpectedly significant effect.

First, radical reduction of the oil use dried the wet and sticky floor and improved the factory environment. A great amount of gates and chips produced through the process are usually remelted and used for aluminum material. Before it needed to remove the water content from them prior to the remelting process and the oil content was burnt in a large rotary kiln. However, near dry machining eliminated such a drying process itself. One of the surprising effects that he was not expected was a significant improvement of a tool life.

Chips created during cutting are dry.

Gate risers left after cutting are also dry.

A regrinded metal saw placed on a new metal saw. The metal saw is regrinded until the diameter decreases to ϕ 260mm from ϕ 300mm and used for about 20 times.

A cutting machining with an automated measuring process by robot control.

◆ Significant improvement of a tool life

The conventional tool such as a diamond chip saw with a water-soluble lubricant could cut 30,000 units per tool but a new method by low rotation speed and high feeding with a metal saw as well as application of near dry machining enabled more than 100,000 cuttings per tool. In addition, this metal saw, which costs about 15,000 yen, is grinded and used repeatedly until the original diameter of φ300 mm reduces to φ260mm.

However, these condition does "not always guaranteed" for any situation (Mr. KURUMISAWA). At least there is no doubt that they are very effective to AC8A used here as an example and its equivalent. Since aluminum changes its nature depending on the metal content, the same effect is not guaranteed for all aluminums. Yashima metal Co.,ltd. uses a carbide chip saw for high silicon aluminum instead of a high-speed metal saw. They also apply the combination of a low rotation speed, high feeding, and near dry machining and obtain a favorable result. In the group companies, there is an office dealing with high silicon aluminum. They could process only a few hundred of materials with one tool in the conventional method, but application of the method above allowed process of several tens of thousands of materials.

However, near dry machining is not universal. In case of the near dry machining used here, the supplied vegetable oil shows high lubricating performance but the cooling effect is not as expected. In addition, chips can not be flushed as in case of conventional supply of lubricants and the mechanical construction that allows chips falling automatically would be needed.

A lubricant applicator for near dry machining installed to the cutting machine. This applicator uses a very limited amount of water-soluble lubricant.

A circular saw with a deposited cutting edge.

◆ Why is the tool life extended?

Mr. KURUMISAWA who established the "low rotation speed and high feeding cutting method" infers as below. The cutting performance stabilizes after 1,000 cuttings since use of a new tool started. At the same time, aluminum deposition to cutting edge starts. The deposited aluminum protected the original edge while cutting is performed.

Since the cutting edge is deposited, surface roughness deteriorates. But this "gate cutting" keeps a very small margin for the post process and the surface roughness is not required at this point.

As described above, the effect greater than originally expected was obtained by combining a metal saw(low cost), a low rotation speed / high feeding method, and near dry machining with the highly rigid cutting machine.

Because of the excellent result including improvement of the factory environment and significant extension of a tool life, "All group companies of Art metal Co.,ltd. employed the cutting system developed here, which turned to be very successful." (Mr. Hiroyuki BABA , Factory Manager) They also received the order from other companies in the same trade and supply a gate cutting machine for a piston cast of different materials to automobile part manufacturers and a cutting machine that allows cutting the gate and the overflow part of the squeeze casting simultaneously to die cast manufacturers.

Yashima metal Co.,ltd. searched, developed and selected the technology and the facility that met the needs at the production site and successfully established the effective technology. Although this technology is not applicable to all processing but it will widely contribute to the other work places where such technology is needed.

(Hiroshi OYAMA, chief editor, TOOL ENGINEER)

Improvement results and effects

Productivity improvement

○ Improvement by a cutting machine

	Before	After
A wide variety of products in small quantities	The time for tool change was long.	The time for tool change was shorter.
Productivity	15 machines, 8 persons, monthly output of 300,000	10 machines, 5 persons, monthly output of 500,000
Remelting	It took a long time since the chips were thin and contained a lot of air.	The chips density is heavier and remelting is easier.
Cost for a cutting machine	3 million yen/unit	6 million yen/unit

○ Improvement by near dry machining system

Remelting	Drying by a rotary kiln was necessary.	Remelting is available without drying since the chips are dry.
Concentration control	It took a lot of trouble and time for concentration control of water-soluble lubricant. Or, the concentration could not be controlled well.	Checking of the oil amount in the oil pot only.

○ Combined effect of improvement of a cutting machine and application of near dry machining

Tool life	It varies depending on the concentration of the water-soluble lubricant. 30,000 cuttings/circular saw	Drastically improved by Bluebe lubricant. 100,000 cuttings/circular saw

Environmental improvement

○ Improvement by near dry machining system

	Before	After
Dirt and cleaning	Chips were thin and tended to fly in the air. The periphery of the machines and the floor were always dirty because of the water-soluble lubricant. Chips were also wet and cleaning was not easy.	Chips are heavier and unlikely to fly in the air. They are also dry and cleaning of the machine and the floor is easy.
Decay	The putrid smell was bad.	No putrid smell.
Oil consumption	Undiluted solution 150L/month (after dilution 4,500L/month)	20 - 30L/month

○ Improvement by a cutting machine

Noise	High-frequency noise was a problem.	Noise is reduce

Yashima metal Co.,LTD
Address: 700 Yashima, Saku-shi, Nagano
TEL 0267-58 – 2800
For information
on a sawing machine of low speed / high feeding near dry machining,
Tatekita Engineering Co.,LTD TEL 0267-58-0250
Web site http://www.tatekita-eng.jp

Small-diameter deep hole drilling

Near dry machining application for small-diameter deep hole drilling

FUJI BC ENGINEERING CO.,LTD.

Small-diameter deep hole drilling as represented by a slant oil hole of a crankshaft requires a specialized machine such as a gun drill and it was common to use a tough HSS drill. When a HSS drill is used, a step process was performed to discharge the chips produced. Because of that, it was believed that shortening the cycle time would be difficult.

In the 2000s, a carbide drill for small deep hole drilling was developed. Use of the carbide drill enabled to finish the work at five times better efficiency than the conventional way. It was also found that this process is better with near dry machining than water-soluble lubricants. In this report, application of near dry machining for small-diameter deep hole drilling as represented by frilling a slant oil hole of a crankshaft was described.

◆ Development of a carbide long drill

First, tool manufacturers started to work on high-efficiency drilling of a small-diameter deep hole. Conventionally it was difficult to make a long drill with the material other than a high tenacious material such as high-speed steel. However, they successfully developed a carbide long drill. The reasons for development of carbide long drill include improvement of deflective strength and chipping-resistant performance due to a micro grain base material, coating with excellent heat resistance and abrasion resistance such as Ti-Al-N coated, improvement of chip discharge due to a flat and smooth coating, and design of an appropriate core diameter considering chip discharge and tool rigidity.

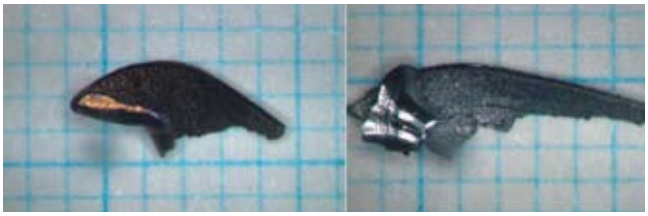
[Pic. 1] Carbide long drill, provided by FUJIKOSHI

◆ Combination with near dry machining

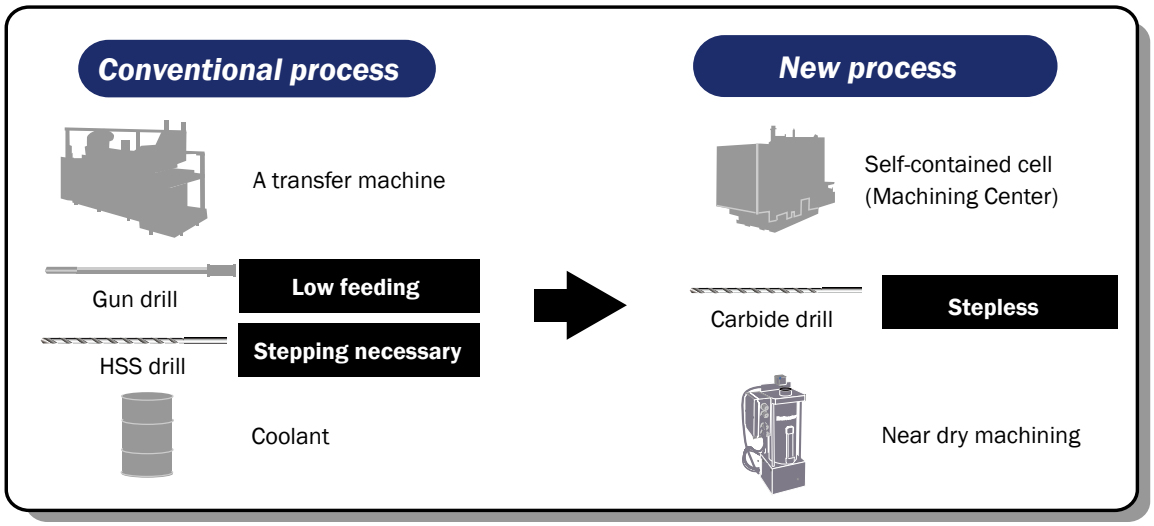
It was found that near dry machining have more advantages on small-diameter deep hole drilling than use of water-soluble lubricants.

As shown in Pic. 2 and 3, shapes of the chips are obviously different between drilling with use of a water-soluble lubricant and near dry machining. The chips created through near dry machining are small and curled, which is better with discharge from a deep hole.

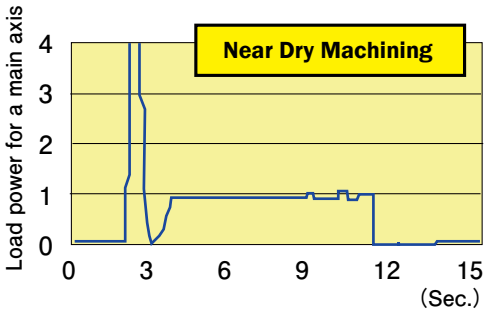
The other points are a tool life and the power for main axis

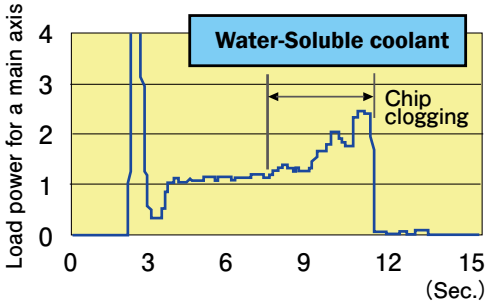


[Pic. 2] Left: near dry machining, right: chips of water-soluble lubricant, provided by FUJIKOSHI



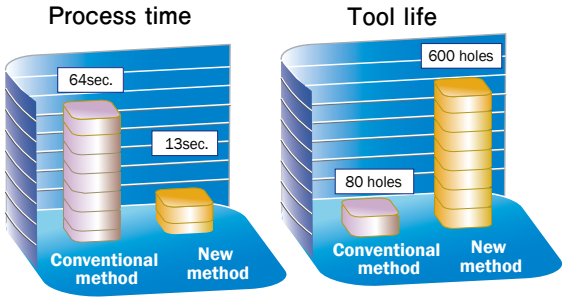
[Graph 1]
Load power for a main axis of near dry machining and water-soluble coolant, data provided by FUJIKOSHI





[Graph 2]
Comparison of tool life and process time between the conventional machining and new machining

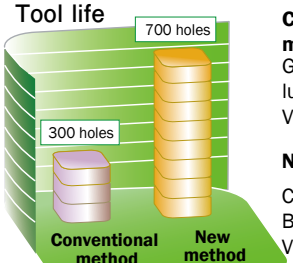
Comparison to a HSS drill



Conventional method
HSS drill and water-soluble lubricant,
13 steps, Vc=18m/min., fn=0.095mm/rev.

New method
Carbide long drill and Bluebe near dry machining,
No steps, Vc=100m/min., fn=0.08mm/rev.

Comparison to a gun drill



Conventional method
Gun drill and water-soluble lubricant,
Vc=60m/min., fn=0.05mm/rev.

New method
Carbide long drill and Bluebe near dry machining,
Vc=80m/min., fn=0.15mm/rev.

[Pic. 3] A chip shape when feeding of a carbide long drill is changed during near dry machining. Chips are small and curled for every feeding which is a good shape for discharge.

load during deep hole. The main axis power load increased halfway when a water-soluble lubricant was used and it is assumed to be caused by chips being stuck. (Graph 1)
Combination of a carbide long drill and near dry machining reduced the cycle time to one-fifth and the tool life improved drastically. (Graph 2) In addition, there were other various effects.
① Reduction of oil agent and energy consumption due to elimination of coolant.
② Reduction of a number of machines and an initial cost due to improvement of the process efficiency (speed-up)
③ Availability of production by a machining center, elimination of a specialized machine and availability of an FMS.
④ Elimination of a coolant pump and reduction of an initial cost and a running cost.
Because of these effects, a high-efficiency small-diameter deep hole drilling enabled to reduce the cost as well as the environmental load.

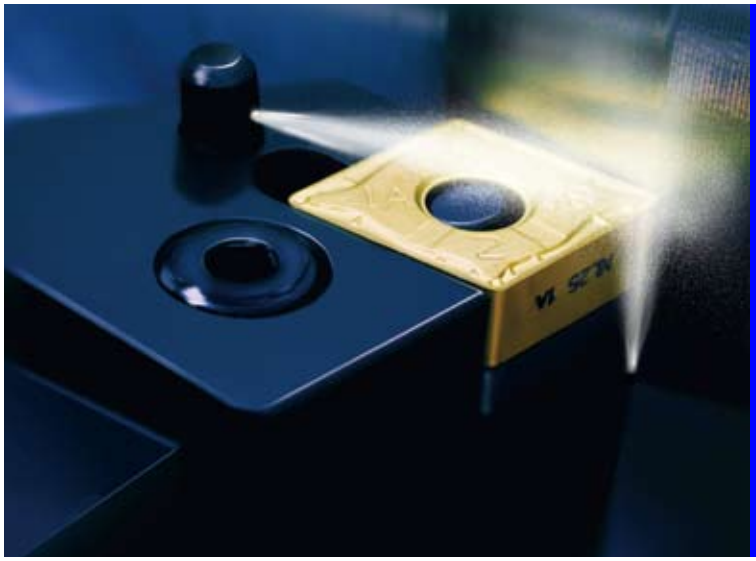
◆ Development of a mist applicator for small-diameter deep hole drilling

Small-diameter oil hole drilling is hard to have the air flow enough to generate oil mist because an oil hole of the drill is small.
In terms of energy saving, EB7 has developed as a device with the system which generates fine oil mist efficiently with low airflow and removes unnecessary larger particles of the oil mist.
The function to limit and select a diameter of the mist particle that is generated and discharged in the applicator is very important to develop a new mist applicator. We used a laser diffraction particle size analyzer for spray and checked the basic function and the mechanism of the applicator by varying the conditions such as how much of mist was generated or how the mist diameter was selected. In addition, it was rotated by a test spindle at 30,000 min- at maximum and change in the discharge by rotation and centrifugal force was checked through development and improvement.
As a result, a particle diameter of the mist discharged from the applicator was expanded 20% (about 73% up for the volume). Because the passing air for the drill used to drill a slant oil hole for the target crankshaft was low, the flow speed of the mist was slow in the delivery path and the mist did not turn to liquid (drop). Then the test spindle and the drill actually used were combined and the oil discharge obtained at the drill end when the tool is rotated and not rotated was repeatedly measured for every prototype and oil type. Then, the effective mist was generated better and a diameter of the mist particle, which is unlikely to be influenced by the centrifugal force generated by the spindle rotation, was determined. After the procedure above was repeatedly performed, Bluebe Eco Booster EB7 was introduced as an applicator that can mist the larger amount of oil to the cutting edge with good response compared to other manufacturer's applicators.
It has been two years since EB7 started to be used in the actual line. Since it is used in an important production line for automobile parts, even today, all applicators to be shipped go through the quality check by measuring the amount of mist oil with the small amount of air. In addition, the applicator
1. can supply the oil while operating,
2. can operate more than 400 hours continuously without applying oil, and
3. is an interlock type that can check the mist generation indirectly
since it is used in the process line of automobile parts. The applicator is also arranged above the panel for easy setup at the machine tool manufacturer. (Pic. 4)

It has been recognized that near dry machining is superior in the crankshaft process line and expectation to near dry machining is raised for the process before and after deep hole drilling for crankshafts and the turning process for camshafts. We established a trial center to try different machining processes so that advantages of near dry machining are fully understood before actual introduction.

Reference
FUJIKOSHI CORP.
NACHI-BUSINESS news Vol.5B2 November/2004

[Pic. 4] A prototype of an inline module exhibited at JIMTOF 2004. The operational status of an applicator is displayed in the panel below.



Lathe process

Turning process
by near dry machining
using Bluebe "**EB-TOOL**"

Turning holder with mist hole

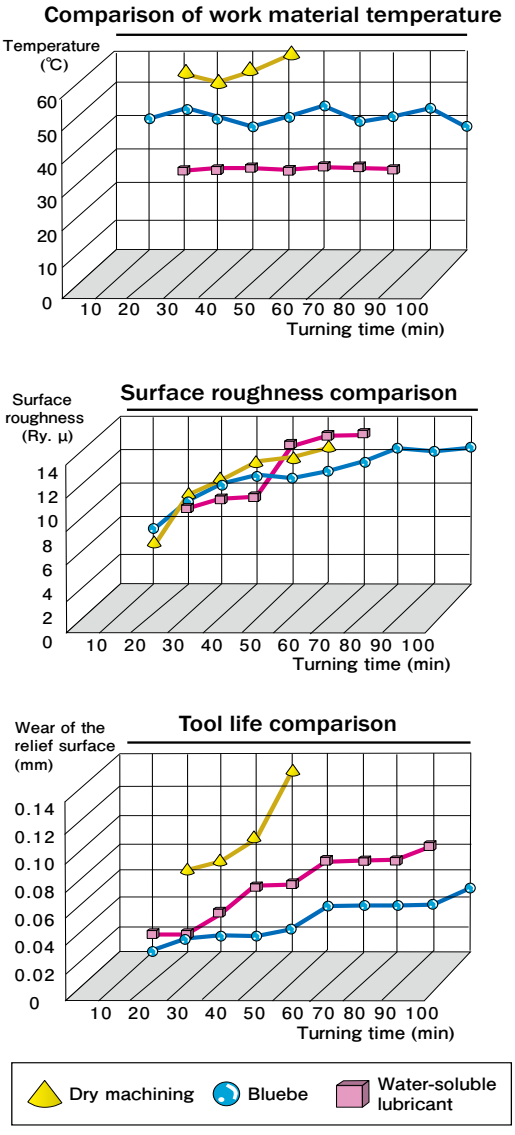
FUJI BC ENGINEERING CO.,LTD.

Near dry machining is a method to apply a very small amount of a high-performance lubricant precisely onto the cutting edge and process the work material. We have applied this method to the suitable processes and succeeded to improve productivity drastically. In particular, it showed good results with aluminum cutting, high-speed die machining, a minimum-diameter drilling, and small-diameter deep hole machining. Characteristics of near dry machining worked well with these processes. In a minimum-diameter drilling less than 1 mm, for instance, the drilling speed can not be increased and the tool tends to be more wearing as a result. Therefore, high-performance lubricant such as vegetable oil and synthetic ester are used to prevent abrasion, and consequently, the tool life became a few to 20 times longer than that with use of water-soluble lubricants. Near dry machining mechanism worked well for each of the process that productivity increased. Now, is near dry machining effective to turning process? Possibility to apply near dry machining to turning process is reviewed below.

◆ Characteristics of turning process and near dry machining

It is a principal characteristic that turning process is continuous processing. Because the cutting edge is always in the work material, a large amount of heat is released and the heat tends to accumulate in the work material if turning process is long. The heat release depends on the cutting depth and the speed while the heat accumulation in the work material depends on the processing time.

Near dry machining has much better lubricating property than use of a large amount of water-soluble lubricant since a high-performance lubricant is used, but the cooling effect is small. Therefore, if the processing time is long such as lathing a round bar, heat accumulation increases in the work material, which makes it difficult to control the accuracy. Meanwhile, near net shaping after press is becoming a mainstream for automobile parts. This process requires small margins and short processing time and releases little heat, which goes well with near dry machining.



[Graph 1] Comparison in turning process

NC lathe turning, Work material: S45C,
Holder: MCLNR2525-12-EB, Applicator: EB-3,
Vc= 150m/min., fn= 0.2mm/rev.,
Cutting depth: 0.5mm,
Machine: NC lathe manufactured by Murata Machinery

◆ Process cases and data

[Case 1]
S45C was used to measure facing temperature, surface roughness, and tool life when dry machining, Bluebe (near dry machining), and water-soluble lubricant were used. Near dry machining released more heat than the water-soluble lubricant but the surface roughness was almost the same. For comparison of the tool life, it shows the least abrasion of the relief surface.

[Case 2]
This is the picture showing the boundary wear after SUS304 is turned 3,200m. Comparison was made between use of the water-soluble lubricant and use of Bluebe. According to the picture shown, the boundary wear is obviously worse for use of the water-soluble lubricant. It is assumed that the better lubrication of Bluebe lubricant prevented surface hardening of the stainless steel.
Turning depth: 3,200m Cutting speed: 150m/min.
Feeding: 0.15 mm/rev. Cutting depth: 1.0 mm
Insert: CNMG120408N-MU (cermet)
Holder: PCLNR2525-12-EB (tool with mist hole)




Bluebe near dry machining　Water-soluble lubricant

[Case 3]
Turning process of SS440. Tool life was extended about 1.5 times longer with use of Bluebe than use of coolant since wear on the relief (VB) after turning process of 53 minutes was 0.194 mm for Bluebe and 0.302 mm for the coolant.
Cutting speed: 200 m/min , Feeding: 0.25 mm/rev.
Cutting depth: 1.5 mm
Holder: MDJNR2525-15-EB (tool with mist hole)
Insert: DNMG150412E-3J SP3036 (Stellram)


Bluebe near dry machining　Water-soluble lubricant

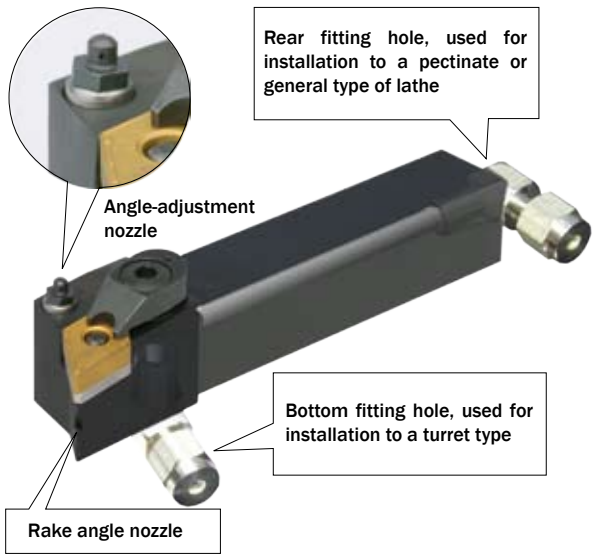
It is known from the past experience that the process that can extend the tool life longer than water-soluble lubricants are near net shaping and the process with cutting of as low heat release as possible and the short continuous processing. In addition, the breakthrough results that near dry machining has achieved can not be expected for the turning process. Normally the tool life is extended at most 1.2 to 2.0 times longer.

◆ Review of tool selection

To apply near dry machining for turning process, it is recommended to review the tool selection. If the coolant is used, thermal cracks that may occur due to quick cooling needed to be considered, but near dry machining does not require considering such concern because it does not have cooling effect as described before. Therefore, highly heat-resistant coated Ti-Al-N and cermets are more appropriate for near dry machining. It is necessary to try the material that fits to the characteristics of near dry machining.

◆ Bluebe EB-TOOL

EB tool (patented) was developed to promote near dry machining for turning. It supplies micro lubrication of a few milli liter per hour from two holes (hereinafter called oil hole) of rake angle and relief angle of a tool holder precisely onto the cutting edge with air and the pin-point application of the lubricant is highly reproducible with any person.
EB tool keeps about 200 items such as outer external ISO holder, a boring bar, and a grooving tool. In particular, a lever-on clamp tool with a new built-in insert clamp mechanism has an adjustable rake angle nozzle that has newly developed. (Pic. 1)
In addition of a turning tool holder, a near dry machining drill, which the hole diameter is optimized for near dry machining to implement high-efficiency machining, also developed and sold. (Pic. 2)
Design and manufacture of a special EB tool as well as turning a hole to the competitor's tool holder are also available.



[Pic. 1]External holder with an adjustment nozzle

[Pic. 2] Near dry machining drill

◆ External turning test by EB-TOOL

External turning was tested to know the efficiency in comparison of EB-TOOl and nomal holder. The supplied fluid was changed to examine the work temperature and the surface roughness. To measure the work temperature, a thermocouple was installed inside the tool to measure the temperature automatically after process. (Table 1)

[Process condition]

- Cutting speed: V=200m/min
- Feeding: fn = 0.4mm/rev
- Cutting depth: a = 2.0mm
- Continuous process time: 3 minutes

[Case]

- Water soluble coolant with nozzle on turret
- Water soluble coolant with EB-TOOL
- Near dry machining (oil mist) with EB-TOOL
- Air blowing with EB-TOOL
- Water and oil mist with EB-TOOL

For turning in wet condition using EB-TOOL, discharge of the coolant is less than 20% compared to the standard nozzle but the work temperature and the surface roughness are almost the same as the standard nozzle case. That is, the EB-TOOL that pinpoints the lubricant to the cutting edge is very effective with wet turning.

Since the oil hole diameter of the EB-TOOL is small and the pressure is lost, a trochoid or a multistage centrifugal medium-pressure pump is preferable for the coolant pump. In addition, a filtering system needs to be added to clean out chips to prevent clogging of the mist nozzles of EB-TOOL.

The work temperature of near dry machining was eight degrees lower than that of air blow due to the lubricant effect. The surface roughness was almost the same. It is assumed that lubrication in the rake side facilitated discharge of the chips, which resulted in temperature reduction.

The reason why the surface roughness was almost the same was assumed high-efficiency turning. Because the temperature of the cutting edge was relatively high, the lubricant was burnt resulting in loss of lubrication. The insert observation after the test showed traces of carbohydrates.

Use of the mixed agent with oil and water cooled the work material down to 30℃ that is much lower than near dry machining. The cutting edge was also at the appropriate temperature and the lubrication was excellent, which resulted in the better surface roughness.

Though it is not listed in Table 1, the work humidity was checked by changing the processing time of near dry turning from 1 min., 2 min., and 3 min., under the same condition. The result showed the temperature rise of approx. 20℃ per minute.

◆ Near dry machining cooling device for turning process

To compensate the cooling disadvantage of near dry machining, a near dry machining cooling device which discharges a minute amount of water-soluble lubricant is proposed for NC lathe application. This device mists the water-soluble lubricant and is expected effective to the process that releases a large amount of heat.

* * *

Further development of new products will be continued to promote and expand near dry machining that is a new environmental-friendly technology with power saving and zero emission. Metal processing in Japan handles highly advanced and challenging parts increasingly and materials more difficult to process are being used due to the lead-free trend.

It will be a great opportunity to check and consider the introduction of near dry machining as well as EB-TOOL with new potentialities in the field.

[Table 1] External turning test using EB-TOOL

Lubricant type Nozzle type	Wet Nozzles OnTurret	Wet EB-TOOL	NDM EB-TOOL	Air Blow EB-TOOL	Oil/Water mist EB-TOOL
Temperature rise on the work material (added to the room temperature) ℃	12	12	60	68	30
Surface roughness Ry (μm)	19	19.2	20.5	20	16
Coolant (emulsion) L/min	6	1 ※	-	-	-
Near dry machining lubricant ml/h	-	-	30	-	30
Water ml/h	-	-	-	-	2000
Air (0.4 MPa) NL/min	-	-	100	100	100

※ Discharge by a trochoid pump

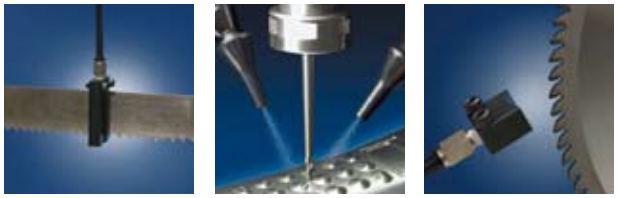
How to perform near dry machining

FUJI BC ENGINEERING CO.,LTD.

Near dry machining decreases the amount of lubricant used to approx. 1/100,000 and supplies a minute amount of the lubricant such as 4 - 30 ml/hour to the cutting edge precisely. In other words, it is a method to combine the advantages of dry machining (the method uses no lubricants) and those of the lubricants. Application of mist is not a new method because it has been used since the early last century. However, the new machining method, near dry machining, uses only the tenth part of the mist used conventionally and this is called as oil air. Actually, this mist is the air containing the oil and too small amount to see. Near dry machining is different from dry machining but extremely similar. The lubricant used is vegetable oil instead of the conventional mineral lubricating oil. Therefore, it is possible to switch to the biodegradable oil, which is harmless to a human body. Near dry machining has been put to practice use in many factory with good results.

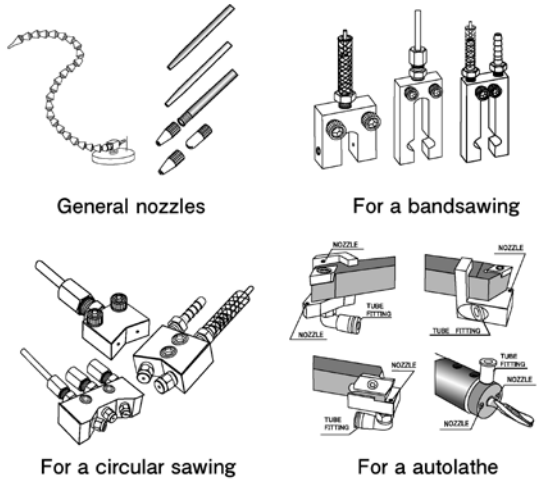
◆ How to supply a minute amount of mist precisely

Described here is how to select the appropriate device and lubricant for people at the manufacturing plant who are considering introduction of near dry machining.
First, to supply the mist precisely at the cutting edge, the easiest way is to mist from the nozzle to the cutting edge. The nozzle can be also easily installed



Bluebe external applicator and the process suitable for the external applicator

[Pic. 1] FK all-in-one type, JK compact type, BK simplified type from the left



[Fig.1]Various nozzles for an external applicator

to the existing equipment. The appropriate equipment includes specialized machine, single-function machine, sawing machine, milling machine without ATC(automatic tool changer), general lathes, auto lathes, pectinate lathes, and radial boring machine. Different from the case where a large amount of lubricant is used, the lubricant is effective only when it is supplied to the cutting edge from the nearest position by the external nozzle. In case of a machining center with ATC, because the tool length changes, it is hard for the nozzle to follow the cutting point. The nozzle also cannot follow the cutting point in case of a NC lathe since the cutting point and the tool used are changed. For drilling, it is more effective to use the drill with an oil hole or a tap instead of applying the lubricant from the outside of the tool. The external applicator mixes the lubricant and the air in the nozzle before supplying it to the cutting point and the amount of the lubricant can be increased unlimitedly.

Bluebe external applicator is equipped with a precise pump allowing application of an extremely small amount of the lubricant with stability. The application of the lubricant is more stable than commercially available lubricators and oilers. The lubricant can be discharge from one nozzle stably at 0.015ml/min. to 2.5ml/min., which the standard is 0.07ml/min. The product lineup for an external applicator includes the superior model FK type which all necessary parts such as a filter and a solenoid valve are built in. JK type was developed to intend to be built in the tool so that the construction is relatively simple and compact without a filter and a solenoid valve. In addition, a pump-free BK type, which the cost performance is excellent (a little over 100,000 yen), is available though the amount of lubricant cannot be adjusted precisely. (Pic. 1)

Many different types of nozzles are also available for different equipment (Fig. 1) A specialized nozzle is easy to be installed and can supply the lubricant mist to the cutting edge precisely.

◆ Internal applicator

The mist, by its nature, sticks to the internal wall of the pipe when it is emitted. This made it difficult to deliver the mist in a long distance. To solve this problem, the internal application decreases a particle diameter of the mist as much as possible to let the mist pass through the pipe. A device that generates the microparticle mist is used to send the mist to the coolant pipe so that the mist can be supplied to the cutting edge even for a through-spindle machining center and a NC lathe. However, if a turbulent flow occurs in the pipe, the mist tends to attach inside the pipe (called devolatilization). Especially if a check valve is installed in the pipe, devolatilization is more likely to occur. While the external applicator mixes the oil and the air in the nozzle and supplies it to the cutting point, the internal applicator delivers the mist in the air passing the pipe so that the oil amount that can be supplied depends on the

[Pic. 2] Bluebe internal applicator and the process suitable for the internal applicator Applicators are ① EB3, ② EB3EP, ③ EB3P, ④ EB3EPCB

air passing the pipe.
The internal applicator is a more complicated device than the external applicator. The product lineup includes EB3 for part machining and EB7 for small-diameter deep drilling with use of a large amount of lubricants. Also each applicator has EB3 type that the oil quantity is manually adjusted according to the control method, EB3P type that the oil quantity is manually adjusted but the air pressure is electrically controlled, EB3-EB that uses the numerical control of a tool (for the newly introduced equipment only), and the superior model EB3-EPCB that incorporates PLC (Programmable Logical Control). (Pic. 2)
In addition, an inline type of the internal applicator is available. This is designed for automobile parts process line. It can supply the lubricant during operation, be continuously operated without refilling of the lubricant for 400 hours, and has interlock function. (Pic. 3)

[Pic. 3] Inline type internal applicator

◆ Water and oil applicator Water-Oil Mist

Near dry machining has shown many good results but it is not appropriate to the process with large heat release. It was especially inappropriate to the long continuous process with large margins such as lathing a round bar. Because the process released a lot of heat and the cooling quality of the near dry machining is not as good as use of a large amount of water-soluble lubricant. To cover such a shortcoming, a coolant applicator that supplies the mist of the water-soluble lubricant to the cutting point only is available. (Pic. 4) Water-Oil Mist shows a certain level of cooling effect that can be applied to heavy metal cutting, which near dry machining could not cover.
Water-Oil Mist uses a smaller amount of lubricant than the conventional application of the water-soluble lubricant but the use of water and oil reaches 10 to 100 times higher than near dry machining. Therefore, it is a difficult question to answer whether or not to keep it in the category of near dry machining. Because the basic concept of near dry machining is reduction of the environmental load and improvement of productivity, Water-Oil Mist may still need to clear the issues on the post process (drying chips and simplification of the degreasing and cleaning process) and improvement of the factory environment.

[Pic. 4] Water and oil applicator Water-Oil Mist

◆ Special tool

Many creative measures will be needed to supply a minute amount of mist precisely to the cutting point only. Accuracy and precision were not a top priority to consider when a large amount of lubricant was used, but to apply a minute amount of mist, subtle displacement can deteriorate the necessary effect. Tools with a oil hole which reaches to a cutting edge are commercially available, especially for drilling tools, and these tools are applied to near dry machining. "Bluebe EB-TOOL" with an oil hole is available for a turning tool (Pic. 5). EB TOOL has mist holes in the rake angle and the relief angle that can be adjusted according to the characteristics of an internal applicator used. Currently approx. 200 types are included in the lineup such as an external/internal turning ISO holder, a grooving holder, a thread turning holder, and a throw-away drill.
The latest lineup includes the one with adjustment function of a rake angle nozzle and more variation is expected in the future. For the tools not included in the lineup, the service to install a mist nozzle to a commercial tool is provided.

[Pic. 5] Tool with mist hole EB-TOOL

◆ Biodegradability of lubricants

Biodegradability means that substances in the nature are degraded by bacteria (microorganism) and changed to other substances such as water and carbon dioxide. If the substance is not degraded, it will be accumulated in the environment. Since mineral oil is a stable substance, it may be hard to be degraded and be accumulated in the environment.

Some of the lubricants and cutting fluids are not only used in the factory but also released in the environment. These types are called open type lubricants and include grease and 2-cycle engine oil used for ships and chain-saw oil used in the forests, and hydraulic actuation oil for heavy equipment. In Europe, biodegradable oil is frequently used for such open type lubricants.

Now, is it unnecessary to use biodegradable oil in the closed environment such as a factory building? It is a fact that various substances leak from the factory. Currently soil contamination became a big issue and as a result, the Soil Contamination Countermeasures Law came into force in January 2003. This obliges the landowner to purify the land if it is contaminated by toxic substances. The target substances include arsenic, trichloroethylene, and so on. The trichloroethylene, however, was commonly used for a degreasing and cleaning agent in the metal process factory. In other words, it is possible that the substances currently accepted and used are pointed out as hazardous in the future. It is essential to avoid release or leakage of any chemical substances in the environment to eliminate such a possibility. It is also necessary to replace the substances that will be accumulated in the environment to the biodegradable substances.

Bluebe lubricant is made of vegetable oil or synthetic ester of the vegetable oil, which are biodegradable (Pic. 6). Since the vegetable oil and the synthetic ester are more expensive than mineral oil, it is difficult to use them as the conventional lubricant that were used at large scale. That is why they are considered as an optimal lubricant for near dry machining because it uses a very small amount of the lubricant.

[Pic. 6] Bluebe lubricant for near dry machining

◆ Near dry machining solution company

We are the first company that proposed near dry machining in Japan in 1989. Near dry machining was called "Super lubricative cutting fluid supply system" at that time, but later, "Semi dry machining" (near dry machining) was coined to promote its concept. Through the process, we understood that engineering was an essential part of near dry machining.

To apply near dry machining to some process, many different conditions need to be considered. In addition to a wide variety of process types, the work material, the tool type, the cutting condition, and the tool rigidity need to be taken into account. Furthermore, a type of lubricant that has been used conventionally, additives, concentration of a water-soluble lubricant, a discharge pressure, a discharge amount, and so on; there are too many of them. These different conditions are complexly influenced each other. Among them, it is most troublesome to find the minimum necessary boundary area.

To organize such a troublesome and complicated work through our experience and the data accumulated and prove the advantages of near dry machining by trial cutting, we established a trial center that is open to the public. The trial center is equipped with a machining center and a NC lathe that a near dry machining applicator is incorporated and various measuring instruments so that the customer can bring the tool and the work material used actually for trial cutting.

(Pic. 7)

◆ Leave installation to the existing equipment to us.

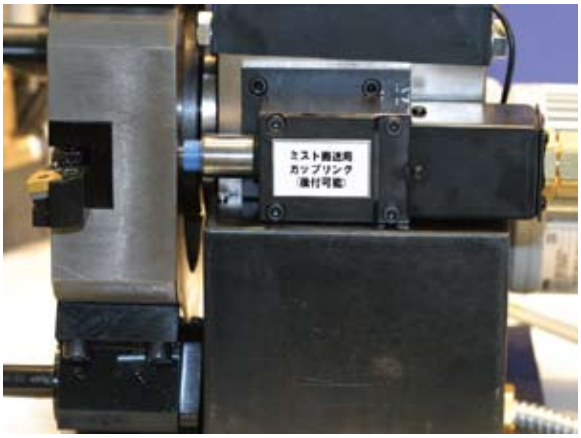
To modify a new tool for near dry machining, it is recommended to request to a tool manufacturer. Almost all tool manufacturers deal with near dry machining applicators as option. The applicator is installed to the existing equipment by us, who is a manufacturer of the applicator. Not only replacement to the applicator but also the option to leave the water-soluble lubricant and switch to the applicator as needed are available.

We also handle any problems occur due to application of near dry machining. For instance, when a NC lathe is modified for near dry machining, the mist is put in the lubricant supply line and delivered to the turret. However, the old machine may not be sealed well and the mist could leak from various points. In case of a large amount of coolant, the coolant is discharged from the turret and little leakage is ignored while the mist slips out of the small gap and does not reach to the cutting edge. It is one way to ask the machine builder to replace the seal but we provide a mist coupling that is retrofitted as shown in the picture (Pic. 8). Please note that it may not be installed depending on the turret shape.

☆ ☆ ☆ ☆

We believe that we have and can provide everything necessary to modify the factory for near dry machining. As well as hardware such as devices, lubricants, and tools, we have experience, technology and process data required for near dry machining. We integrate them to our trial center so that the customer can fully understand advantages and disadvantages of near dry machining before introduction.
We are looking forward to inquiries from customers seeking the way to improve the factory environment and hoping to improve productivity by near dry machining.

[Pic. 7] Near dry machining trial center (Nagoya)



[Pic. 8] A mist coupling

Bluebe

The most progressive Brand for Near Dry Machining

Bluebe
BLUE CATALOGUE

Near Dry Machining

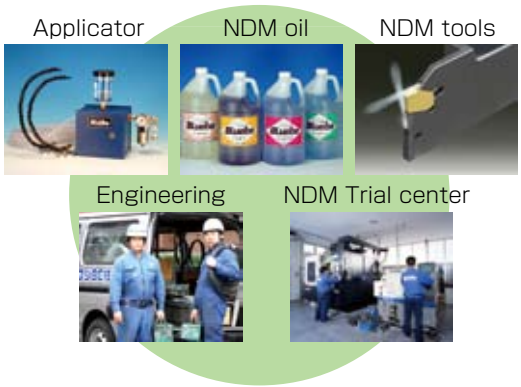
Applicator

Oil

Bluebe
RED CATALOGUE

Cutting tools with mist nozzles

EB-TOOL



Bluebe, the pioneer of Near Dry Machining, develops all kinds of devices and services. Applicators, oils, special tools and engineering.
Further more, we established a Near Dry Machining trial center that is open to the public. The trial center is equipped with a machining center and a NC lathe that a near dry machining applicator is incorporated.

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We are providing a one to two-hour workshop by PowerPoint regarding the content of this brochure. Please contact us for further information if you would like to use it for presentation at the factory where is interested in near dry machining or the training at the factory where already introduced near dry machining.

Bluebe

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