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Minimum Quantity Lubrication with Timer Based Control in Machining of EN9 Material

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Abstract: *The effect of cutting tool geometry has long been an issue in understanding mechanics of turning. Tool geometry has significant influence on chip formation, heat generation, tool wear, surface finish and surface integrity during turning. This article presents a survey on variation in tool geometry i.e. tool nose radius, rake angle, groove on the rake face, variable edge geometry, wiper geometry and curvilinear edge tools and their effect on tool wear, surface roughness and surface integrity of the machined surface in the turning operation of components from EN9 (C-45 Plain carbon steel) & EN24 (40 Ni 2Cr1Mo28 -Alloy steel).*

A certain M/s Paramount Industries, produce blanks for gear cutting from the above said materials. Conventional inserts are used in the turning operations of the components. Component turning using these conventional inserts has shown moderate to low production rates, lower surface finish and dimensional inaccuracies while machining components.

Earlier method of lubrication uses the coolant pump to circulate cooling fluid using coolant pump this method proved costly and so also the machine environment conditions were affected namely floor becoming slippery etc, hence it was decided to implement the minimum quantity lubrication on the machine.

Minimum quantity lubrication (MQL) has increasingly found its way into the area of metal cutting machining and, in many areas, has already been established as an alternative to conventional wet processing. In contrast to flood lubrication, minimum quantity lubrication uses only a few drops of lubrication (approx. 5 ml to 50 ml per hour) in machining. Today, the enormous cost-saving potential resulting from doing almost entirely without metalworking fluids in machining production is recognized and implemented by many companies, primarily in the automotive industry. While in the early 1990s small applications (sawing, drilling) were done "dry", today we are able to produce cylinder heads, crankcases, camshafts and numerous other components made of common materials – such as steel, cast iron and aluminums – using MQL in the framework of highly automated large volume production.

Keywords: *MQL ,Surface roughness, EN9 ,Timer based machining.*

1. Introduction

MQL consists of a mixture of pressurized air and oil micro-droplets applied directly into the interface between the tool and chips. However, the question of how the lubricants can decrease the friction under very high temperature and loads is still not answered especially for long engagements times. MQL decreased the contact length compared to dry cutting for both short and long engagement time. Minimum quantity lubrication (MQL) has increasingly found its way into the area of metal cutting machining and, in many areas, has already been established as an alternative to conventional wet processing. In contrast to flood lubrication, minimum quantity lubrication uses only a few drops of lubrication (approx. 5 ml to 50 ml per hour) in machining. Today, the enormous cost-saving potential resulting from doing almost entirely without metalworking fluids in machining production is recognized and implemented by many companies, primarily in the automotive industry. While in the early 1990s small applications (sawing, drilling) were done "dry", today we are able to produce cylinder heads, crankcases, camshafts and numerous other components made of common materials – such as steel, cast iron and aluminum – using MQL in the framework of highly automated large volume production.

The advantages of this new technology are clear. With respect to occupational safety, MQL offers numerous advantages over water-mixed metalworking fluids. A major advantage is the substantially better compatibility concerning skin care. Minimum quantity lubrication is a total-loss lubrication method rather than the circulated lubrication method used with emulsions. This means using new, clean lubricants that are fatty-alcohol or ester based. Additives against pollution, e.g. biocides and fungicides, are not necessary at all, since microbial growth is possible only in an aqueous phase. The extreme reduction of lubrication quantities results in nearly dry work pieces and chips. This greatly reduces health hazards caused by emissions of metalworking fluids in breathed-in air and on the skin of employees at their workplaces. Metalworking fluids do not spread throughout the area around the machine, thus making for a cleaner workplace.

The present work experimentally investigates the role of MQL on surface roughness of EN9 material with help of timer based controlling in machining process.

2. PROBLEM DEFINITION

Paramount Industries, Pune one of the gear blank manufacturing company, they having found some problems frequently at the time of manufacturing the gear blank such as low production rates, lower surface finish and dimensional inaccuracies while machining components.

Earlier method of lubrication uses the coolant pump to circulate cooling fluid using coolant pump this method proved costly and so also the machine environment conditions were affected namely floor becoming slippery etc.

3. SCOPE OF WORK & OBJECTIVES

In this paper the ultimate aim of the proposed work is to overcome the problem of convectional lubrication system by providing alternative system i.e. minimum quantity lubrication system. As per the problem defined, we are overcome the problem by implement the minimum quantity lubrication on the machine with the help of timer based controlling in machining process.

3.1. Design and Development

1) System design as to the number of components required , their sizes as per machining conditions
2) Design calculation for selection and design of following parts:
   a) Double acting hydraulic cylinder / non return valves/piping/connectors
   b) Pneumatic atomizer chamber /Flow control valve selection.
   c) Design of oil mist application nozzle as per cutting requirements.
   d) Derivation of tank size and other considerations on operational features
   e) Design of square threaded screw arrangement / nut / bearing selection.
   f) Prime mover motor selection.

3.2. Manufacturing of Set-Up

1) Manufacturing of square thread screw /nut/bearing housing/holder/guide mechanism etc.
2) Manufacturing of pneumatic atomizer mist chamber
3) Fabrication of tank and frame arrangement
4) Hydraulic circuit
5) Pneumatic circuit

3.3. Testing of Set-Up

1) Test will be conducted using minimum quantity lubrication on Lathe for the following conditions and materials:
   a) Turning of EN9 material under following conditions – with and without MQL
      1. Variation of cutting speed (v m/min)
      2. Variation of feed (f mm/rev)
      3. Variation of depth of cut (d mm)

4. RESULTS TO STUDY (ANALYSIS)

1) Dimensional tolerances
2) Surface finish
3) Machining time
4) Tool life

4.1. Graphs

a) Tool life VS speed / Tool life VS feed / Tool life VS depth of cut with /without MQL
b) Surface finish VS speed/ Surface finish VS feed/ Surface finish VS depth of cut with /without MQL
c) Machining time VS speed / Machining time VS feed / Machining time VS depth of cut with /without MQL
d) Graphical plotting of tolerance zone with /without MQL Comparative study will be done using above graphs for EN(9) material and results discussion will lead to recommendation of MQL parameters for various Speed/feed/depth of cut for optimal performance

5. LUBRICANTS FOR MINIMUM QUANTITY LUBRICATION

5.1. Lubricant Properties for Minimum Quantity Lubrication

Minimum quantity lubrication is total-loss lubrication. The lubricant in use is often subject to high thermal and mechanical loads and is applied to the work zone in the form of mists and aerosols. The user should therefore ensure that only toxicologically harmless lubricants are used. For fault-free, low-emission metal machining when using minimum quantity lubrication, lubricants with very good lubricity and a high thermal rating are best. In industrial manufacturing, synthetic ester oils and fatty alcohols with favourable, vaporization behaviour and a high flash point are used.

Synthetic esters are preferable for all machining processes in which the lubricating effect between tool, the work piece and separation from the chips is of prime importance.(Prevention of abrasive wear) Examples of this are threading, drilling, reaming and turning). Synthetic esters have the advantage that, despite low viscosity, they have a high boiling point and flash point. This means that much less vapour is emitted in the workspace compared to conventional mineral oils. In addition to these properties, ester oils exhibit verygood biodegradability, and owing to their low toxicity are rated as Water Pollution Category 1 (WPC 1) or “non-hazardous to water”.

Compared to ester oils, fatty alcohols have a lower flash point at the same viscosity. In contrast to ester oils, they offer less lubricity.

Fatty alcohols are preferred for machining processes in which the separation effect rather than the lubricating effect is of prime importance (avoidance of built-up edges). An example of this is the machining of non-ferrous metals.

Fatty alcohols have very good biodegradability, are toxicologically harmless, and likewise are rated as non-hazardous to water (nhw) or Water Pollution Category 1 (WPC)

	Esters	Fatty alcohols
Vaporisation *	slow	fast
MQL – residual amount on work piece	low	"dry"
Lubricating effect	high	low
Flash point *	high	low
Water Pollution Category	nhw/1	nhw/1

* based on the same viscosity

Table 5 Basic differences between esters and fatty alcohols

Experience deriving from industrial use shows that the choice of lubricant should be process and application-specific

5.2. Criteria to Select a MQL Lubricant

When choosing a suitable MQL lubricant, the user should take into account the criteria below.

Low-emission lubricants: The following guide values have proven useful in selecting a low-emission lubricant.

Viscosity at 40 °C DIN 51562 Part 1	Flashpoint CoC DIN EN ISO 2592	Evaporation losses at 250 °C acc. to Noack DIN 51581 Part 1
> 10 mm²/s	> 150 °C	< 65%

Table 6 Guide values for selecting a low-emission lubricant
(source: BGIA workbook "Measuring hazardous substances, category 6")

Smell: The smell of the lubricant is not inconsequential. Spraying the lubricant can cause the smell to be intensified.

Sprayability: The lubricant should spray easily and, especially with 1-channel systems, be able to produce a stabile aerosol (oil-air mixture).

Additives: The additives should be adjusted to the processing requirements, particularly when Processing non-ferrous metals and difficult to cut steels.

Residues on machine parts: Despite minimum spray amounts and the use of extraction devices, lubricants may leave residues on work pieces and machine parts. The lubricant should not resinate and should be easy to clean off if necessary.

Viscosity range: Practical experience shows that the best results with lubricants (ester or fatty alcohol) are achieved at a viscosity range of 15 to 50 mm 2/s and in some cases up to 100 mm2/s at 40 °C. Upper viscosity limits should be discussed with the MQL system manufacturer (check device suitability for sprayability). In general the MQL system and lubricant should be compatible with each other.

Lubricant change: Before a new lubricant is used, the system should be completely drained and flushed. The flushing process should be performed with the new lubricant.

Corrosion protection: A check should be made as to whether the thin MQL residual film on the work-piece after machining offers corrosion protection that meets the requirements or whether additional corrosion protection is necessary.

Unsuitable lubricants for minimum quantity lubrication

The following products have proven not to be suitable for minimum quantity lubrication and should therefore not be used:

Natural oils and greases: Esters (rape seed oil, etc.) have the disadvantage that they are very prone to oxidation. They tend to gum up machine elements.

Water-miscible metalworking fluids and their concentrates: These products may contain biocides and thus can be found in the spray aerosols.

Lubricants with additives containing organic chlorine or zinc: Due to high process-related machining temperatures encountered when using Minimum quantity lubrication, reaction products harmful to health may result.

Lubricants with mandatory marking: (Orange hazard symbol in compliance with the hazardous substances ordinance).These products have a hazard potential level that is already high.

Mineral oil-based products with high aromatic compound content: (> 3 ppm benzo[a]pyrene in the metalworking fluid)

Polycyclic aromatic compounds have a carcinogenic potential: More information on the topic of lubricants for minimum quantity lubrication can be found in the BGIA workbook "Measuring hazardous substances, category 6".

6. DESIGN

Design consists of application of scientific principles, technical information and imagination for development of new or improvised machine or mechanism to perform a specific function with maximum economy & efficiency.

Hence a careful design approach has to be adopted. The total design work , has been split up into two parts

- System design
- Mechanical Design.

System design mainly concerns the various physical constraints and ergonomics, space requirements, arrangement of various components on main frame at system, man + machine interactions, No. of controls, position of controls, working environment of machine, chances of failure, safety measures to be provided, servicing aids, ease of maintenance, scope of improvement, weight of machine from ground level, total weight of machine and a lot more.

In mechanical design the components are listed down and stored on the basis of their procurement, design in two categories namely,

- Designed Parts
- Parts to be purchased

For designed parts detached design is done & distinctions thus obtained are compared to next highest dimensions which is readily available in market. This amplifies the assembly as well as postproduction servicing work. The various tolerances on the works are specified. The process charts are prepared and passed on to the manufacturing stage

The parts which are to be purchased directly are selected from various catalogues & specified so that any body can purchase the same from the retail shop with given specifications.

7. SYSTEM DESIGN

In system design we mainly concentrated on the following parameters:

1. System Selection Based on Physical Constraints

While selecting any machine it must be checked whether it is going to be used in a large-scale industry or a small-scale industry. In our case it is to be used by a small-scale industry. So space is a major constrain. The system is to be very compact so that it can be adjusted to corner of a room.

The mechanical design has direct norms with the system design. Hence the foremost job is to control the physical parameters, so that the distinctions obtained after mechanical design can be well fitted into that.

2. Arrangement of Various Components

Keeping into view the space restrictions the components should be laid such that their easy removal or servicing is possible. More over every component should be easily seen none should be hidden. Every possible space is utilized in component arrangements.

3. Components of System

As already stated the system should be compact enough so that it can be accommodated at a corner of a room. All the moving parts should be well closed & compact. A compact system design gives a high weighted structure which is desired.

4. Man Machine Interaction

The friendliness of a machine with the operator that is operating is an important criteria of design. It is the application of anatomical & psychological principles to solve problems arising from Man – Machine relationship. Following are some of the topics included in this section.

- Design of hand lever
- Energy expenditure in foot & hand operation
- Lighting condition of machine.

5. Chances of Failure

The losses incurred by owner in case of any failure is an important criteria of design. Factor safety while doing mechanical design is kept high so that there are less chances of failure. Moreover periodic maintenance is required to keep unit healthy.

6. Servicing Facility

The layout of components should be such that easy servicing is possible. Especially those components which require frequents servicing can be easily disassembled.

7. Scope of Future Improvement

Arrangement should be provided to expand the scope of work in future. Such as to convert the machine motor operated; the system can be easily configured to required one. The die & punch can be changed if required for other shapes of notches etc.

8. Height of Machine from Ground

For ease and comfort of operator the height of machine should be properly decided so that he may not get tired during operation. The machine should be slightly higher than the waist level, also enough clearance should be provided from the ground for cleaning purpose.

9. Weight of Machine

The total weight depends upon the selection of material components as well as the dimension of components. A higher weighted machine is difficult in transportation & in case of major breakdown, it is difficult to take it to workshop because of more weight.

7.1. Force Analysis

Motor Torque

P= 2 Π N T/60

T = (60 x 15)/ (2 Π x 30)

T = 4.77 N-m

T design motor = 4.7 N-m

Design Of Spur Pinion & Gear

Stage 1: Drive as GEAR and pinion arangement

Maximum load =Maximium torque / Radius of gear

Maximum torque = 4.7 N-m

No of teeth on gear = 60

Module = 1.5 mm

Radius of gear by geometry = (60 x 1.5) /2=45mm

Maximum load = T/r = 4.7 x 103 /45 =104 N

b = 10 m

Material of spur gear and pinion = Nylon 66

Sult pinion = Sult gear = 300 N/mm2

Service factor (Cs) = 1.5

The gear and pinion arrangement where as pinion has 10teeth and gear has 60 teeth share the entire tooth load…

⇒Pt = (W x Cs) 156 N.

Peff = 156 N (as Cv =1 due to low speed of operation)

Peff = 156 N (A)

Lewis Strength equation

WT = Sbym

Where;

Y= 0.484 – 2.86

Z ⇒ yp = 0.484 - 2.86/10= 0.198

yg = 0.484 – 2.86/60= 0.436

⇒ Syp = 59.4

Syg = 130.8

As Syp < Sys ⇒ pinion is weaker

WT = (Syp) x b x m

=59.4 x 10m x m

WT= 594m2 (B)

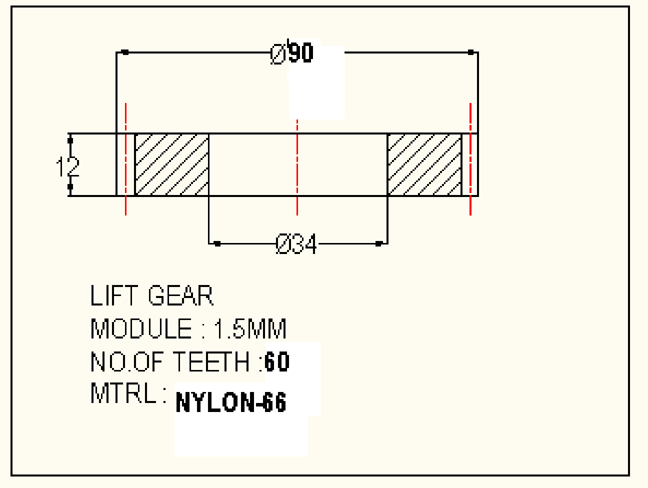
Equation (A) & (B)

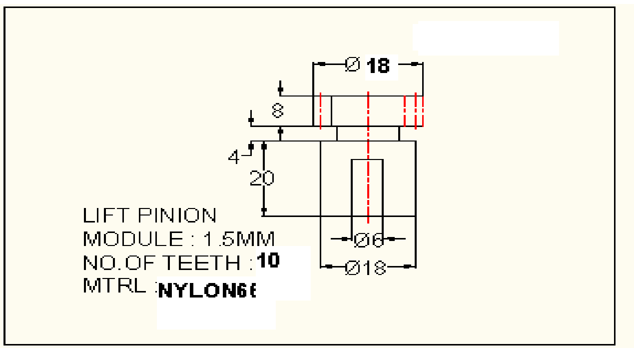
594 m2 = 156

⇒m=51 mm

Selecting standard module = 1.5 mm ----for ease of construction as we go for single stage gear box…making size compact …achieving maximum strength and proper mesh.

Hence gear pair dimensions are as follows,





Selection of Cylinder

STANDARD CATALOGUE IS NOT AVAILABLE SEPERATELY FOR CYLINDER THAT WE USE, Ie, 50 mm piston dia and 40 mm stroke… the data below is standard sheet as example to ordering code and cylinder details…….

Standard cylinders DNC, ISO 15552

FESTO

Type codes

DNC – 80 – 320 – PPV – A

Type	
Double-acting	
DNC	Standard cylinder

Piston ∅ [mm]

Stroke [mm]

Cushioning	
P	Flexible cushioning rings/pads at both ends
PPV	Pneumatic cushioning, adjustable at both ends

Position sensing	
	Without position sensing
A	Via proximity sensor

Note

The standard cylinder DNC can be ordered using either a fixed part number and type designation or via the modular product system. The type code listed above only applies to the DNC standard cylinder with fixed part number and type designation. Variants can only be ordered using the modular product system.

Standard cylinders DNC, ISO 15552

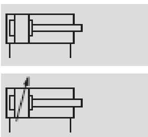
FESTO

Technical data

Function

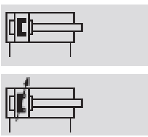
DNC-...

Without position sensing



DNC-...-A-...

With position sensing



Diameter
32 ... 125 mm

Stroke length
10 ... 2,000 mm

www.festo.com

Wearing parts kits
→ 22

- Standards-based cylinders to ISO 15552 (corresponds to the withdrawn standards ISO 6431, DIN ISO 6431, VDMA 24 562, NF E 49 003.1 and UNI 10290)

ISO DIN VDMA

General technical data								
Piston ∅		32	40	50	63	80	100	125
Pneumatic connection		G⅛	G¼	G¼	G⅜	G⅜	G½	G½
Piston rod thread		M10x1.25	M12x1.25	M16x1.5	M16x1.5	M20x1.5	M20x1.5	M27x2
	K3	M6	M8	M10	M10	M12	M12	M16
	K5	M10	M12	M16	M16	M20	M20	M27
Constructional design		Piston						
		Piston rod						
		Profile barrel						
Max. torsional backlash of piston rod [°]	Q	±0.65	±0.6	±0.45	±0.45	±0.45	±0.45	–
Cushioning		Flexible cushioning rings/pads at both ends						
		Pneumatic cushioning, adjustable at both ends						
Cushioning length PPV	[mm]	20	20	22	22	32	32	42
Position sensing		Via proximity sensor						
Type of mounting		Via female thread						
		Via accessories						
Mounting position		Any						

Note: This product conforms with the ISO 1179-1 standard and the ISO 228-1 standard.

Standard cylinders DNC, ISO 15552

Technical data

FESTO

Operating and environmental conditions								
Piston ∅		32	40	50	63	80	100	125
Operating medium		Filtered compressed air, lubricated or unlubricated						
Operating pressure		0.6 ... 12						0.6 ... 10
[bar]	R8	1.5 ... 12						1.5 ... 10
	S11	0.1 ... 12						0.1 ... 10
	TT	1 ... 12						–
Ambient temperature[1]		−20 ... +80						
[°C]	S6	0 ... 120						
	TT	−40 ... +80						–
Corrosion resistance class		2						
CRC[2]	R3	3						
Certification		Germanischer Lloyd						
ATEX		Specified types → www.festo.com						

1) Note operating range of proximity sensors

2) Corrosion resistance class 2 as per Festo standard 940 070
Components subject to moderate corrosion stress. Externally visible parts with primarily decorative surface requirements which are in direct contact with a normal industrial environment or media such as coolants or lubricating agents.
Corrosion resistance class 3 as per Festo standard 940 070
Components requiring higher corrosion resistance. External visible parts in direct contact with industrial atmospheres or media such as solvents and cleaning agents, with a predominantly functional requirement for the surface.

Force [N] and impact energy [J]								
Piston ∅		32	40	50	63	80	100	125
Theoretical force at 6 bar,		483	754	1,178	1,870	3,016	4,712	7,363
advancing	S2/S20	415	633	990	1,682	2,721	4,418	6,881
Theoretical force at 6 bar,		415	633	990	1,682	2,721	4,418	6,881
retracting	S2/S20	415	633	990	1,682	2,721	4,418	6,881
Max. impact energy at the end positions[1]		0.1	0.2	0.2	0.5	0.9	1.2	5

1) The permissible impact energy is reduced by approx. 10% for variants K10 and S20

Permissible impact velocity: $v_{perm.} = \sqrt{\frac{2 \times E_{perm.}}{m_{dead} + m_{load}}}$

Maximum permissible load: $m_{load} = \frac{2 \times E_{perm.}}{v^2} - m_{dead}$

$v_{perm.}$ Permissible impact velocity
$E_{perm.}$ Max. impact energy
$m_{intrinsic}$ Moving load (drive)
m_{Load} Moving effective load

Note
This data represents the maximum values that can be achieved. The maximum permissible impact energy must be observed.

Standard cylinders DNC, ISO 15552

Technical data

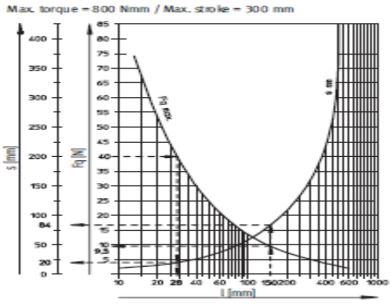
FESTO

Lateral force Fq as a function of stroke length l and lever arm s

Q – Square piston rod

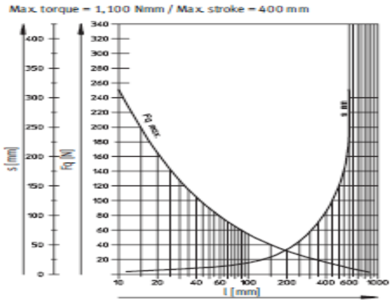
∅ 32

Max. torque = 800 Nmm / Max. stroke = 300 mm



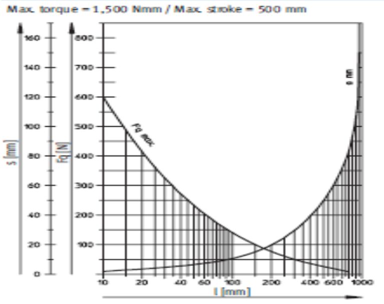
∅ 40

Max. torque = 1,100 Nmm / Max. stroke = 400 mm



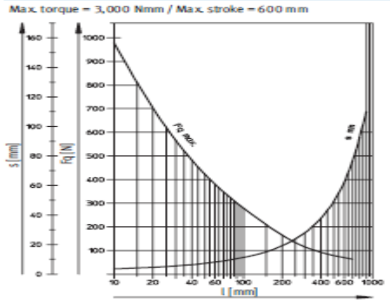
∅ 50/63

Max. torque = 1,500 Nmm / Max. stroke = 500 mm



∅ 80/100

Max. torque = 3,000 Nmm / Max. stroke = 600 mm

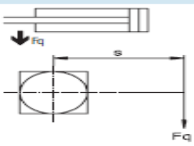


Examples for piston ∅ 32 mm

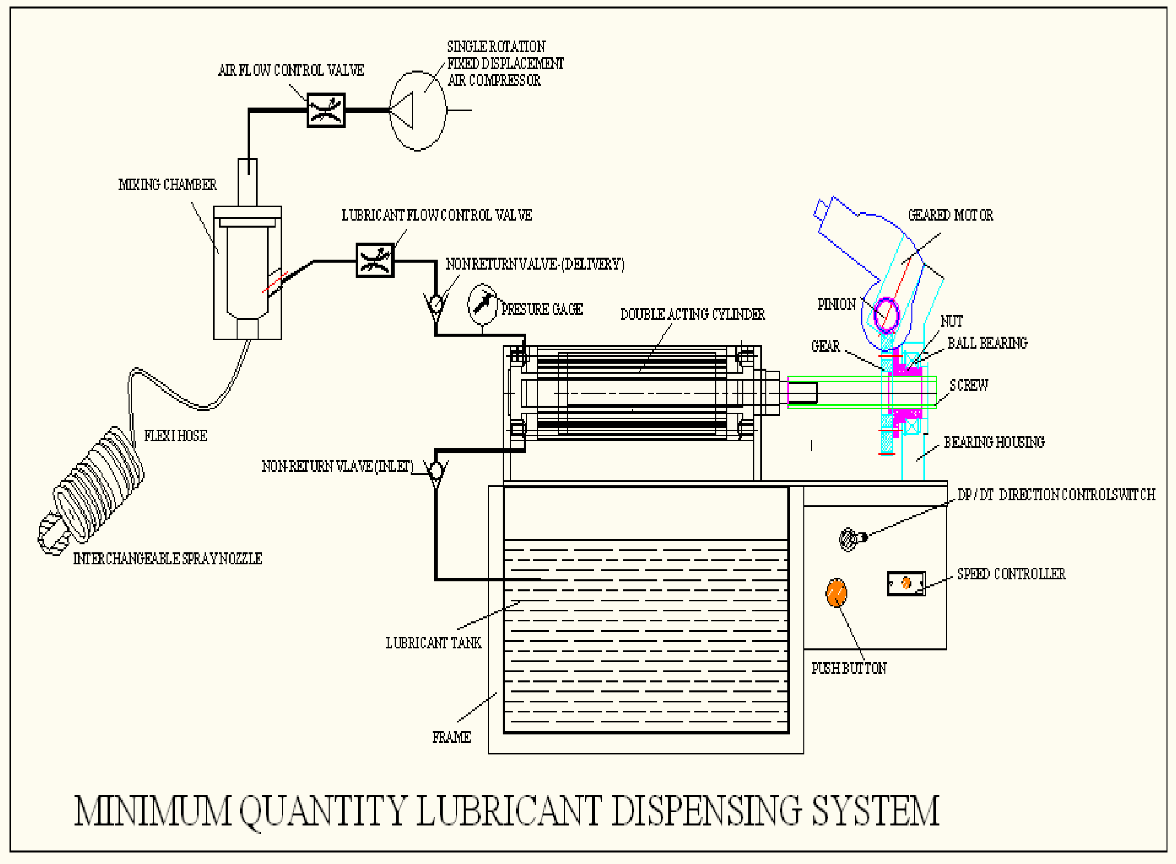
Example 1:
Stroke length l = 150 mm
Result: permissible
Lateral force Fq = 9.5 N
Lever arm s = 84 mm

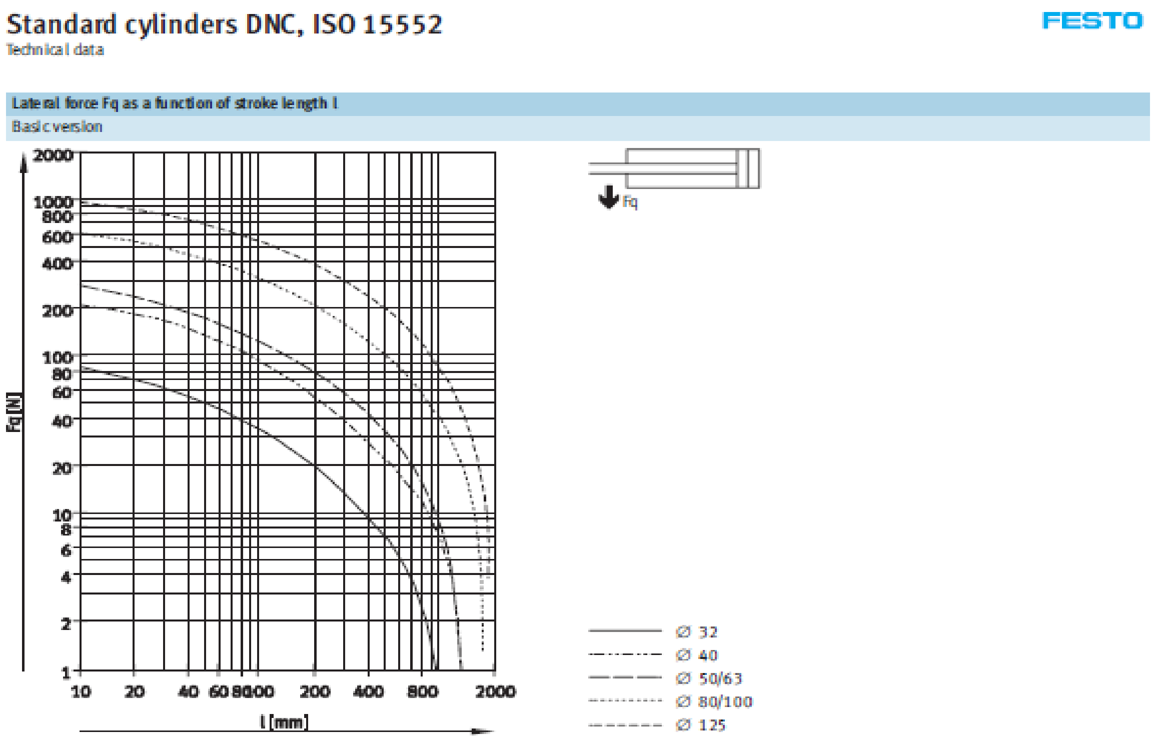
Example 2:
Lateral force Fq = 40 N
Result: permissible
Stroke length l = 28 mm
Lever arm s = 20 mm

Example 3:
Stroke length l = 150 mm
Lever arm s = 20 mm
$Fq = \frac{\text{Max. torque 800 Nmm}}{\text{Lever arm 100 mm}}$
= 8 N
Result: permissible
$Fq = 8\ N < Fq_{max.} = 9.5\ N$



12 → Internet: www.festo.com/catalogue/... Subject to change – 2009/05


SINGLE ROTATION
FIXED DISPLACEMENT
AIR COMPRESSOR
AIR FLOW CONTROL VALVE
MIXING CHAMBER
LUBRICANT FLOW CONTROL VALVE
NON RETURN VALVE-(DELIVERY)
PRESURE GAGE
DOUBLE ACTING CYLINDER
GEARED MOTOR
PINION
NUT
BALL BEARING
GEAR
SCREW
FLEXI HOSE
NON-RETURN VLAVE (INLET)
BEARING HOUSING
DP/DT DIRECTION CONTROL SWITCH
INTERCHANGEABLE SPRAY NOZZLE
SPEED CONTROLLER
LUBRICANT TANK
PUSH BUTTON
FRAME
MINIMUM QUANTITY LUBRICANT DISPENSING SYSTEM


Standard cylinders DNC, ISO 15552
Technical data
FESTO
Lateral force Fq as a function of stroke length l
Basic version
Fq [N]
l [mm]
Fq
Ø 32
Ø 40
Ø 50/63
Ø 80/100
Ø 125

Weight [g]							
Piston ∅	32	40	50	63	80	100	125
Basic version							
Product weight with 0 mm stroke	517	800	1,260	1,709	2,790	4,653	6,771
Additional weight per 10 mm stroke	30	45	64	73	106	115	168
Moving load with 0 mm stroke	162	307	538	663	1,131	1,544	2,809
Additional load per 10 mm stroke	9	16	25	25	38	38	63
Q – Square piston rod							
Product weight with 0 mm stroke	504	738	1,187	1,632	2,652	4,508	–
Additional weight per 10 mm stroke	29	41	60	68	99	108	–
Moving load with 0 mm stroke	149	244	465	587	994	1,399	–
Additional load per 10 mm stroke	8	11	20	20	31	31	–
S2 – Through piston rod							
Product weight with 0 mm stroke	576	895	1,390	1,917	3,114	5,297	7,529
Additional weight per 10 mm stroke	39	61	89	98	144	153	231
Moving load with 0 mm stroke	170	330	560	711	1,200	1,660	2,925
Additional load per 10 mm stroke	18	32	50	50	76	76	126
K10 – Smooth anodised piston rod							
Product weight with 0 mm stroke	443	655	1,001	1,437	2,302	4,138	5,719
Additional weight per 10 mm stroke	24	35	47	57	81	90	127
Moving load with 0 mm stroke	88	162	279	391	643	1,029	1,757
Additional load per 10 mm stroke	3	6	8	9	13	13	22
S2-K10 – Through, smooth anodised piston rod							
Product weight with 0 mm stroke	514	766	1,181	1,676	2,701	4,821	6,674
Additional weight per 10 mm stroke	27	40	56	65	94	103	148
Moving load with 0 mm stroke	108	201	351	470	787	1,184	2,070
Additional load per 10 mm stroke	6	11	17	17	26	26	43
TT – Low temperature							
Product weight with 0 mm stroke	520	876	1,279	2,112	2,972	5,039	–
Additional weight per 10 mm stroke	31	46	65	73	108	116	–
Moving load with 0 mm stroke	108	204	363	460	802	1,045	–
Additional load per 10 mm stroke	9	16	25	25	39	39	–
TT-S2 – Low temperature with through piston rod							
Product weight with 0 mm stroke	606	1,020	1,546	2,401	3,453	5,617	–
Additional weight per 10 mm stroke	40	62	89	98	147	154	–
Moving load with 0 mm stroke	169	326	573	687	1,199	1,473	–
Additional load per 10 mm stroke	18	32	49	49	77	77	–

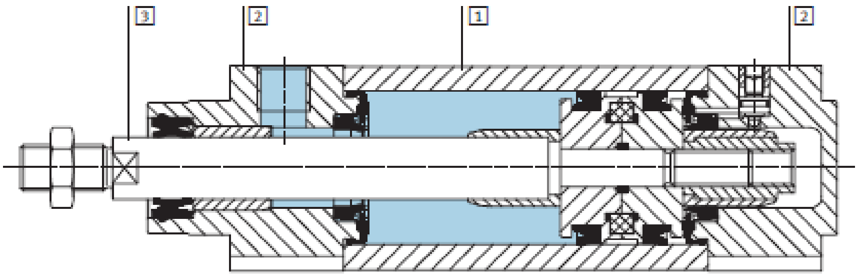
Standard cylinders DNC, ISO 15552

FESTO

Technical data

Materials

Sectional view



Standard cylinder		Basic version	CT	K10	R3
1	Profile barrel	Wrought aluminium alloy, smooth anodised	Wrought aluminium alloy, anodised	Wrought aluminium alloy, smooth anodised	
2	Bearing and end caps	Die-cast aluminium			
3	Piston rod	High-alloy steel		Wrought aluminium alloy, anodised	High-alloy stainless steel
–	Seals	Polyurethane, nitrile rubber			

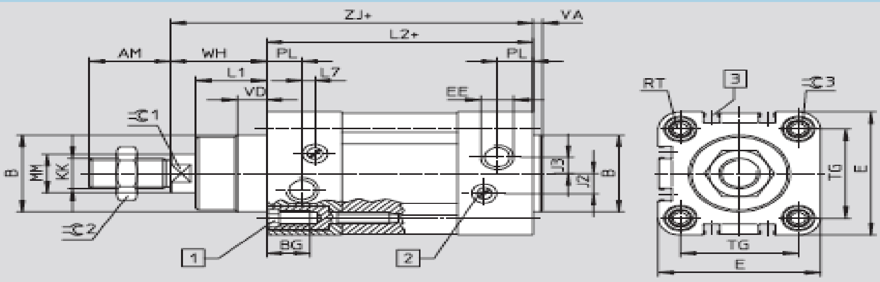
Standard cylinder		R8	S6	S10	S11	TT
1	Profile barrel	Wrought aluminium alloy, smooth anodised				
2	Bearing and end caps	Die-cast aluminium				Coated aluminium
3	Piston rod	Tempered steel, hard-chromium plated	High-alloy steel			
–	Seals	Polyurethane, nitrile rubber	Fluoro rubber			Polyurethane

Standard cylinders DNC, ISO 15552

FESTO

Technical data

Dimensions – Basic version Download CAD data → www.festo.com



1 Socket head screw with female thread for mounting attachments

2 Regulating screw for adjustable end-position cushioning

3 Slot for proximity sensor SME/SMT-8

+ = plus stroke length

Ø [mm]	AM	B Ø d11	BG	E	EE	J2	J2 TT	J3	KK	L1	L2
32	22	30	16	45	G⅛	6		5.2	M10x1.25	18	94
40	24	35	16	54	G¼	8		6	M12x1.25	21.5	105
50	32	40	17	64	G¼	10.4	11	8.5	M16x1.5	28	106
63	32	45	17	75	G⅜	12.4		10	M16x1.5	28.5	121
80	40	45	17	93	G⅜	12.5		8	M20x1.5	34.7	128
100	40	55	17	110	G½	12		10	M20x1.5	38.2	138
125	54	60	22	134	G½	13		8	M27x2	46	160

Ø [mm]	L7	MM Ø	PL	RT	TG	VA	VD	WH	ZJ	=C1	=C2	=C3
32	3.3	12	15.6	M6	32.5	4	10	26	120	10	16	6
40	3.6	16	14	M6	38	4	10.5	30	135	13	18	6
50	5.1	20	14	M8	46.5	4	11.5	37	143	17	24	8
63	6.6	20	17	M8	56.5	4	15	37	158	17	24	8
80	10.5	25	16.4	M10	72	4	15.7	46	174	22	30	6
100	8	25	18.8	M10	89	4	19.2	51	189	22	30	6
125	14	32	18	M12	110	6	20.5	65	225	27	36	8

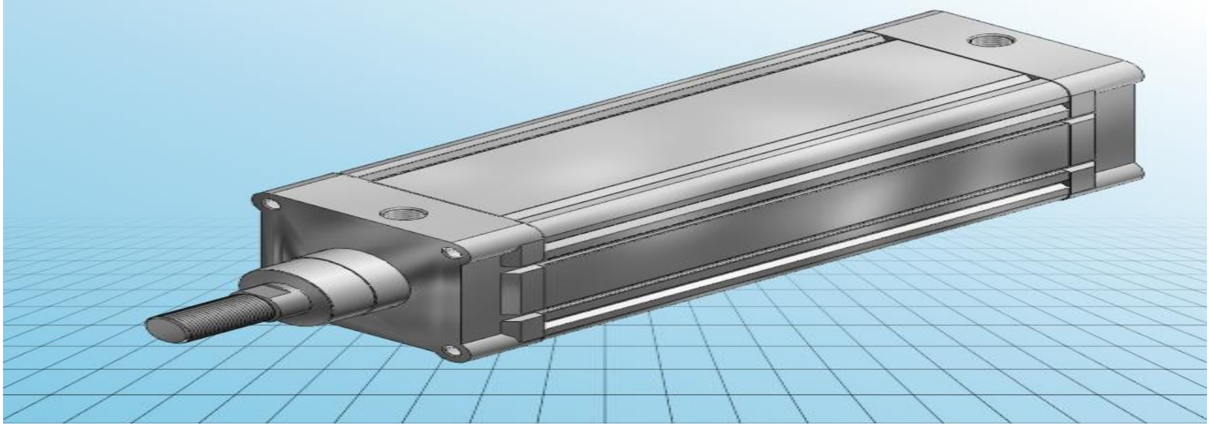
Note: This product conforms with the ISO 1179-1 standard and the ISO 228-1 standard.

Cylinder Selected

DNC – 50 – 40-PPV-A

Criterion	Feature
Stroke	80 mm
Piston diameter	32 mm
Piston rod thread	M10 x 1.25
Cushioning	PPV: Pneumatic cushioning adjustable at both ends
Assembly position	Any
Conforms to standard	ISO 15552 (previously also VDMA 24652, ISO 6431, NF E49 003.1, UNI 10290)
Piston-rod end	Male thread
Design structure	Piston
	Piston rod
Position detection	For proximity sensor
Variants	Single-ended piston rod
Operating pressure	0.6 - 10 bar
Mode of operation	double-acting
Operating medium	Dried compressed air, lubricated or unlubricated
Corrosion resistance classification CRC	2
Ambient temperature	-20 - 80 °C
Authorisation	Germanischer Lloyd
Impact energy in end positions	5 J
Cushioning length	22 mm
Theoretical force at 6 bar, return stroke	754N
Theoretical force at 6 bar, advance stroke	620 N
Moving mass with 0 mm stroke	800 g
Additional weight per 10 mm stroke	168 g
Basic weight for 0 mm stroke	677 g
Additional mass factor per 10 mm of stroke	63 g
Mounting type	with internal (female) thread
	with accessories
Pneumatic connection	G1/2
Materials information for cover	Aluminium die cast
	Anodised
Materials information for seals	NBR
	TPE-U(PU)
Materials information, housing	Wrought Aluminium alloy
	Smooth anodised
Materials information for piston rod	High alloy steel
Materials information for cylinder barrel	Wrought Aluminium alloy
	Smooth anodised

PART NAME: MAIN NUT				**MATERIAL SPECIFICATION: gun metal** **RAWMATERIAL SIZE: ∅50X40** **QUANTITY: - 01 NO'S.**				
Sr. No	Description of Operation		Tools			Time in minutes		
		Jigs & Fixture	M/c Tools	Cutting Tools	Measuring Instrument	Setting Time	M/c Time	Total Time
1.	Clamp stock	Three jaw chuck	Lathe	-	-	15	-	15
2.	Facing B/S to total length 24 mm & center drilling	Three jaw chuck	Lathe	Facing tool & center drill	Vernier	5	12	17
4.	Turning OD Ø 40mm through out length	Three jaw chuck	Lathe	Turning tool	Vernier	-	13	13
5.	Step turning Ø 34 to 6mm length,	Center support & carrier	Lathe	Turning tool	Vernier	-	9	9
6.	Step turning Ø 30 to 13mm length,	Center support & carrier	Lathe	Turning tool	Vernier	-	9	9
5.	Boring Ø 18 to 24mm length	Three jaw chuck	Lathe	Boring tool	Vernier	-	7	7
6.	Threading M24, 6 mm pitch	Three jaw chuck	Lathe	Threading tool	Vernier	40	35	75



3- D MODEL OF PNEUMATIC CYLINDER DNC 80 – 200 – PPV – A

PART NO :
PART NAME : NUT BEARING HOUSING

MATERIAL SPECIFICATION: EN 9
RAWMATERIAL SIZE: Ø70X30
QUANTITY: - 01 NO'S.

Sr. No	Description of Operation		Tools			Time in minutes		
		Jigs & Fixture	M/c Tools	Cutting Tools	Measuring Instrument	Setting Time	M/c Time	Total Time
1.	Clamp stock	Three jaw chuck	Lathe	-	-	15	-	15
2.	Facing B/S to total length 18 mm & center drilling	Three jaw chuck	Lathe	Facing tool & center drill	Vernier	5	12	17
4.	Turning OD Ø 62mm through out length	Three jaw chuck	Lathe	Turning tool	Vernier	-	13	13
5.	Boring Ø 48to 18mm length	Three jaw chuck	Lathe	Boring tool	Vernier	-	7	7
6.	Boring Ø 55to 13mm length	Three jaw chuck	Lathe	Boring tool	Vernier	-	7	7

8. SCHEMATIC OF MQL SYSTEM

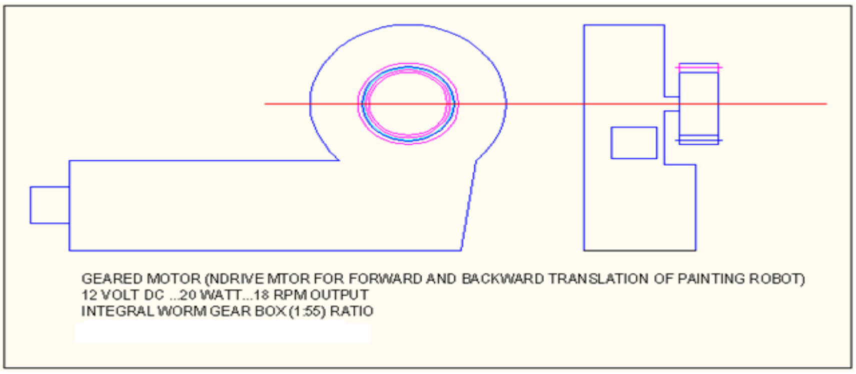
The MQL system comprises of following parts

1. Lubricant tank & frame: These are fabricated structural components of the MQL with primary functions of tank to hold the MQL lubricant and the frame to support the entire assembly of the MQL system.
2. Dispenser actuator: The dispenser actuator is a double acting hydraulic cylinder with 32mm bore and 100 mm stroke, thus the dispenser volume is 80 cc, ie in one stroke of the dispenser it is possible to dispense 80 ml of MQL lubricant. The rate of displacement of the dispenser piston is thus important to determine the minimum quantity of oil dispensed per min.
3. Dispenser Actuator driving mechanism: The forward stroke of the displacer piston is used for the dispensing activity where as the return stoke charges the dispenser. The to and fro motion of the piston is achieved using a power screw and nut arrangement. The power screw is held in a nut supported in ball bearing in a bearing housing. The nut carries an spur gear driven by an spur pinion mounted on the geared motor. The geared motor under consideration is specified below Motor is an 12 volt DC motor , with following specification:

   Voltage: 12 Volt DC

   Power = 20 watt

   Mounting: Face mounted



Motor rotates in clockwise and counter clockwise directions to effect the forward and reverse motion of the screw and thereby the piston. Motor speed is regulated by speed regulator where as the direction control is done using a direction control 2 pole -2 way switch

4. Inlet circuit to dispenser: The inlet circuit to the dispenser uses a non return valve opening into the cylinder side and closing on the tank side. This allows lubricant flow from the lubricant tank to the cylinder during suction stroke where as prevents reverse flow from the cylinder to tank during dispensing stroke.
5. Dispensing Circuit: Dispensing circuit connects the outlet of cylinder to the mixing chamber. The circuit comprises the an non return valve opening into the mixing chamber side and closing on the cylinder side. This allows lubricant flow from the cylinder to mixing chamber during dispensing stroke where as prevents reverse air flow from the mixing chamber to cylinder during suction stroke. Circuit also has flow control valve for fine adjustments of flow rate of lubricant to mixing chamber, and pressure gage indicates the pressure in the delivery line.
6. Mixing chamber : Mixing chamber is the device that mixes the MQL lubricant and the compressed air to create lubricant mist to be directed onto the cutting action area to serve a three fold purpose ;
    6.1. Lubricate the tool tip and job contact area during cutting to minimize the friction between them, thereby reducing the heat produce. Misty nature of the lubricant ensure effective application of lubricant and better heat extraction.
    6.2. The second advantage of using compressed air mist that, it helps chip evacuation from the cutting area which is one of the major reasons of development of ‘built-up-edges ‘on tool tip leading to reduced tool life and improper surface finish on job.
    6.3. The compressed air offer other advantage that , fumes that are likely to be developed due to burning of the lubricant are not developed due to the high velocity of the lubricant particles (they do not reach flash point).
7. Flex hose with interchangeable nozzle: The flex hose connects the mixing chamber and the nozzle, two set of spray nozzle with tip diameters1.5 and 2.0 mm are provided for spraying.

9. WORKING

9.1. Dispenser Charging Cycle

Motor is rotated in clockwise direction that rotates the nut in counter clockwise direction due to spur gearing , nut rotate and screw is constrained to translate hence it moves back thereby moving the piston in backward direction thereby effecting the suction stroke. The inlet circuit to the dispenser uses a non return valve opening into the cylinder side and closing on the tank side. This allows lubricant flow from the lubricant tank to the cylinder during suction stroke where as prevents reverse flow from the cylinder to tank during dispensing stroke.

9.2. Timer Based Dispenser Delivery Cycle

Timer based cycle will start at the programmed interval thereby discharging predetermined quantity of lubricant into the mixing chamber. The timer controls the motion of the motor used in the dispensing cycle Motor is rotated in counter-clockwise direction that rotates the nut in clockwise direction due to spur gearing , nut rotates and screw is constrained to translate hence it moves forward thereby moving the piston in forward direction thereby effecting the delivery stroke. Dispensing circuit connects the outlet of cylinder to the mixing chamber. The circuit comprises the an non return valve opening into the mixing chamber side and closing on the cylinder side. This allows lubricant flow from the cylinder to mixing chamber during dispensing stroke where as prevents reverse air flow from the mixing chamber to cylinder during suction stroke. Circuit also has flow control valve for fine adjustments of flow rate of lubricant to mixing chamber, and pressure gage indicates the pressure in the delivery line.

MOTOR-The drive motor is 12 VDC motor coupled to an planetary gear box.

Specifications of motor are as follows:

A) Power 15 watt

B) Speed = 30 rpm

c) Gear box: Planetary /epicyclic type (reduction ratio: 1:5)

d) Mounting dimensions (Face mounted M12 x 1.5) pitch

10. RESULT & DISCUSSION

In convectional lubrication system having further drawbacks during turning like

1. chip formation.
2. heat generation.
3. tool wear.
4. surface finish and surface integrity. Hence to overcomes above disadvantages MQL system is preferred, the reason behind it the advantages o MQL over convectional method.

10.1. Advantages

1. Lubricant wastage is minimized
2. Lubricant optimum utilization is possible
3. Chip-disposal is easy
4. Tool life is increased
5. Better surface finish is achieved.
6. Clean machine and machine environment.

10.2. Disadvantages

1. Intial infrastructure cost is high.
2. Maintenance cost is added.
3. Operator skill and intervention necessary.

11. FUTURE SCOPE

1. Time can be introduced for measured performance.
2. Microprocessor introduction can make computer control possible.

12. CONCLUSION

As per the analysis & result, the conclusion o this paper is MQL technique offer better surface finish and dimensional accuracies than convectional lubrication in terms while machining the components. Also improve in tool life & reduction in tool wear & heat generation.

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