International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Design and Modification of Oil Supply Unit in the Automotive Industry

Shantanu Pawar*

[a]*UG Student, Savitribai Phule Pune University, Pune,Maharashtra, India.*

ABSTRACT

Modification is a treatment approach, based on principles of operant conditioning that replaces undesirable behaviours with more desirable ones through reinforcement. Modifications can be Quality modification, Functional modification or Style modification. Modification is necessary in every organization for improving the effectiveness of the available resources. We are working on functional modification. In BOSCH Ltd. Nashik we are working on two machines i.e. Gun-drilling machine and Vertical Machining Centre. Vertical Machining Centre requires the Oil Supply for heat dissipation from spindle, tool, workpiece and also for bed cleaning. For this, there are two different oil supply units on machine. For cooling of the tool, workpiece and bed cleaning Central Filtration System (CFS) is used while for the Spindle Cooling separate oil supply unit is used with heat exchanger and water chiller lines. Moreover, for Gun drilling operation Kennametal line is present which needs the continuous oil supply for the functions like spindle cooling, bed flushing, through cooling etc. This system all the mentioned functions are satisfied with the help of individual oil supply unit. In this project for AMS line we are going to replace these two different oil supply systems with one Central Filtration System (CFS) and for Kennametal line we are going to connect all the individual oil supply circuits to the CFS unit to improve the effectiveness of oil supply system, cost saving, energy saving etc. So for this purpose we are designing a New Oil Supply System and then after designing we will implement the system on both the machines.

Key Words- CFS, Oil supply unit, VMC, Gun drilling, Heat exchanger, Spindle cooling, Bed cleaning, workpiece cleaning, Kennametal, AMS

1. INTRODUCTION

Company information

About Bosch India

Bosch is a German multinational engineering and electronics company headquartered in Gerlingen, near Stuttgart, Germany. It is the world's largest supplier of automotive components measured by 2011 revenues. The company was founded by Robert Boschin Stuttgart in 1886. Bosch is 92% owned by Robert Bosch Foundation.

Bosch's core products are automotive components (including brakes, controls, electrical drives, electronics, fuel systems, generators, starter motors and steering systems), industrial products (including drives and controls, packaging technology and consumer goods) and building products (including household appliances, power tools, security systems and thermo technology).

Bosch in India

Bosch entered India in 1922, when Illies & Company set up a sales office in Calcutta. For three decades, the company operated in the Indian market only through imports.In 1951, Bosch set up its first manufacturing plant in India. Currently, Bosch India has a turnover of over $2 billion and over 26000 employees spread across 10 locations and 7 application development canteRs.84% of BoschIndia revenues come from its automotive business, with the remaining 16% split between its non-automotive businesses that include packaging, energy and building solutions,

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

power tools and consumer retail. Bosch also has an R&D facility in Coimbatore and Bangalore, India. This is Bosch's largest R&D facility outside its home market of Germany. In September 2014, Bosch announced the launch of a locally developed eye-care solution in India. The company‟s new eye screening and detection system offers a combination of hardware and software and provides affordable eye care. Bosch India is listed on the Indian stock exchanges and has a market capitalization of over $12 billion.

BOSCH Nashik Plant, NAP

Nashik Plant is one of the important establishments of Bosch in India since last 40 years. With the constant efforts for excellence in Quality and delivery commitments, the plant received good acceptance by customers in Europe, USA and South East Asia. At present the export business is about 25% of the plant output. The plant is committed to continue its efforts for total customer satisfaction in areas of Quality, Cost and Delivery. Bosch Limited in Nashik is manufacturing nozzles and injectors asshown in fig (1) for classical as well as Euro series. The plant is spread on 400,000 sq.m, having 4 manufacturing hangars. In addition to TS 16949, plant is also certified forISO 14000, the internationally acknowledged certificate for Environment protection. Plant is well equipped with latest in manufacturing, cleanliness and proving of product performance.

Address –Nashik Plant, Bosch Limited 75, MIDC, Satpur, Nashik-422007, India.

Problem Statement

The History of Kennametal ϕ 2.2mm shows the major issues of concern are:

- High energy consumption
- Chips accumulation in machine
- Low coolant flow problem
- Coolant overflow
- High pressure not achieved
- Frequent clogging of coolant filter
- Highly crowded machine area

It is necessary to counter all the mentioned problems as they directly affect the qualityof the product, workers safety and cost of production.

So our aim of the project is to do necessary modifications in existing oil supply unit inorder to minimize or eliminate the issues.

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

- **Chips Accumulation In Machine**:

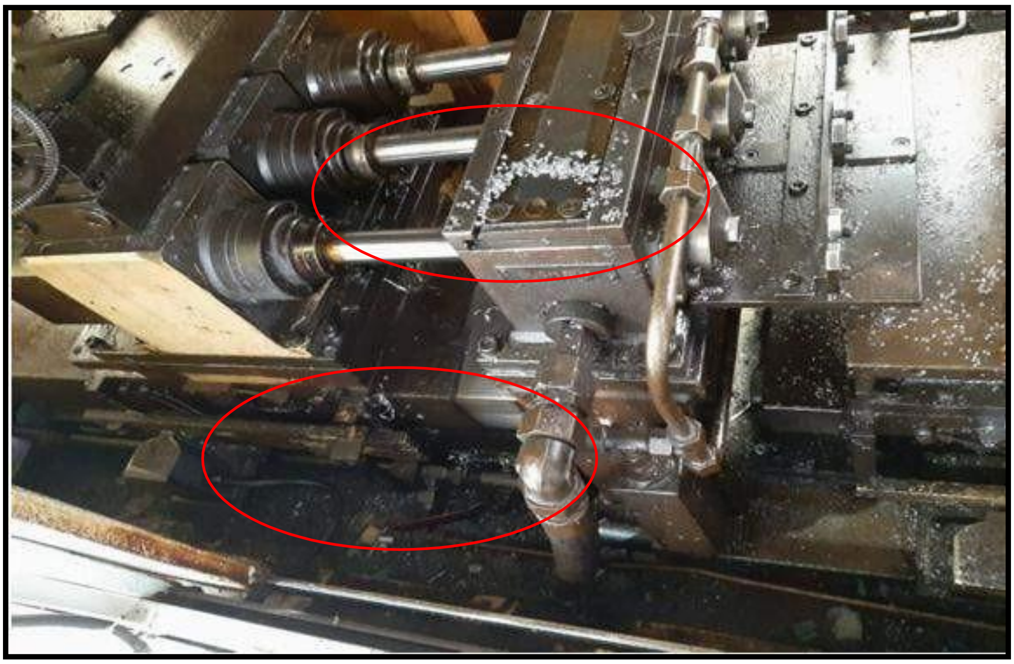


Fig. 1.2.1 Chips Accumulation in Machine

- **Overflow Due To Chips Clogging:**

Fig. 1.2.2 Overflow Due To Chips Clogging

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Objective

The objectives of this project are as follows:

- To avoid frequent interruption of cooling circuit.
- To remove the unnecessary energy consuming equipments.
- To introduce integrated oil supply system for all machine.
- To eliminate the individual chillers line.

Scope

The scope of our project is:

- Utilise the CFS effectively
- Save the energy
- Improve safety
- Spares and maintenance cost saving
- Improve overall performance of system
- Increase OEE

Methodology

1. Problem Identification.
2. Observation and Understanding of current setup.
3. Study of oil supply system and CFS Unit.
4. Design of Integrated modified oil supply unit.
5. List out the required components and send for quotation.
6. Proposal of modified unit to industry.
7. Response from Industry.
8. Implementation or Further modification of unit.
9. Monitoring of the Machine.

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

2. achine Information And Need Of Oil Supply System

WIDMA-Kennametal ϕ 2.2 mm

This machine used in soft stage line during the manufacturing of Injector body. It is the four spindle drilling machine use to produce the hole of ϕ 2.2mm diameter in the injector body accurately and precisely. Drilling of 4 injector is takes place at the same time in it.

Operation Performed

- Gun-drilling of ϕ 2.2mm diameter.

AMS Machine (VMC)

This is Vertical Machining Center, which ensures consistent high working accuracy and high degree of machine utilization. This is general purpose compact flexile, productive, robust and high precision machine equipped for working to cater different kind of prismatic/circular components with flood type coolant system. This is the 4- axis machine.

Operations Performed

AMS-A

- Butterfly operation
- Dowel hole operation
- Spot face operation
- Central drill operation
- Chamfer operation
- Milling operation
- Drilling operation
- Form tool operation
- Tapping operationAMS-B

- Taper Flat operation
- Small and big hole

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Oil Supply Systems

- Spindle cooling jacket.
- Tool cooling during and after operation (through cooling).
- Work piece cooling during operation.
- Bed flushing and cleaning after machining.
- Work piece cleaning after machining.

Spindle Cooling Jacket

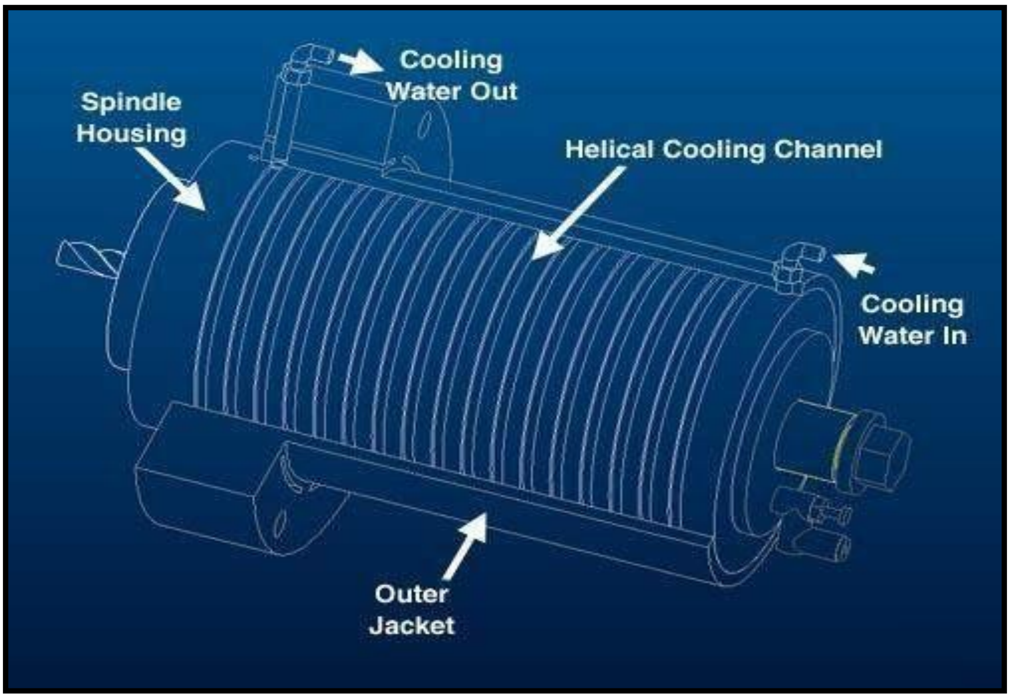


Fig.3.3.1 Spindle cooling Jacket

Oil takes heat from the spindle by flowing through the spindle jacket and makes the spindle cool. This heated oil then passes through the chillers and heat is given to the cool liquid (water, glycol etc.). Heat exchange takes place between heated oil and cool liquid. Both the oil and cool liquid are passing through the heat exchanger in parallel flow or counter flow manner. Then cooloil again passes through the spindle jacket to make it cool and the process repeats.

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Through Spindle Cooling

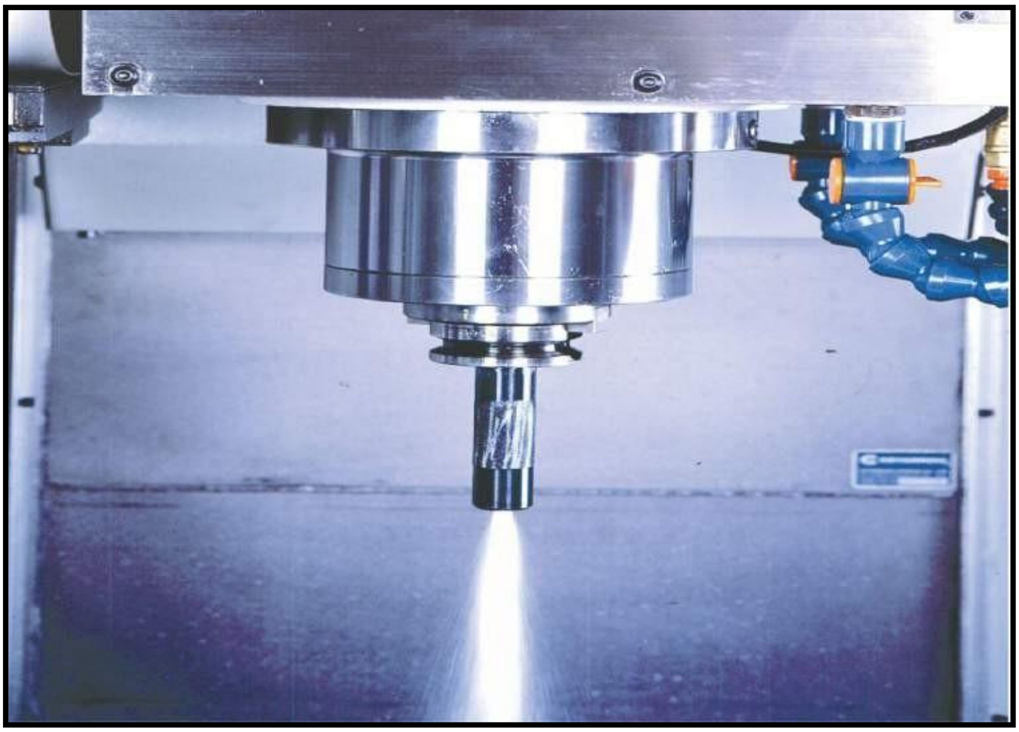


Fig.3.3.2 Through Spindle Cooling

Some places are just not accessible for the cleaning. Consider the bottom of a deep hole you are trying to drill. You can"t aim the nozzle there because it is below the surface of the material and there is no access. In that case this is suitable method. This is also suitable to remove the heat from tool itself. Through Spindle Coolant (abbreviated TSC) gains access by feeding coolant through your spindle like the name says, and from there is an exit via passagesinside the tool. You really can have a nozzle built into the bottom of your drill bit. With Through Spindle Coolant, performance can be greatly increased.

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

High Pressure Cooling

Fig.3.3.3 High Pressure cooling

If through spindle cooling is not suitable for our application then we can use the high pressure cooling. With Through Spindle Coolant you have made sure the coolant is being delivered to exactly the right location. This improves chip evacuation. High Pressure Coolant can provide an alternative. By using very high pressures, 1000 psi or more, as well as high volumes, its intent is to deliver so much coolant that nearly all of the heat will be carried away beforeit can ever build up. Practically speaking, what this means is higher surface speeds, more rpm at the spindle, higher material removal rates, and longer toollife. Performance with a High Pressure Coolant system can be amazing.

ed Flushing

In this method the chips and burr which is situated on the bed during operation is removed by using the oil supply system. There are number of nozzles are provide at the both side of the bed. Once the operation is completed on workpiece the flowof oil through nozzle is start the oil comes out from nozzle and flow over the bed and this oil carries chips and burr with it to the dirty tank. Bed flushing takes placeafter each cycle i.e. when the all operations on one workpiece are completed.

Methods of Spindle Cooling and Type Of Heat Exchanger3.4.1.Methods of Spindle

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Cooling

1. Liquid Chillers.
2. Air vortex generators.

- **Liquid Chillers:**

Industrial chillers are the best method of removing excess heat from the spindle tool. Its working is nearly same as that of the car radiator. Oil takes heat from the spindle by flowing through the spindle jacket and makes the spindle cool. This heated oil then passes through the chillers and heat is given to the cool liquid (water, glycol etc.). Heat exchange takes place between heated oil and cool liquid. Both the oil and cool liquid are passing through the heat exchanger in parallelflow or counter flow manner. Then cool oil again passes through the spindle jacket to make it cool and the process repeats. These units are ideal for motorized spindles with high horsepower ratings.

The initial capital investment can be somewhat higher for liquid chiller systems but lower operating cost. For multiple spindles in one location, a single chiller unit can supply the cooling needs for several spindles simultaneously.

- **Air vortex generators:**

There is one another option for spindle cooling involves the use of compressed air as the cooling medium. In this method the surrounding air is passes through the specific vortex tube and blown all over the spindle. This method is only suitable for motorized spindle with capacity 3 HP and less.

Overall cost of this system is less. It provides the clean shop floor. While thismethod does not provide the advanced thermal protection of liquid systems

Heat Exchangers

Different types of heat exchangers are as follows:

1. Air cooled
2. Water cooled
3. Parallel flow type
4. Counter-flow type
5. Cross flow type
6. Natural convection type
7. Forced convection type

WWW.IJRPR.COM

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

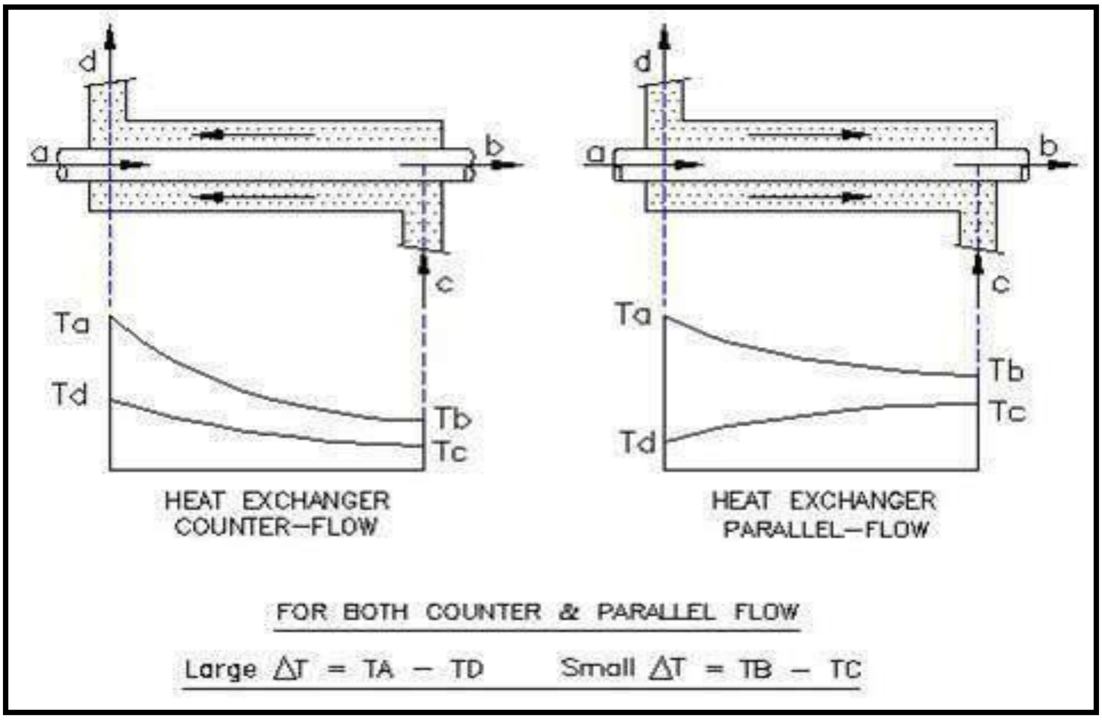


Fig.3.4.2 Working principle of Heat Exchanger **[15]**

- Air cooled: Air is used as cooling medium and heat transfer takes place fromhot oil to air
- Water cooled: Water is used as cooling medium and heat transfer takes placefrom oil to water

- Parallel flow type: In this type of Heat exchanger direction of flow of hot fluidand cooling fluid is same
- Counter flow type: In this type of Heat exchanger direction of flow of hot fluidand cooling fluid is opposite
- Cross flow type: In this type of Heat exchanger direction of flow of hot fluidand cooling fluid is perpendicular to each other.
- Natural convection type: In this type of heat exchanger flow of coolingmedium is due to density difference only.
- Forced convection type: In this type of heat exchanger flow of coolingmedium is due to External energy.

4. Introduction to C.F.S.

What Is C.F.S.?

A Centralized Filtration System is basically a Common Filtration System for a groupof machines. Hence centralized filtrations can fulfill the requirement of filtered oil forsmall group of machines or the complete shop. It is generally a combination ofvarious Coolant Filtration System Products and Accessories such as PHE filter housings etc. A Centralized Filtration System is the most effective and efficientideology in Coolant Filtration System and Cutting Oil Filtration System. ACentralized Filtration System has large benefits over an Individual Filtration System. **4.2.Parameters of C.F.S.**

- **Capacity of Filtration system**: 4000 LPM for OIL
- **Coolant capacity**

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

1) Scraper Conveyor Tank: 20750 Liters.

2) Semi-Clean Tank: 33500 Liters.

3) Clean Tank: 11000 Liters.

- **Oil collection bin: Use** for oil transfer from dirt bin to dirty tank in automode.
- **Semi clean pump**

  Pump: 3 working +one stand by Flow: 1350 Lpm at 55 meter head.
- **Clean pump**

  Pump: 3 Working +One stand by Flow: 1350 LPM at 55 Meter Head.

Components of C.F.S.

1. Diffuser- The main function of diffuser is to bring oil at high pressure toatmospheric pressure.
2. Dirty Tank - To collect dirty oil.
3. Magnetic Conveyor belt - To remove Chips and dirt particles from oil
4. Semi-Clean Tank- To collect the semi clean oil after removing chips.
5. Semi-Clean Pumps - To pump oil from Semi-Clean tanks to filter housing.
6. Filter- Filter housing consist number of paper filter elements to clean the oilcompletely.
7. Heat Exchanger-To cool the filter oil at required temperature.
8. Clean Tank -To collect clean oil.
9. Clean Pump -To pump oil from clean tank to the oil supply line whichsupplies oil to machines.

Diffuser

Introduction & Functioning:-

- A diffuser is a conical portion of chute placed just above the tank. The coolant& chips enter in the tangentially.
- Its purpose is to kill velocity of incoming coolant so that the coolant in thetank is not disturbed.
- A wide grill is provided at its bottom so that very large pieces do not drop inthe tank.

Scraper Conveyor System

Introduction & functioning:-

- The scraper conveyer is used to handle the chips / dirt from machine outlet. It is designed to handle 4000 LPM of cutting oil.
- The machine outlet is connected to the Diffuser of conveyer by rigid piping. The chips & oil drop in the chip conveyer.
- Small volume trough allows the chip to the bottom of the conveyer. The chips are handled by the conveyer, dripping the oil back to trough.
- The conveyor chain is provided with tensioning arrangement. This allows the conveyer to rotate in reverse direction. This facility is useful in case of jamming. Auto cut-off arrangement is provided.

WWW.IJRPR.COM

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

- In case of jamming, the drive rotates in three times reverse and forward if in between jamming problem solved then drive rotates its normal direction. If jamming problem is not solved then drive motor supply cutoff electrically and gives jam signal.
- A swing type wiper provided at the chip outlet to wipe off the sticking chips from the scraper blades.

Wall Mounted Drum Type Magnetic Separator

Introduction & functioning:-

- These types of magnetic separators are used to separate suspended magnetic dirt from overflowing coolant from a tank. These are usually mounted covering an opening on a tank wall usually a scraper conveyer.

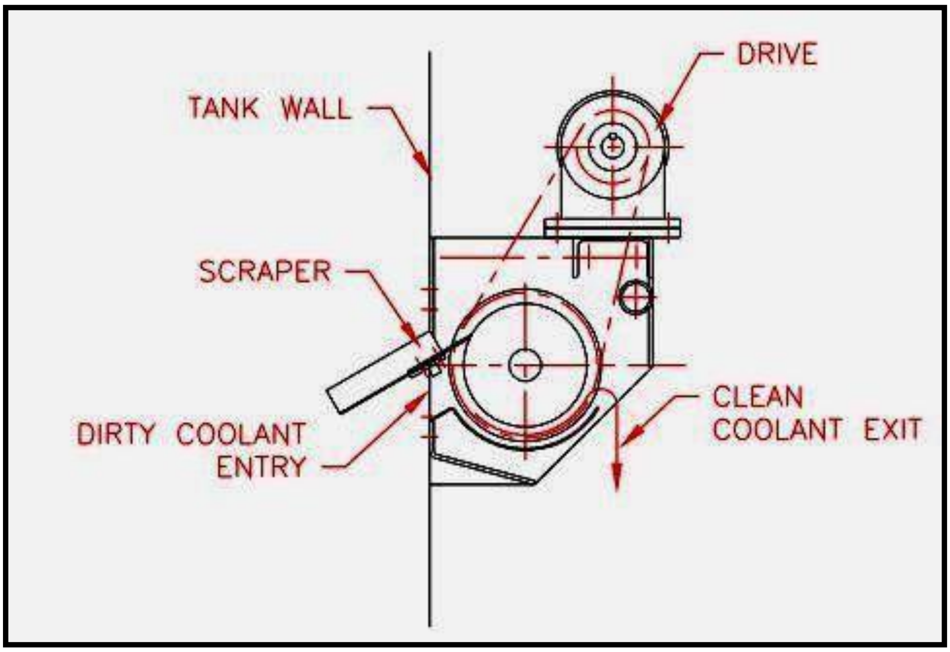


Fig.4.3.3 Wall Mounted Drum Type Magnetic Separator **[14]**

- Overflowing dirty coolant is exposed to high density magnetic field as it passes trough gap between magnetic drum & SS trough. Suspended magnetic particles are picked up by magnetic drum.
- As the magnetic drum rotates, the collected dirt is scraped off & is dumped back in the tank (usually a scraper conveyer tank).
- As this dirt is magnetically bound, it sediments to bottom and is handled bythe scraper conveyer along with the other chips. Clean coolant is collected in other tank & pumped further.

Filter Element Housing

Introduction & functioning:-

- The filter element housings are sized to suite flow requirement & Cleanliness of coolant after filtration. Usually, one hosing is kept isolated from coolant flow, to be used as standby.
- These housings are designed for 8 bar working pressure. Used "O" ring for sealing. Lid lifting arrangement, vent valve & drain are provided for Maintenance.

WWW.IJRPR.COM

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

- Differential pressure switch / Pressure Transducer are provided to monitor the pressure drop in the housings. (1.5 BAR)

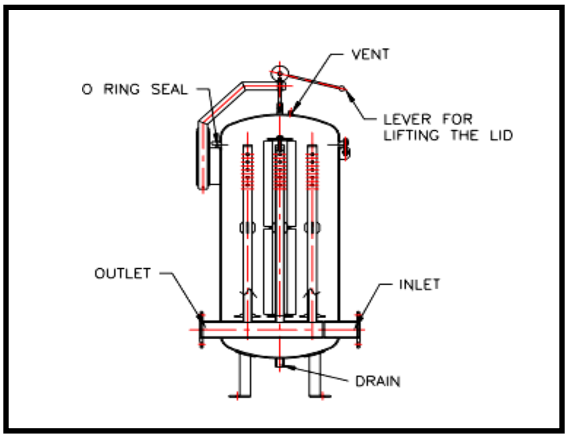


Fig.4.3.4 Filter Element Housing **[14]**

Plate Type Heat Exchanger

Introduction & functioning:-

- The Plate type heat exchanger used to maintain coolant oil temperature and tosuite flow requirement.
- One Plate type heat exchanger is kept isolated from coolant oil flow, to beused as "standby".
- Chilling water supply 2200 Lpm @ 3 bar 12 ºC is connected to return piping.
- Coolant oil supply line is connected to clean coolant oil tank.

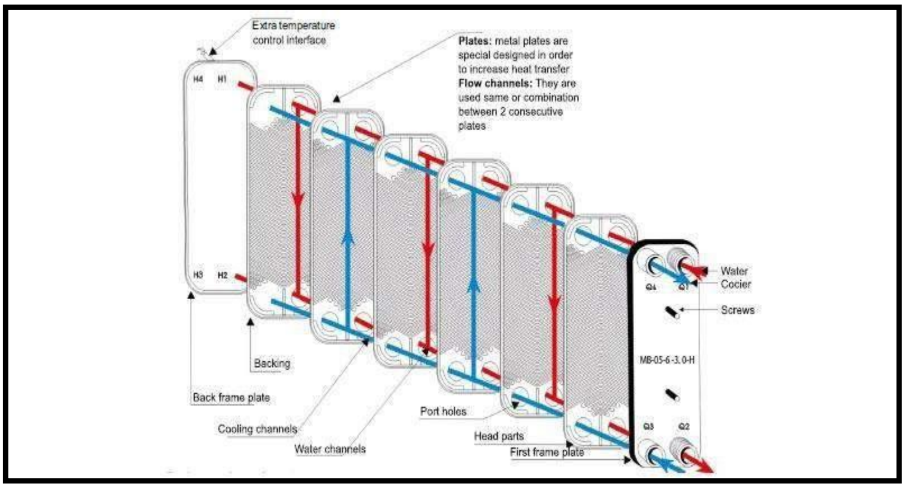


Fig.4.3.5 Plate Type Heat Exchanger **[14]**

The used heat exchangers are of water cooled type. Therefore, for such a big manufacturing plant we need huge amount of cooling water. To save the water bosch ltd. comes one step forward in innovation. They are utilizing the condensate collected from different air driers for the purpose of cooling. A separate Trough of 20,000Liters of capacity collects the condensate extracted from whole plant.

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Oil Used In C.F.S.Variocut-G650

Variocut G 650 is low viscosity; low misting and low vapour neat cutting oil based on the latest generation of EHVI hydro cracked base oils and newchlorine free additive technology.

Application Areas: -

- Variocut G 650 has been designed for gear grinding and shaping with CBN- and carborundum wheels. Furthermore it has demonstrated success in deep drilling operations of moderate and high alloyed steels, where low viscosity and high lubrication are critical.
- Variocut G 650 can be used in both individual machines and in centralizedsystems.
- In order to maximize product performance it is recommended that adequate filtration equipment is used.

Properties of Oils used:

Table 4.3.6 Properties of Variocut G650

Properties	**Variocut G650**
Viscosity, CST. At 40 ♂C	9.1
Density @15°C	827 kg/m^3
Flash Point, ♂C	170

Working Of C.F.S.

First the used oil from machine is return to the CFS through return line. Distributer distributes the oil from return line into two different dirty tanks. Diffuser is used to reduce the pressure according to requirement. Magnetic conveyer belt removes the chips and other metal debris from the oil that is collected in the dirty tank. Then oil transferred to the semi clean tank. Semi clean pump pumps the oil from semi clean tank to the filter. Filter has filter housing which consists number of filter elements which is used to remove the dust, dirt and other unwanted particles from the oil completely. Then oil is passing through the heat exchanger to reduce the temperature of oil according to the requirement. The cooled oil is collects in the clean tank. This oil from clean tank is transferred to the oil supply line by using the clean pumps. This oil passes through the supply line to the machines.

WWW.IJRPR.COM

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

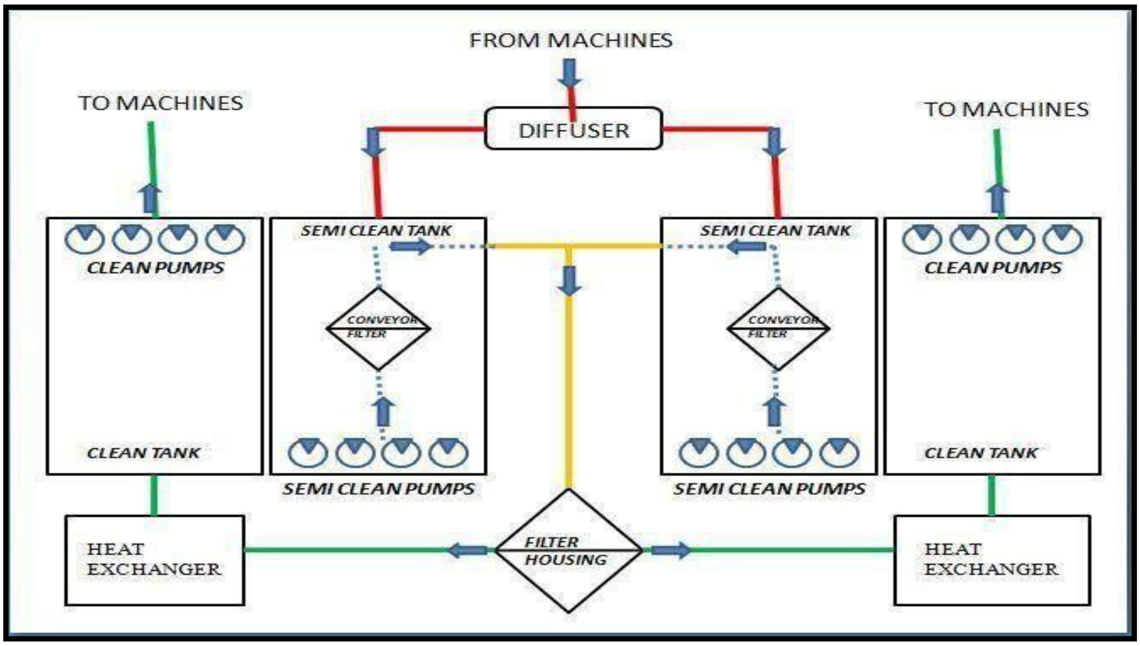


Fig. 4.4 Circuit diagram of CFS Unit

5. Kennametal ϕ 2.2 mm

Previous Oil Supply System:

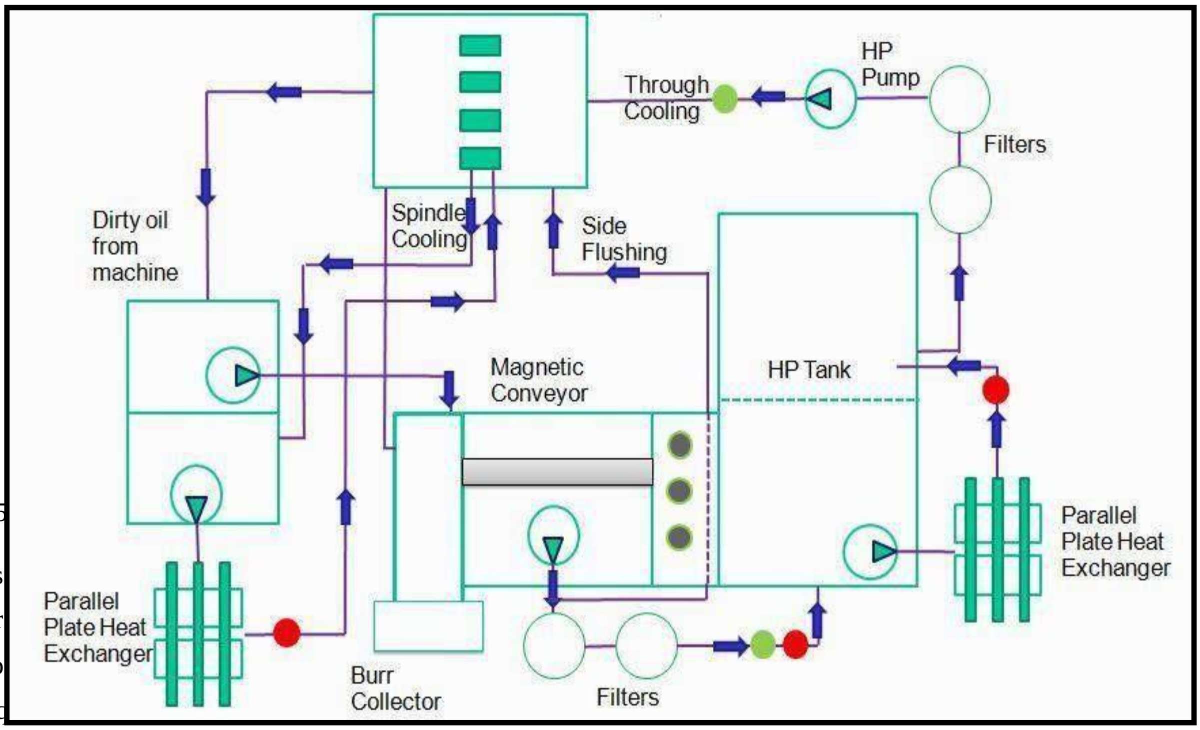


Fig.5

- As
  thr
- To
  rec
- Individual oil supply unit consist of heat exchanger, filters, various pumps, oil tanks, Chillier line etc for each machine.

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Construction and Working

1. **Spindle Cooling:**

- From the tank oil is supplied to the heat exchanger by the pump after coolingof the oil at required temperature.
- This cooling oil is supplied to the spindle where heat transfer occurs and thespindle is cooled.
- Cooling oil takes the heat from the spindle and makes it cool. After that the oilagain comes to the tank and by this way cycle repeats.

2. **Through Cooling System:**

- Through cooling is required to cool the tool as well as remove the burr from the workpiece during the drilling operation.
- For this purpose high pressure oil is required so from tank oil is enters into the high pressure pump where the pressure of the oil is increases.
- Before entering the high pressure pump oil is passed through the filter in orderto remove very fine amount of burr from oil at micron level.
- Because in case of through cooling oil is passed through very fine hole in tool.As oil passes through very fine hole of tool it is called as through cooling. Thisoil is comes to dirty tank from machine.

3. **Side Flushing/Bed Flushing Unit:**

- This is to clean the workpiece after operation as well as to clean the bed forthe purpose of removing chips and burr from machine.
- The dirty oil is collected in tank where firstly the chips and burr remove with the help of magnetic separator. After that oil passed through net type filter where large size of chips and burr removed.
- After that oil is collected in semi clean tank, further the pump is used to pass the oil through filter housing in order to remove fine amount of burr and chips from oil.
- After that oil enters into the clean tank, further the oil is pumped into the plate type heat exchanger to obtain the required temperature. So this low temperature high pressure oil is supplied to the machine.

WWW.IJRPR.COM

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

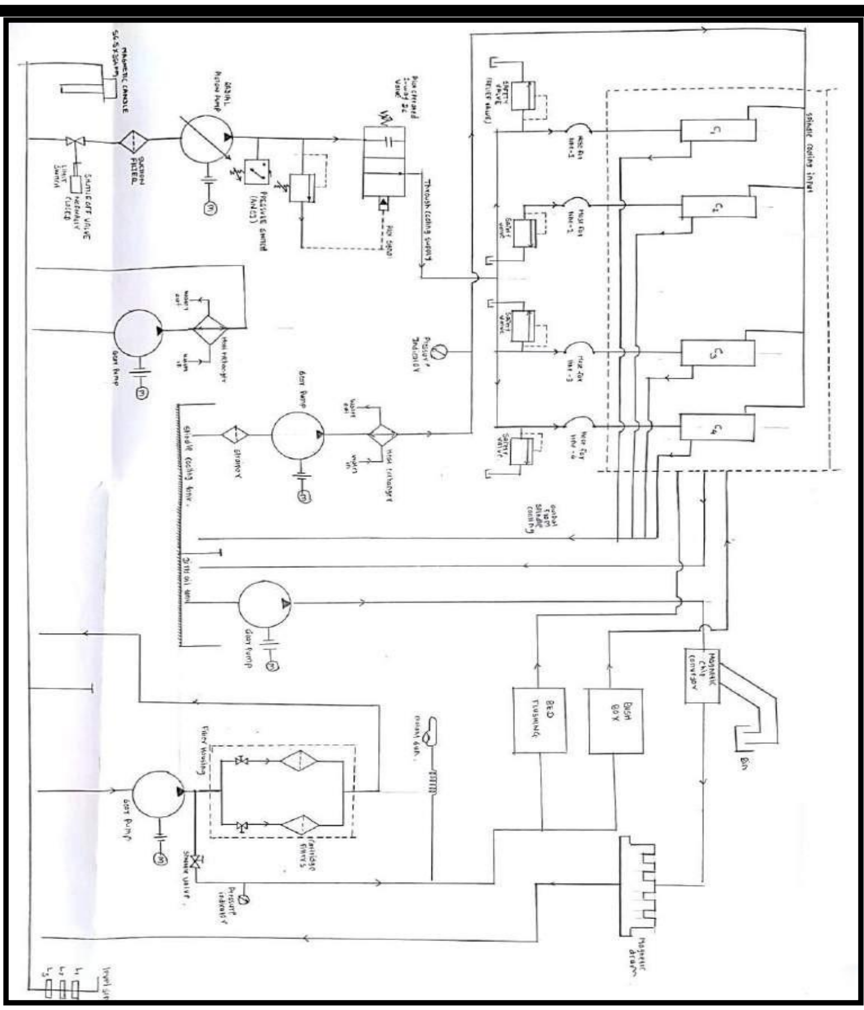
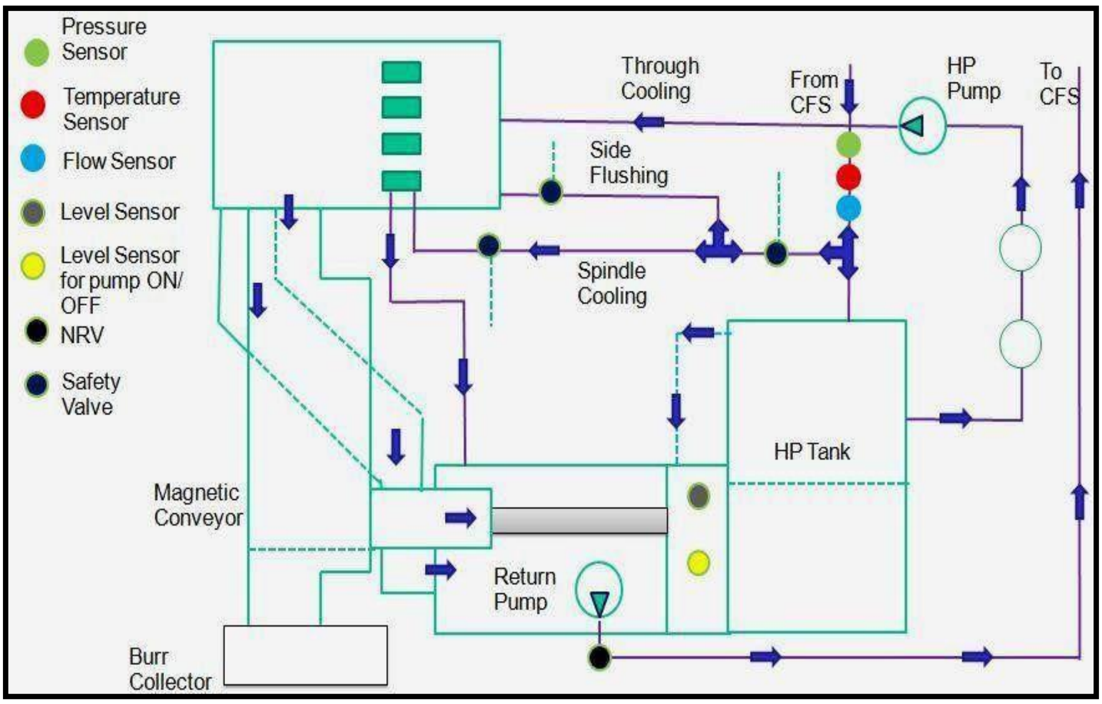


Fig.5.1.2 Detailed circuit diagram for previous oil supply unit setup for Kennametalmachine

Current Modified Oil Supply System



WWW.IJRPR.COM

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Fig.5.2.1 Layout of Modified oil supply unit setup for Kennametal machine

- In modified oil supply system instead of using individual oil supply unit foreach machine one Centralized Filtration System (CFS) is used.
- When CFS is connected to the machine a separate heat exchanger, chillerlines, some pumps, tanks, filter housing etc are eliminated.
- When large numbers of machines are there in industry then CFS is mostsuitable system than the individual one.

Construction and Working:

- At the outlet of the CFS 4-6 bar pressure and low temperature oil is obtained which suitable to direct use for spindle cooling and side flushing.
- After the spindle cooling and side flushing oil collected in dirty tank where is passed to semi clean tank after removing burr and chips with the help of magnetic separator.
- From CFS the high pressure low temperature oil is collected in the tank furtherthis oil is passed through fine filter to remove the burr and chips at micron level.

- This filtered oil is pressurized to high pressure with the help of high pressurepump and passed for the through cooling.
- This oil used for various purposes is collected in semi tank and send back tothe CFS with the help of return pump, by this way cycle repeats.
-

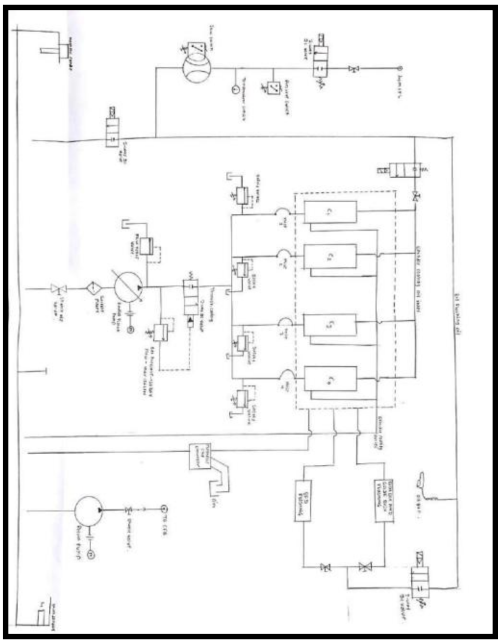


Fig.5.2.2 Detailed circuit diagram for Modified oil supply unit setup for Kennametalmachine

WWW.IJRPR.COM

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Calculation and Selection of ComponentsSelection of components used in circuit:-

Given,

P_{input}= 2.5 barP_{output} = 4 bar

Head = 4 m

Oil used= Variocut 650ρ = 827 kg/m^3

R_e = 2000

V = 2 m/s

A) Selection of oil pipelines:

1. Oil supply from CFS

$Q_{supplied}$ = 3600 LpmV = 2 m/s

Q = A×V

$(3600\times10^{-3})/60 = (\pi/4)\times d^2\times 2$

d = 0.195 = 0.2 m

2. Oil supply for Spindle Cooling

As per user manual of Kennametal ϕ2.2 mm machine, the oil flowrequired for spindle cooling is 38 Lpm,

$Q_{required}$ = 38 Lpm$(Q/A)_1 = (Q/A)_2$

$(3600\times4)/\pi\times0.2^2 = (38\times4)/\ \pi\times D_S^2$

D_S = 20.54 = 25.4 mm

3. Oil supply for Bed Flushing

As per user manual of Kennametal ϕ2.2 mm machine, the oil flow required for bed flushing is 38 Lpm. There are two points from main supply line for Bed Flushing.

$Q_{required}$ = 38 LpmV = 2 m/s $(Q/A)_1 = (Q/A)_3$

$(3600\times4)/\pi\times0.2^2 = (38\times4)/\ \pi\times D^2_B$

D_B = 20.54 = 25.4 mm

WWW.IJRPR.COM

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

4. Oil supply for Through Cooling

As per user manual of Kennametal ϕ2.2 mm machine, the oil flow required for Through Cooling is 20 Lpm. There is one such point for the four cylinder.

$Q_{required} = 20$ Lpm$(Q/A)_1 = (Q/A)_3$

$(3600\times4)/\pi\times0.2^2 = (20\times4)/\ \pi\times D_T^{\ 2}$

$\mathbf{D_T = 14.91 = 15\ mm}$

5. Selection of main supply line

$Q_{Total} = Q_S + (2Q_B) + (4Q_T)$

$= 38 + (2\times38) + (4\times20)$

$Q_{Total}= 194$ Lpm$Q_{Total}= A\times V$

$(194\times10^{-3})/60 = (\pi/4)\times D_{main}^{\ 2}\times2$

$D_{main} = 45.38$ mm

$\mathbf{D_{main}= 50.8\ mm}$

Summary:

$\mathbf{D_{CFS} = 200\ mm D_S = 25.4\ mm}$

$\mathbf{D_B = 25.4\ mm\ D_T = 15\ mm}$

$\mathbf{D_{main} = 50.8\ mm}$

Now, checking safe thickness of high pressure pipe thickness for the possible case of blocking. The high pressure pipe is through cooling oil supply pipe which is subjectedto internal pressure of 100-110 bar pressure.

Internal Pressure, Pi= 11 MpaOuter Diameter,

Do= 15 mm Yield strength, Syt= 250 MpaFactor

of safety, FOS= 4

According to Barlow"s Equation Internal pressure is given by,Pi= (2 x Syt x T)/ (FOS x

Do)

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

11= (2 x 250 x T)/ (4 x 15)

T= 1.32 mm

T= 1.5 mm

Therefore, the pipe for through cooling oil supply of **15 mm** outer diameter with **mm** thickness was selected.

Selection of Hoses:

Application – Hydraulic Oil Type – Extremely Low Pressure

1) Hose for Suction Pipe Working Pressure = 4-6 bar Operating Temperature = 25-40°C

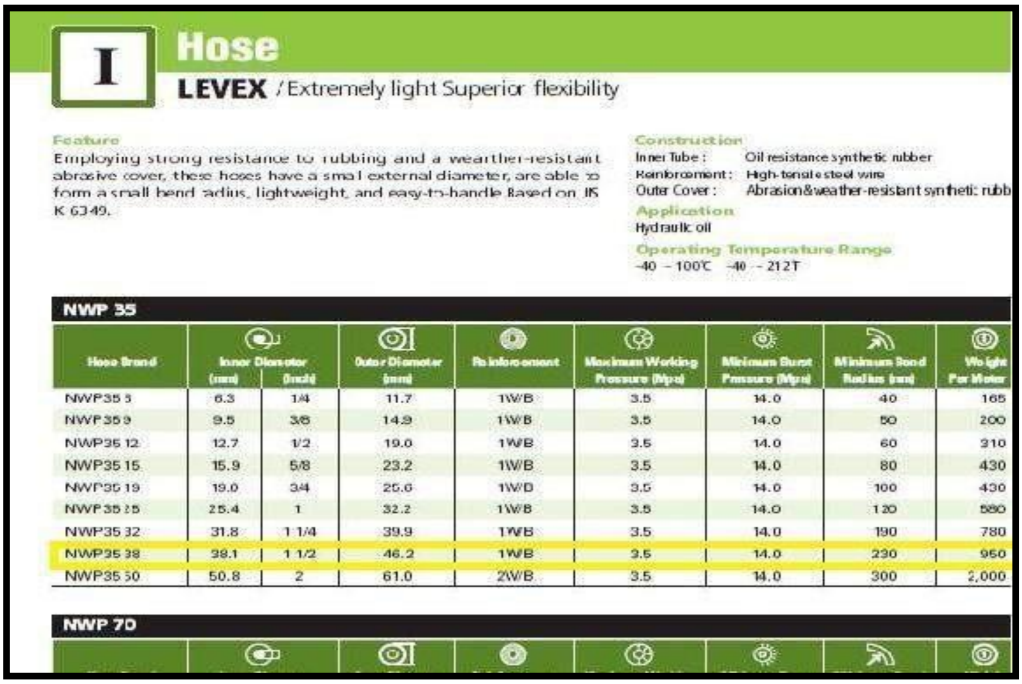
Selected Hose (From Catalogue):

Make - LEVEX Type **- NWP 3538**

Size - OD – 46.2 mm

ID – 1 ½ inch

Maximum Working Pressure – 35 bar Maximum Bursting Pressure – 140 bar



I Hose

LEVEX / Extremely light Superior flexibility

Feature

Employing strong resistance to rubbing and a wearther-resistant abrasive cover, these hoses have a smal external diameter, are able to form a small bend radius, lightweight, and easy-to-handle Based on JIS K 6349.

Construction

Inner Tube : Oil resistance synthetic rubber

Reinforcement : High-tensile steel wire

Outer Cover : Abrasion&weather-resistant synthetic rubb

Application

Hydraulic oil

Operating Temperature Range

-40 – 100℃ -40 – 212℉

NWP 35

Hose Brand	Inner Diameter (mm)	Inner Diameter (inch)	Outer Diameter (mm)	Reinforcement	Maximum Working Pressure (Mpa)	Minimum Burst Pressure (Mpa)	Minimum Bend Radius (mm)	Weight Per Meter
NWP35 6	6.3	1/4	11.7	1WB	3.5	14.0	40	165
NWP35 9	9.5	3/8	14.9	1WB	3.5	14.0	50	200
NWP35 12	12.7	1/2	19.0	1WB	3.5	14.0	60	310
NWP35 15	15.9	5/8	23.2	1WB	3.5	14.0	80	430
NWP35 19	19.0	3/4	25.6	1WD	3.5	14.0	100	430
NWP35 25	25.4	1	32.2	1WB	3.5	14.0	120	580
NWP35 32	31.8	1 1/4	39.9	1WB	3.5	14.0	190	780
NWP35 38	38.1	1 1/2	46.2	1WB	3.5	14.0	230	950
NWP35 50	50.8	2	61.0	2WB	3.5	14.0	300	2,000

NWP 70

Fig.5.3.1 Selection of Suction Hose from catalogue **[20]**

WWW.IJRPR.COM

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

2) Hose for Return Line Working Pressure =

90-100 barOperating Pressure = 35-50°C

Selected Hose (From Catalogue):

Make **-** LEVEX Type **- NWP 14019**

Size **-** OD – 27.9 mm

ID – 3/4 inch

Maximum Working Pressure – 140 bar

NWP 140

Hose Brand	Inner Diameter (mm)	(inch)	Outer Diameter (mm)	Reinforcement	Maximum Working Pressure (Mpa)	Minimum Burst Pressure (Mpa)	Minimum Bend Radius (mm)	Weight Per Meter (g)
NWP140 6	6.3	1/4	12.3	1W/B	14.0	56.0	45	175
NWP140 9	9.5	3/8	15.0	1W/B	14.0	56.0	50	220
NWP140 12	12.7	1/2	19.1	1W/B	14.0	56.0	60	340
NWP140 15	15.9	5/8	24.0	2W/B	14.0	56.0	95	620
NWP140 19	19.0	3/4	27.9	2W/B	14.0	56.0	110	790
NWP140 25	25.4	1	35.4	2W/B	14.0	56.0	140	1,170
NWP140 32	31.8	1 1/4	43.5	4W/S	14.0	56.0	240	1,750
NWP140 38	38.1	1 1/2	50.5	4W/S	14.0	56.0	290	2,410
NWP140 50	50.8	2	64.5	4W/S	14.0	56.0	370	3,550

NWP 175

Hose Brand	Inner Diameter (mm)	(inch)	Outer Diameter (mm)	Reinforcement	Maximum Working Pressure (Mpa)	Minimum Burst Pressure (Mpa)	Minimum Bend Radius (mm)	Weight Per Meter (g)
NWP175 6	6.3	1/4	12.4	1W/B	17.0	68.0	45	180
NWP175 9	9.5	3/8	16.2	1W/B	17.0	68.0	60	310
NWP175 12	12.7	1/2	20.3	2W/B	17.0	68.0	80	470
NWP175 15	15.9	5/8	24.1	2W/B	17.0	68.0	100	640
NWP175 19	19.0	3/4	28.7	2W/B	17.0	68.0	120	900
NWP175 25	25.4	1	35.6	2W/B	17.0	68.0	160	1,300
NWP175 32	31.8	1 1/4	44.3	4W/S	17.0	68.0	250	1,930
NWP175 38	38.1	1 1/2	51.4	4W/S	17.0	68.0	300	2,750
NWP175 50	50.8	2	64.5	4W/S	17.0	68.0	430	3,600

NWP 210

Hose Brand	Inner Diameter (mm)	(inch)	Outer Diameter (mm)	Reinforcement	Maximum Working Pressure (Mpa)	Minimum Burst Pressure (Mpa)	Minimum Bend Radius (mm)	Weight Per Meter (g)
NWP210 6	6.3	1/4	12.4	1W/B	20.5	82.0	45	180
NWP210 9	9.5	3/8	16.7	2W/B	20.5	82.0	60	360
NWP210 12	12.7	1/2	20.4	2W/B	20.5	82.0	80	490
NWP210 15	15.9	5/8	24.1	2W/B	20.5	82.0	110	640
NWP210 19	19.0	3/4	28.7	2W/B	20.5	82.0	130	930
NWP210 25	25.4	1	35.9	4W/S	20.5	82.0	180	1,380
NWP210 32	31.8	1 1/4	44.3	4W/S	20.5	82.0	280	1,980
NWP210 38	38.1	1 1/2	51.4	4W/S	20.5	82.0	330	2,800
NWP210 50	50.8	2	65.9	4W/S	20.5	82.0	430	4,600

Fig.5.3.2Selection of Retusrn Hose from catalogue **[20]**

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Validation

- Testing of return pump after circuit modification :

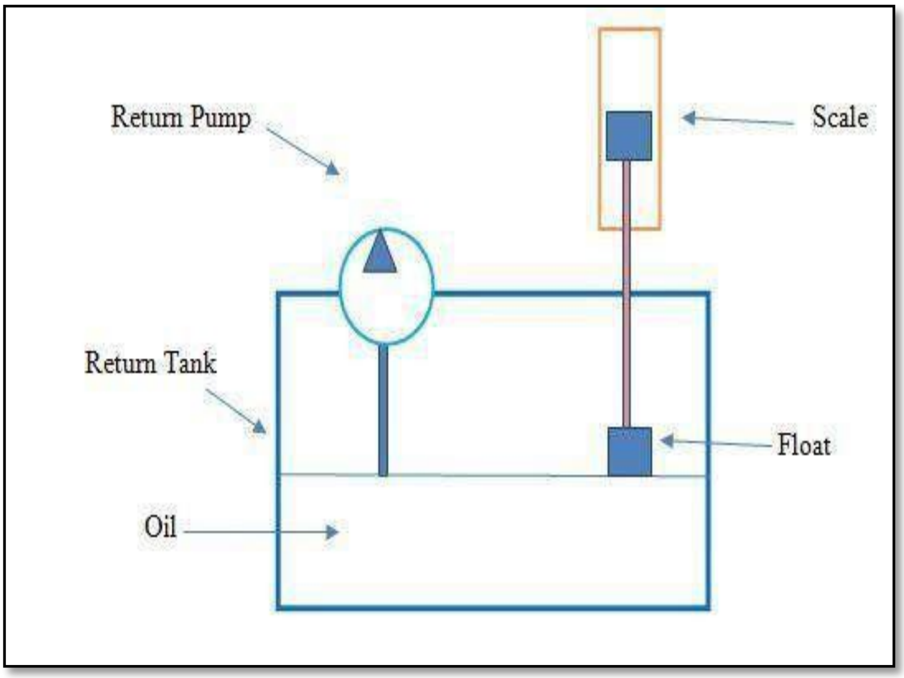


Fig.5.4. Validation

Tank dimension: 0.98 m ×1.4 mTotal rise of oil

level: 55 mm

Time taken for oil level rise: 26 sec

Therefore total flow added in return tank = (0.055×0.98×1.4)/26

Q_{Added} = 2.9023 Lps Q_{Added} =

174.138 Lpm**Q Selected>Q Added**

Therefore, selected pump is Safe in operation

Selection of the components:

1) Pump Selection

During Selection of Return pump the biggest challenge was to select the pump which is capable to lift the total oil flow collected in return tank. As discussed in previous section the major sources of oil flowing into the return tank are:

- Oil Supplied for spindle cooling
- Oil Supplied for Bed flushing

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

- Oil Supplied for through cooling

As Per the user manual of Kennametal 2.2mm Diameter machine, The oil flowrequirements are as follows:

- Oil Supply for spindle cooling (38 LPM)
- Oil Supply for Bed flushing (38 LPM)
- Oil Supply for through cooling (20 LPM)

For this machine the spindle cooling has one supply line, the bed flushing has two lines and through cooling has four lines. Thus, total oil collected in return tank becomes 194 LPM. Further going for safe side we assumed factor of safety 2. So, the selection of pump was conducted for flow rate of 388 LPM and total Head of 4m.

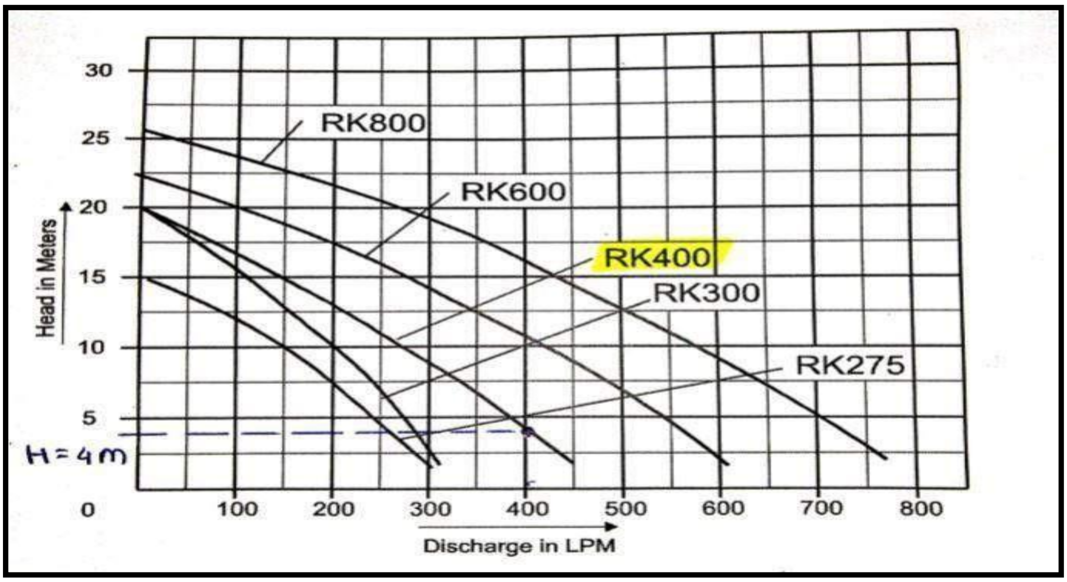


Fig. 5.5Selection of Return pump **[19]**

Using Rajmane‟s Pump Catalogue for Flow rate of 388 LPM and Head 4m,The pump of RK Series RK400 Was selected.

Table 5.5. Selected Components

Sr. No.	**Component**	**Specification**
1.	Pressure sensor	PN7094, 0-10 bar, IFM make
2.	Temperature sensor	TN7511, -40°C to 150°C, IFM make
3.	Flow sensor	S15010, IFM make
4.	Return pump	Centrifugal Pump, RK400, RAJMANE make

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

5.	D.C.V.	I-VXZ23-60H-10F-5DZ1-B, SMC make
6.	Tank Overflow Switch	FTL 260 0020,ENDRESS,HAUSER make

Flow Sensor

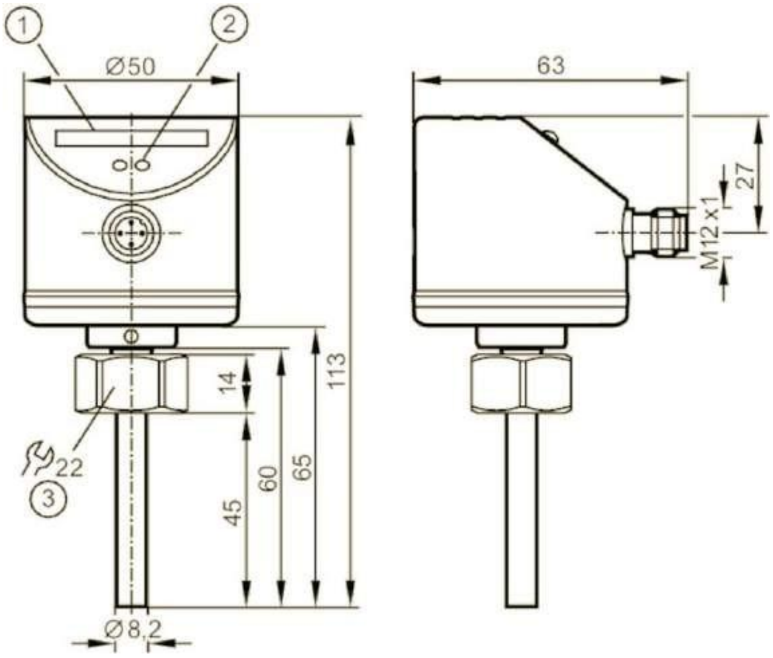


Fig.5.5.1 Flow Sensor **[18]**

1. LED bar display
2. Setting pushbutton
3. Tightening torque 25 N-m

Application		
Media		Liquids; Gases
Medium temperature	[°C]	-25...80
Pressure rating	[bar]	300
MAWP (for applications according to CRN)	[bar]	208
Liquids		
Medium temperature	[°C]	-25...80
Gases		
Medium temperature	[°C]	-25...80

WWW.IJRPR.COM

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Temperature Sensor

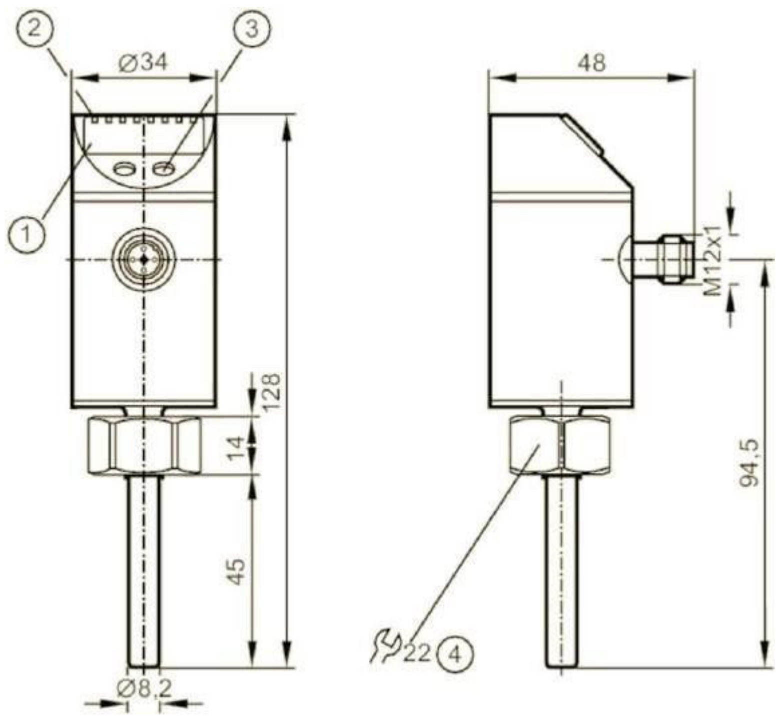


Fig. 5.5.2 Temperature Sensor **[16]**

1. Alphanumeric display 4-digit
2. Status LEDs
3. Programming button
4. Internal thread M18 x 1.5

Application		
Measuring element		1 x Pt 1000; (to DIN EN 60751, class B)
Media		liquids and gases
Pressure rating	[bar]	300
Minimum installation depth	[mm]	12

Measuring/setting range			
Probe length L	[mm]	45	
Measuring range		-40...150 °C	-40...302 °F
Set point SP		-39.5...150 °C	-39...302 °F
Reset point rP		-40...149.5 °C	-40...301 °F
In steps of		0.1 °C	0.1 °F

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Pressure Switch

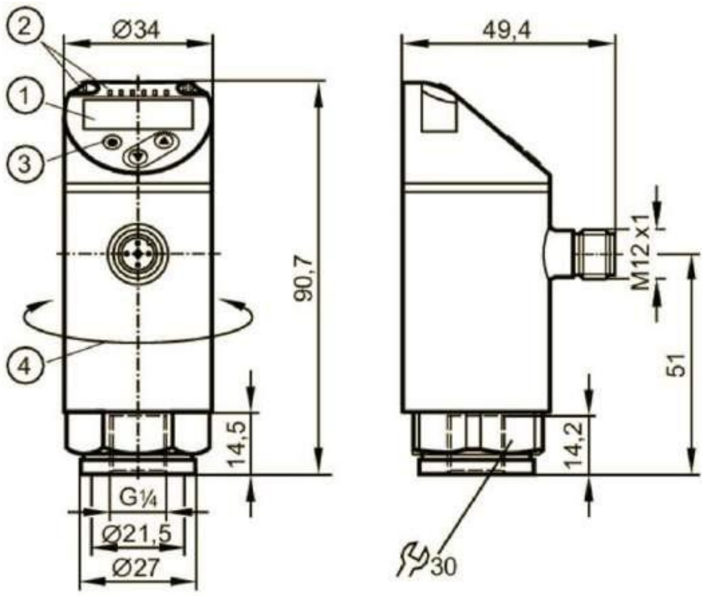


Fig.5.5.3. Pressure Switch **[17]**

1. Alphanumeric display 4-digit red/green
2. LEDs Display unit / switching status
3. Programming button
4. Upper part of the housing can be rotated 345°

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Cost of Components and Implementation

Table No.5.6 Cost Of Components and Implementation

Sr. No.	Component	Qty	Cost/ piece ( )	Total Cost ( )
1.	Level Sensor	1	14181	14181
2.	Flow Switch	1	8995	8995
3.	Temperature Sensor	1	16284	16284
4.	Pressure Switch	1	9034	9034
5	Coolant valve with coil	3	11008	33024
6.	Return Pump	1	12460	12460
7.	N.R.V.	1	2045	2045
8.	Fixed pipe	–	600	600
9.	Straight Connector	4	225	900
10.	Tee Connector	1	586	586
11.	Elbow	1	1072	1072
12.	ON OFF valve ($1\frac{1}{2}$")	1	3388	3388
13.	ON OFF valve(1")	1	2006	2006
14.	Straight connector	4	192	192
15.	Drain Line Chute	1	335	3375
16.	Fabrication	1	15000	15000
	TOTAL COST			1,23,142

International Journal of Research Publication and Reviews Vol. 2, no. 10, pp.897-948, October 2021

WWW.IJRPR.COM

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Implementation Action Plan:

Table No.5.7. Implementation - Action plan

Kennametal Machine CFS connection									
Sr. No.	Activity	Responsibility	Support required	Total Time required	Day 1	Day 2	Day 3	Day 4	Remark
1	Oil condition monitoring (PPM, Viscosity etc.)	MFC21-Production team	MFC21.3 - Sawant Himansu		▲▼				
1	Oil removal & tank cleaning	Pratik services	MFC21.3 - Sawant Himansu	4hrs	▲▼				
2	Removal of existing line/filter	Gurukripa services	TEF32-TPM- Shingare	5 hrs	▲▼				
3	Tank cutting for return line pump mounting	Om sai ram fabricator	MFC21.3 - Sawant Himansu	4hrs	▲	▼			
4	fabrication work for sensor mounting hole at tank	Om sai ram fabricator	TEF32-E- Rajapurkar	4hrs		▲▼			
5	CFS pipe line work	Om sai ram fabricator	FCM 1- Mandlik	24 hrs	▲	▽		▼	
6	Pump mounting	Gurukripa services	TEF32-TPM- Shingare	4hrs		▲▼			
7	Fixed-pipe line work, sensor & valve mounting	Gurukripa services	TEF32-TPM- Shingare	8hrs		▲	▼		
8	Chute mounting	Abhay product	TEF32-TPM- Shingare	8hrs	△	▲	▼		
9	Logic preparation & hardware	TEF32-E- Rajapurkar				▲	▽	▼	Backup corrupted
10	Trail of valve, level switch & return pump	MFC21-Production team	MFC21.3 - Sawant Himansu + CFT	4hrs				▲▼	

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Before Implementation:

Fig. 5.7.1 Coolant circuit before Implementation

After Implementation:

Fig. 5.7.2 Coolant circuit after Implementation

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Energy Saving

Energy consumption by previous equipments:

1. Parallel plate heat exchanger Pump: 0.75 kW
2. Side Flushing Tank Pump-I : 0.75 kW
3. Side Flushing Tank Pump-II : 0.37 kW
4. Spindle cooling tank Pump-I: 0.37 kW
5. Spindle cooling tank Pump-II: 0.75 kWCost of energy

consumption at this rate

= (Total kW consumption of all pumps) × (hours of working per day) × (number of working days per month) × (total number of months) × (Industrial Rate per unit of electricity)

= (0.75+0.75+0.37+0.37+0.75) × 24 × 25 × 12 ×□ 7

= 2.99 × 24 × 25 × 12 × 7

= Rs.1, 50,696

Energy Consumption for the newly proposed system:

1. Return pump: 1.5 kW

Cost of energy consumption at this rate

= (Total kW consumption) × (hours of working per day) × (number of working daysper month) × (total number of months) × (Industrial Rate per unit of electricity)

= (1.5) × 24 × 25 × 12 ×□ 7

= Rs. 36,918

Hence cost of energy saved per machine= Rs. 1, 50,696 – Rs. 36,918

= Rs. 76,860

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Technical Monitoring of Kennametal ϕ 2.2 mm

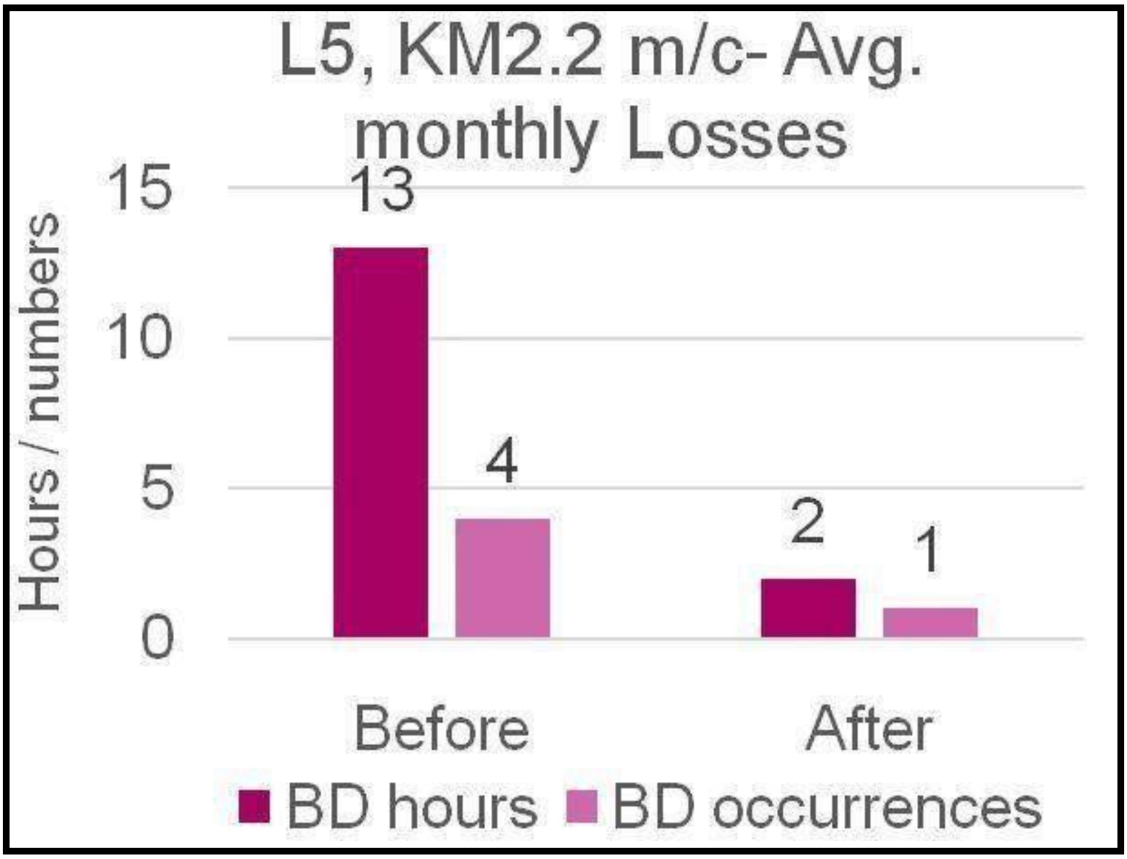


Fig.5.9 Monitoring of Kennametal ϕ 2.2 mm

Leakage Check

- After the implementation of our modified circuit on Kennametal ϕ 2.2 mm the machine was kept idle for 12hrs to examine any leakages.
- After 4 hrs. a minor leakage of oil through the bushes was detected.
- Then in corrective action we applied Permatex clear silicon Adhesive sealant on bushes in order to prevent the leakage.
- After that not a single drop of oil leakage was detected in remaining hours. Thus we succeed in making a leak proof system. The next task was of performance checking.

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Performance Check

- After getting a green card from leak test now the time was to check theperformance of the machine.
- For this test the machine was kept in functioning along with observation for 12hrs and the data recorded was as expected.

Monthly Performance Check:

- The machine was under observation for a month for comparing the breakdownwith previous machine setup.
- The occurrence of breakdown was just once and in terms of hours it was 2hours which is very less as compared to the previous breakdown hours.
- The breakdown occurrences was 4 times and time consumed was 13 hours.

Oil viscosity Test

No significant change was detected in oil viscosity. The oil viscosity for previous setup sample was 9.1 CST which is similar for the oil sample of new setup.

Oil Contamination Test

Due to good quality of filtration done in CFS the oil contamination was reduced by 40%. The test was conducted for 15 days, the dirt contamination of oil in previous setup was 15 ppm and after implementation of modified system it is reduced up to 9 ppm.

Oil temperature Test

The effectiveness of the heat exchanger used in CFS system is higher than theeffectiveness of old individual heat exchanger. The output temperature of old heat exchangers was 29-32°C and in case of Heat exchanger used in CFS the output temperature is 20-26°C

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

5.10. Cost Benefits:

1) Cost saving by in-house integration to CFS:

OEM cost (Service+ Material) – 600000Rs. + 100000Rs. =700000Rs per m/cIn-house cost = 125000 Rs. per m/c.

Cost Avoidance Saving = (OEM cost - In house cost)

= (700000 - 125000) × 4

= **2300000Rs. for all 4 Machines**

2) Oil Top up cost saving:

Oil Top up frequency = 4 Times in a monthQuantity of oil

replaces = 10 liters

Cost of oil = 1000 Rs. per 10 liters Cost required per month

= (4 × 1000)

= 4000 Rs.

Cost saving for oil top up per year = **48000 Rs.**

3) Filters changing cost saving:

Filters changing frequency = once in three monthsQuantity of Filters

required = 2 Nos.

Cost of Filter = 1000 per filter

Cost saving for Filter replacement per year = (4 × 2 × 1000)Cost saving for Filter

replacement per year = **8000 Rs.**

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

6. AMS machine(VMC)

Previous oil Supply unit for AMS

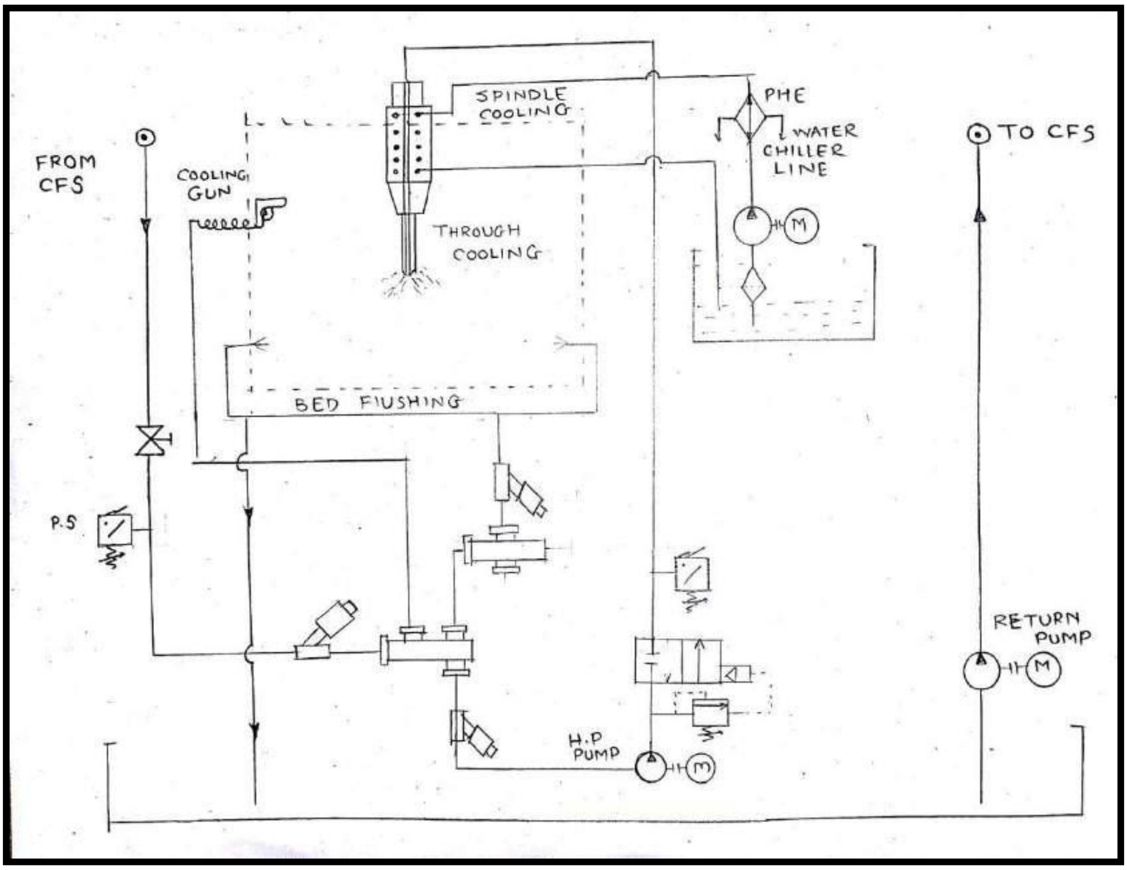


Fig. 6.1 AMS Previous Coolant Circuit DiagramCONSTRUCTION:

- Previous AMS coolant circuit was the integration of three different circuits namely spindle cooling circuit, bed flushing circuit and through cooling circuit.
- Spindle cooling circuit has individual oil pump, oil filter and Heat exchanger.
- Bed flushing circuit has its input port connected direct to the CFS unit and has no separate oil pump, filter and Heat exchanger.
- Through cooling circuit also has its input connected to CFS unit. But, CFS oil pressure is 4-5bar and as per the user manual of AMS the oil pressure requirement for through cooling operation is 100 bars. Therefore, a High pressure pump is connected in this circuit.

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

- Safety valves and direction control valves are used at various locations forsafety purposes and to maintain oil flushing timings.
- The used oil gets collected at the bottom of machine in return tank. Andfurther it is sent back to CFS unit by using a return pump.
- A separate oil tank for spindle cooling circuit is also provided near themachine.

WORKING:

- The oil from CFS (Centralized Filtration System) is directly connected to the Bed flushing line. A temperature switch is used to measure the oil temperature. The effective time of bed flushing is 42 sec for 1 minute timetest.
- The On-Off valves of bed flushing circuit are operated by pneumatic pilot signal. And they are so programmed that there will be no accumulation of burron machine bed after each machining operation.
- The oil used for bed flushing operation will get collected in return tank.
- Another circuit whose input is connected directly to CFS is through cooling circuit. But, this circuit needs a High pressure pump to increase oil pressure upto 100bar. The effective time for through cooling is 39 sec for 1 minute time test.
- The other circuit is spindle cooling circuit which differs from mentioned two circuits in many aspects. Its input is not connected with CFS unit.
- Spindle cooling circuit has its separate oil tank. A separate oil pump is used to circulate the oil for spindle cooling.
- This circuit needs a separate filter as well as a separate Heat exchanger. A chiller line is extended upto the machine and connected to the heat exchanger for oil cooling purpose.
- The oil used for spindle cooling is collected in spindle cooling tank and not in return tank. There is requirement of frequent top-up of oil for spindle cooling.

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Modified oil Supply unit for AMS

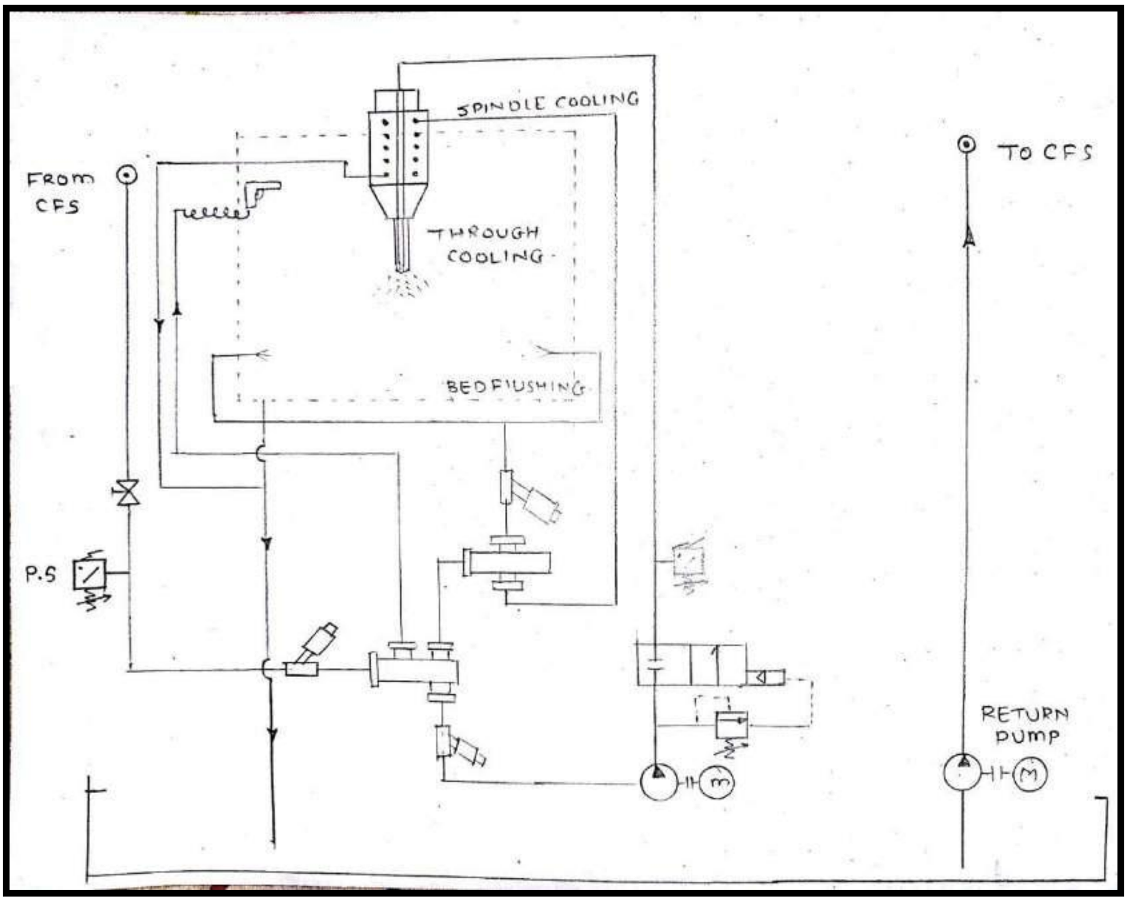


Fig. 6.2 AMS Modified Coolant Circuit Diagram

CONSTRUCTION:

- The constructional details of modified AMS cooling circuit are almost similar to the previous one. Only the considerable change is that its individual spindle cooling circuit is integrated with other two circuits namely bed flushing circuitand through cooling circuit.
- In other words the spindle cooling circuit is also connected to CFS which in turn eliminated the individual oil pump, filter and heat exchanger
- Bed flushing circuit has its input port connected direct to the CFS unit and has no separate oil pump, filter and Heat exchanger.
- Through cooling circuit also has its input connected to CFS unit. But, CFS oil pressure is 4-5bar and as per the user manual of AMS the oil pressure

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

requirement for through cooling operation is 100 bars. Therefore, a Highpressure pump is connected in this circuit.

- Safety valves and direction control valves are used at various locations forsafety purposes and to maintain oil flushing timings.
- The used oil gets collected at the bottom of machine in return tank. Andfurther it is sent back to CFS unit by using a return pump.

WORKING:

- The oil from CFS (Centralized Filtration System) is directly connected to the Bed flushing line. A temperature switch is used to measure the oil temperature. The effective time of bed flushing is 42 sec for 1 minute timetest.
- The On-Off valves of bed flushing circuit are operated by pneumatic pilot signal. And they are so programmed that there will be no accumulation of burron machine bed after each machining operation.
- The oil used for bed flushing operation will get collected in return tank.
- Another circuit whose input is connected directly to CFS is through cooling circuit. But, this circuit needs a High pressure pump to increase oil pressure upto 100bar. The effective time for through cooling is 39 sec for 1 minute time test.
- In modified circuit the spindle cooling circuit uses the oil from CFS unit. This oil passes through the spindle oil jackets in order to cool down the spindle.The temperature of oil sent to the jacket and oil coming out from the jacket is measured with the help of temperature sensors.
- The oil coming out from spindle cooling jacket is collected in return tank and further sent back to CFS unit using a return pump.
- The main advantage of this modified circuit is that it eliminated the some unnecessary components like spindle cooling pump, Oil filter, heat exchanger, spindle cooling oil tank and chiller line etc.
- Also by Horizontal deployment of this concept over 42 machines we would beable to utilize the CFS more effectively.

Calculations AMS

Selection of components used in Circuit

A) Selection of Oil supply Hoses.

1) Selection of Bed flushing hose:

As per user manual of AMS machine, the oil required for bed flushing operation is 38LPM.

Q = A x V

$(38 \times 10^{-3})/60 = (\pi/4) \times Db^2 \times 2$Db= 20.07 mm

Corrected value, Db= 25.4 mm Application:

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Hydraulic Oil Operating Temperature: 25-40°C

Operating Pressure: 4-5 bar

Therefore, for the calculated diameter of Db= 25.4 mm and Operating conditions theselected Hose from the catalogue is **NWP3525.**

I

Hose

LEVEX / Extremely light Superior flexibility

Feature

Employing strong resistance to rubbing and a wearther-resistant abrasive cover, these hoses have a small external diameter, are able to form a small bend radius, lightweight, and easy-to-handle.Based on JIS K 6349.

Construction

Inner Tube: Oil resistance synthetic rubber

Reinforcement: High-tensile steel wire

Outer Cover: Abrasion&weather-resistant synthetic rubber

Application

Hydraulic oil

Operating Temperature Range

-40 ~ 100℃ -40 ~ 212℉

NWP 35

Hose Brand	Inner Diameter (mm)	Inner Diameter (inch)	Outer Diameter (mm)	Reinforcement	Maximum Working Pressure (Mpa)	Minimum Burst Pressure (Mpa)	Minimum Bend Radius (mm)	Weight Per Meter (g)
NWP35 6	6.3	1/4	11.7	1W/B	3.5	14.0	40	165
NWP35 9	9.5	3/8	14.9	1W/B	3.5	14.0	50	200
NWP35 12	12.7	1/2	19.0	1W/B	3.5	14.0	60	310
NWP35 15	15.9	5/8	23.2	1W/B	3.5	14.0	80	430
NWP35 19	19.0	3/4	25.6	1W/B	3.5	14.0	100	430
NWP35 25	25.4	1	32.2	1W/B	3.5	14.0	120	580
NWP35 32	31.8	1 1/4	39.9	1W/B	3.5	14.0	190	780
NWP35 38	38.1	1 1/2	46.2	1W/B	3.5	14.0	230	950
NWP35 50	50.8	2	61.0	2W/B	3.5	14.0	300	2,000

Fig. 6.3.1 Selection of Bed flushing hose **[20]**

2) Selection of Spindle cooling Hose:

As per user manual of AMS machine, the oil required for Spindle cooling operation is10LPM.

Q = A x V

$(10 \times 10^{-3})/60 = (\pi/4) \times Ds^2 \times 2$Ds= 10.30 mm

Corrected value, Ds= 12.5 mm Application:

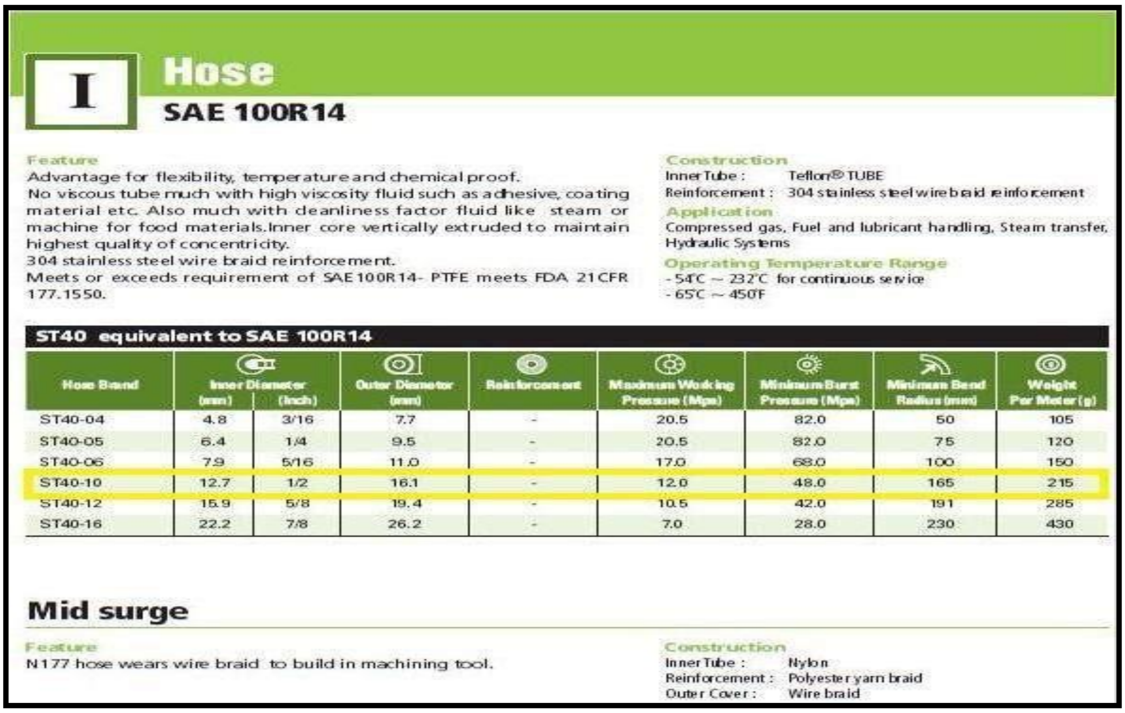
Hydraulic Oil Operating Temperature: 25-40°C

Operating Pressure: 4-5 bar

Therefore, for the calculated diameter of Ds= 12.5 mm and Operating conditions theselected Hose from the catalogue is **ST40-10.**

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421



I

Hose

SAE 100R14

Feature

Advantage for flexibility, temperature and chemical proof.
No viscous tube much with high viscosity fluid such as adhesive, coating material etc. Also much with cleanliness factor fluid like steam or machine for food materials.Inner core vertically extruded to maintain highest quality of concentricity.
304 stainless steel wire braid reinforcement.
Meets or exceeds requirement of SAE100R14- PTFE meets FDA 21CFR 177.1550.

Construction

Inner Tube : Teflon® TUBE
Reinforcement : 304 stainless steel wire braid reinforcement

Application

Compressed gas, Fuel and lubricant handling, Steam transfer, Hydraulic Systems

Operating Temperature Range

-54℃ ~ 232℃ for continuous service
-65℃ ~ 450℉

ST40 equivalent to SAE 100R14

Hose Brand	Inner Diameter (mm)	Inner Diameter (Inch)	Outer Diameter (mm)	Reinforcement	Maximum Working Pressure (Mpa)	Minimum Burst Pressure (Mpa)	Minimum Bend Radius (mm)	Weight Per Meter (g)
ST40-04	4.8	3/16	7.7	-	20.5	82.0	50	105
ST40-05	6.4	1/4	9.5	-	20.5	82.0	75	120
ST40-06	7.9	5/16	11.0	-	17.0	68.0	100	150
ST40-10	12.7	1/2	16.1	-	12.0	48.0	165	215
ST40-12	15.9	5/8	19.4	-	10.5	42.0	191	285
ST40-16	22.2	7/8	26.2	-	7.0	28.0	230	430

Mid surge

Feature

N177 hose wears wire braid to build in machining tool.

Construction

Inner Tube : Nylon
Reinforcement : Polyester yarn braid
Outer Cover : Wire braid

Fig. 6.3.2 Selection of Spindle cooling hose **[20]**

3) Selection of through cooling Hose:

As per user manual of AMS machine, the oil required for through cooling operation is38LPM.

Q = A x V

$(38 \times 10^{-3})/60 = (\pi/4) \times Dt^2 \times 2$Dt= 20.07 mm

Corrected value, Dt= 25.5 mm Application:

Hydraulic Oil Operating Temperature: 32-45°C

Operating Pressure: 100-110 bar

Therefore, for the calculated diameter of Dt= 25.5 mm and Operating conditions the selected Hose from the catalogue is **WSR2Z-16.** Also, the operating pressure of this hose is too high therefore the hose of SAE certified category was selected.

WWW.IJRPR.COM

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

I

Hose

SAE 100R5

Feature

W series is high pressure hose which cleared SAE standard specification. Fittings of W series was implemented field assembly.

① Easy for on site assembly. Hose can be cut suitable length for equipments.

② It enhance minimized down time to replace hose assembly built into equipments.

③ No needs to purchase full assembly hose. It minimize excess inventory.

Construction

Inner Tube : Oil resistance synthetic rubber.

Reinforcement : Wire braid, Spiral Wire braid.

Outer Cover : Abrasion & weather-resistant synthetic rubber.

Application

Hydraulic oil

Operating Temperature Range

-40 ~ 93℃ -40 ~ 199℉

WSR2Z equivalent to SAE 100R2

Hose Brand	Inner Diameter (mm)	Inner Diameter (inch)	Outer Diameter (mm)	Reinforcement	Maximum Working Pressure (Mpa)	Minimum Burst Pressure (Mpa)	Minimum Bend Radius (mm)	Weight Per Meter (g)
WSR2Z-04	6.4	1/4	17.5	2W/B	35	140	100	500
WSR2Z-06	9.5	3/8	21.4	2W/B	28	112	125	650
WSR2Z-08	12.7	1/2	24.6	2W/B	24.5	98	175	850
WSR2Z-12	19.0	3/4	31.8	2W/B	15.7	62.8	240	1,100
WSR2Z-16	25.4	1	39.7	2W/B	14	56	300	1,600
WSR2Z-20	31.8	1 1/4	50.8	2W/B	11.3	45.2	420	2,550
WSR2Z-24	38.1	1 1/2	57.1	2W/B	8.7	34.8	500	3,000

Fig. 6.3.3 Selection of Through cooling hose **[20]**

4) Selection of Work piece cooling Hose:

As per user manual of AMS machine, the oil required for work piece cooling operation is38LPM.

Q = A x V

$(38 \times 10^{-3})/60 = (\pi/4) \times Dw^2 \times 2$Dw= 20.07 mm

Corrected value, Dw= 25.5 mm Application:

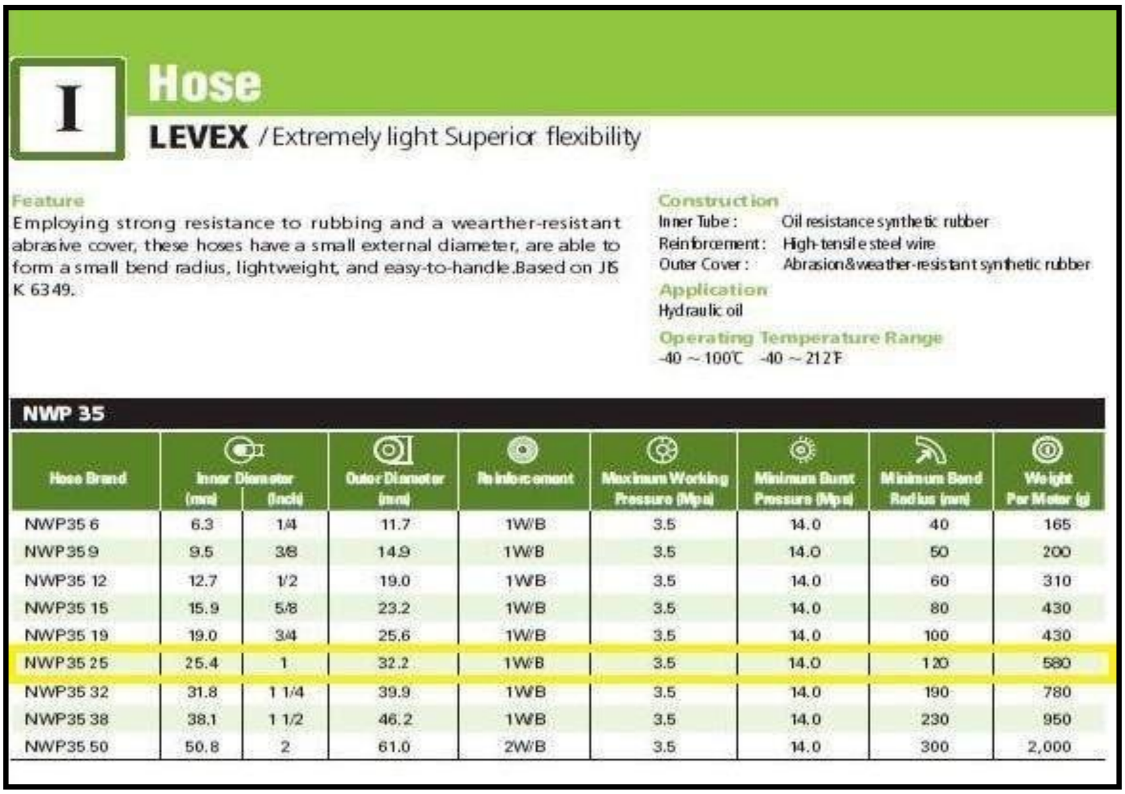
Hydraulic Oil Operating Temperature: 25-40°C

Operating Pressure: 4-5 bar

Therefore, for the calculated diameter of Dw= 25.5 mm and Operating conditions theselected Hose from the catalogue is **NWP3525.**

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421



I Hose

LEVEX / Extremely light Superior flexibility

Feature

Employing strong resistance to rubbing and a wearther-resistant abrasive cover, these hoses have a small external diameter, are able to form a small bend radius, lightweight, and easy-to-handle.Based on JIS K 6349.

Construction

Inner Tube: Oil resistance synthetic rubber

Reinforcement: High-tensile steel wire

Outer Cover: Abrasion&weather-resistant synthetic rubber

Application

Hydraulic oil

Operating Temperature Range

-40 ~ 100℃ -40 ~ 212℉

NWP 35

Hose Brand	Inner Diameter (mm)	Inner Diameter (inch)	Outer Diameter (mm)	Reinforcement	Maximum Working Pressure (Mpa)	Minimum Burst Pressure (Mpa)	Minimum Bend Radius (mm)	Weight Per Meter (g)
NWP35 6	6.3	1/4	11.7	1W/B	3.5	14.0	40	165
NWP35 9	9.5	3/8	14.9	1W/B	3.5	14.0	50	200
NWP35 12	12.7	1/2	19.0	1W/B	3.5	14.0	60	310
NWP35 15	15.9	5/8	23.2	1W/B	3.5	14.0	80	430
NWP35 19	19.0	3/4	25.6	1W/B	3.5	14.0	100	430
NWP35 25	25.4	1	32.2	1W/B	3.5	14.0	120	580
NWP35 32	31.8	1 1/4	39.9	1W/B	3.5	14.0	190	780
NWP35 38	38.1	1 1/2	46.2	1W/B	3.5	14.0	230	950
NWP35 50	50.8	2	61.0	2W/B	3.5	14.0	300	2,000

Fig. 6.3.4 Selection of Work piece cooling hose **[20]**

B) Selection of return pump.

It is important to calculate the total amount of oil flow collected per minute inside thereturn tank in order to perform Return pump selection calculations.

Total Discharge collected in return tank=

(Oil flow for bed flushing x 3) + (Oil flow for spindle cooling) + (Oil flow for throughcooling) + (Oil flow for Work piece cooling) + (Other sources)

Total Flow in Return tank= (38x3) + (10) + (38) + (38) + (20)Total Flow in Return

Tank= 220LPM **(Ideally)**

But, the effective cycle times for various oil flows in 1 minute test were observed asfollows,

- Oil flow for bed flushing= 42 Sec
- Oil flow for spindle cooling= 60 Sec
- Oil flow for Through cooling= 39 Sec
- Oil flow for Work piece cooling= 50 Sec

Therefore, Actual oil flow in return tank can be calculated as follows,

WWW.IJRPR.COM

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

- Oil flow for bed flushing= 26.6LPM
- Oil flow for spindle cooling= 10 LPM
- Oil flow for Through cooling= 24.7LPM
- Oil flow for Work piece cooling= 31.67LPM

Total Flow in Return tank= (26.6x3) + (10) + (24.7)+(31.67)+(20)Total Flow in Return

Tank= 167LPM **(Actual)**

FOS= 2

Total Flow in Return Tank= 167LPM x 2Total Flow in Return

Tank= 334LPM Head = 4m

Using Rajmane‟s Pump catalogue,Q = 334 LPM & H =

4 m

The pump of RK series **RK400** was selected

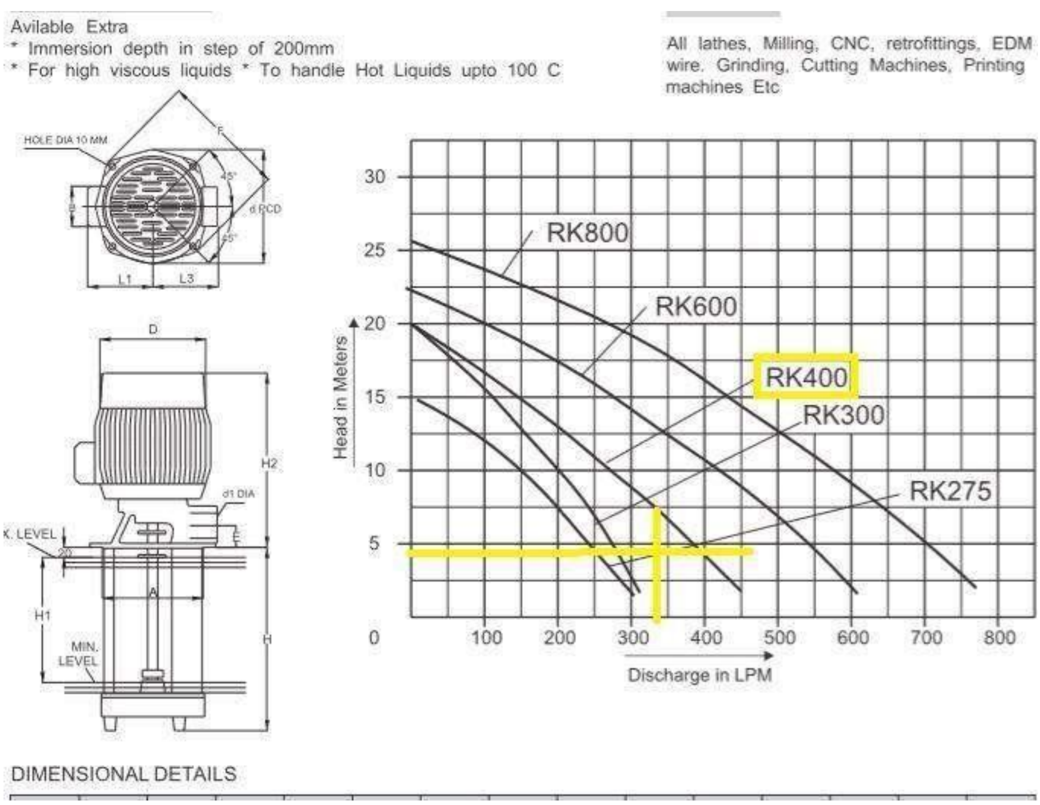


Fig.6.3.5 Selection of Return pump for AMS from Rajmane‟s Catalogue **[19]**

WWW.IJRPR.COM

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

C) Selection of Different Electronic components

1) Temperature Sensor:

For operating temperature of range 28-40°C, the best suitable temperature sensor wasselected on the basis of availability.

Selected Type: TN7531 Working Range: -40 to

150°C

TN7531

Temperature sensor with display

TN-013KBBD10-QFPKG/US/ /V

Outputs			
Total number of outputs		2	
Output signal		switching signal; IO-Link; (configurable)	
Electrical design		PNP/NPN	
Number of digital outputs		2	
Output function		normally open / normally closed; (parameterisable)	
Max. voltage drop switching output DC	[V]	2	
Permanent current rating of switching output DC	[mA]	250	
Short-circuit protection		yes	
Type of short-circuit protection		pulsed	
Overload protection		yes	
Measuring/setting range			
Probe length L	[mm]	45	
Measuring range		-40...150 °C	-40...302 °F
Set point SP		-39.5...150 °C	-39...302 °F
Reset point rP		-40...149.5 °C	-40...301 °F
In steps of		0.1 °C	0.1 °F
Resolution			
Resolution of switching output	[K]	0.1	
Resolution of display	[K]	0.1	
Accuracy / deviations			
Switch point accuracy	[K]	± 0,3	
Display accuracy	[K]	± 0,3	
Temperature drift per 10 K	[K]	0.1	
Response times			
Dynamic response T05 / T09	[s]	1 / 3; (to DIN EN 60751)	
Interfaces			
Transmission type		COM2 (38,4 kBaud)	
IO-Link revision		1.0	
Operating conditions			
Ambient temperature	[°C]	-25...70	
Storage temperature	[°C]	-40...100	
Protection		IP 67	
Tests / approvals			
EMC		DIN EN 61000-4-2 ESD	4 kV CD / 8 kV AD
		EN 61000-4-3 HF radiated	10 V/m
		DIN EN 61000-4-4 Burst	2 kV
		DIN EN 61000-4-5 Surge	1 kV
		EN 61000-4-6 HF conducted	10 V
Shock resistance		DIN IEC 68-2-27	50 g (11 ms)
Vibration resistance		DIN EN 60068-2-6	20 g (10...2000 Hz)
MTTF	[years]	242	

ifm electronic gmbh • Friedrichstraße 1 • 45128 Essen — We reserve the right to make technical alterations without prior notice. — EN-GB — TN7531-00 — 10.07.2013 —

Fig. 6.3.6 Selection of temperature sensor **[16]**

WWW.IJRPR.COM

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

2) Pressure Sensor:

For operating Pressure of range 4-110 bar, the best suitable Pressure sensor wasselected on the basis of availability.

Selected Type: PN7071 Working Range: 0 to 250

bar

PN7071

Pressure sensor with display

PN-250-SER14-QFRKG/US/ /V

Outputs				
Total number of outputs		2		
Output signal		switching signal; IO-Link; (configurable)		
Electrical design		PNP/NPN		
Number of digital outputs		2		
Output function		normally open / closed; (configurable)		
Max. voltage drop switching output DC	[V]	2.5		
Permanent current rating of switching output DC	[mA]	150; (200 (...60 °C) 250 (...40 °C))		
Switching frequency DC	[Hz]	< 170		
Short-circuit protection		yes		
Type of short-circuit protection		yes (non-latching)		
Overload protection		yes		
Measuring/setting range				
Measuring range		0...250 bar	0...3625 psi	0...25 MPa
Set point SP		2...250 bar	40...3620 psi	0.2...25 MPa
Reset point rP		1...249 bar	20...3600 psi	0.1...24.9 MPa
In steps of		1 bar	20 psi	0.1 MPa
Accuracy / deviations				
Switch point accuracy	[% of the span]	< ± 0,5		
Repeatability	[% of the span]	< ± 0,1; (with temperature fluctuations < 10 K)		
Characteristics deviation	[% of the span]	< ± 0,25 (BFSL) / < ± 0,5 (LS); (BFSL = Best Fit Straight Line; LS = limit value set		
Hysteresis deviation	[% of the span]	< ± 0,25		
Long-term stability	[% of the span]	< ± 0,05; (per 6 months)		
Temperature coefficient zero point	[% of the span / 10 K]	0,2; (-25...80 °C)		
Temperature coefficient span	[% of the span / 10 K]	0,2; (-25...80 °C)		
Reaction times				
Response time	[ms]	< 3		
Delay time programmable dS, dr	[s]	0...50		
Software / programming				
Parameter setting options		hysteresis / window; normally open / closed; switching logic; switch-on/switch-off delay; Damping; Display unit		

Fig. 6.3.7 Selection of Pressure sensor **[17]**

WWW.IJRPR.COM

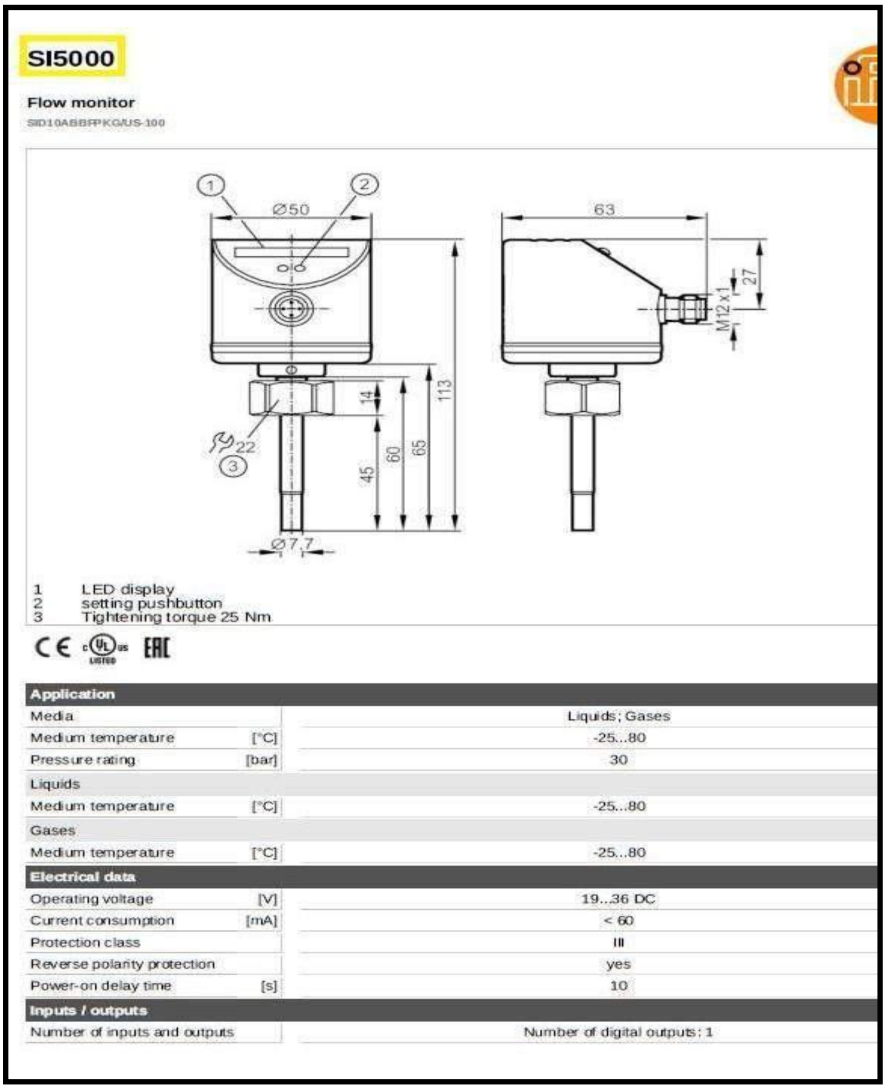
International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

3) Flow Sensor:

Selected Type: S15000 Temperature Range: -25 to

80°C



Application		
Media		Liquids; Gases
Medium temperature	[°C]	-25...80
Pressure rating	[bar]	30
Liquids		
Medium temperature	[°C]	-25...80
Gases		
Medium temperature	[°C]	-25...80
Electrical data		
Operating voltage	[V]	19...36 DC
Current consumption	[mA]	< 60
Protection class		III
Reverse polarity protection		yes
Power-on delay time	[s]	10
Inputs / outputs		
Number of inputs and outputs		Number of digital outputs: 1

ig. 6.3.8 Selection of flow sensor **[18]**

WWW.IJRPR.COM

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

6.4. List of Selected Components

Table 6.4 List of selected components

NO	Name of component	Specifications	Make	Material Category	Quantity
1	Pressure Sensor	PN7071	IFM	F002.Z40.567	2
2	Temperature Sensor	TN7531	IFM	M350.289.929	2
3	Flow Sensor	S15000	IFM	F002.Z57.784	1
4	Return pump	RK400	Rajman e‟‟s	CLASS-4	1
5	Through cooling Hose	WSR2Z-16	SAE10 0R5	CLASS-4	1
6	Work piece cooling Hose	NWP3525	LEVE X	CLASS-4	1
7	Spindle cooling Hose	ST40-10	SAE10 0R14	CLASS-4	1
8	Bed flushing hose	NWP3525	LEVE X	CLASS-4	1

6 Conclusion And Future Scope

Conclusion

Thus at the end we would like to conclude that the Modification of oil supply unit for Kennametal ϕ 2.2 mm and its implementation was as per the plan. We successfully achieved all the desired and planned objectives through this project.

All the objectives are discussed below:

1) Energy Saving

At the preliminary stage we observed high energy consumption is the major problem with Kennametal ϕ 2.2 Gun drilling machine. This high energy consumption is due to parallel plate heat exchanger and other four pumps mountedon tank for different purposes such as side flushing, spindle cooling etc.

As we proceed further we found that all this energy consuming equipments can beeliminate after integration of Kennametal ϕ 2.2 Gun drilling machine with the Centralized Filtration System i.e. replacing the various individual

WWW.IJRPR.COM

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

oil supply system with the CFS.

Energy consumption by previous equipments:

1. Parallel plate heat exchanger Pump: 0.75 kW
2. Side Flushing Tank Pump-I : 0.75 kW
3. Flushing Tank Pump-II : 0.37 kW
4. Spindle cooling tank Pump-I: 0.37 kW
5. Spindle cooling tank Pump-II: 0.75 kW

Cost of energy consumption at this rate

= (Total kW consumption of all pumps) × (hours of working per day) × (number of working days per month) × (total number of months) × (Industrial Rate per unit of electricity)

= (0.75+0.75+0.37+0.37+0.75) × 24 × 25 × 12 ×□ 7

= 2.99 × 24 × 25 × 12 × 7

= Rs. 1, 50,696

Energy Consumption for the newly proposed system:

Return pump: 1.5 kW

Cost of energy consumption at this rate

= (Total kW consumption) × (hours of working per day) × (number of working daysper month) × (total number of months) × (Industrial Rate per unit of electricity)

= (1.5) × 24 × 25 × 12 ×□ 7

= Rs. 36,918

Hence cost of energy saved per machine = Rs. 1, 50,696 – Rs. 36,918

= Rs. 76,860

2) **Reduce Breakdown**

While performing various operations on previous machine, many problems occurred which lead to breakdown of the machine. Problems which caused thebreakdown are coolant filter clogging, low coolant flow, coolant overflow, andchip accumulation in machine. For repairing the machine much time is consumed which increase the breakdown hours.

After implementation of modified circuit this problems which caused thebreakdown are reduced. So indirectly the breakdown hours are reduced.

- Number of breakdown on Old setup= 4 Nos

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

- Number of breakdown on new setup= 1 Nos
- Reduction in Number of breakdown= 3 Nos
- Hours of breakdown on Old setup= 13 Hrs.
- Hours of breakdown on New setup= 2 Hrs.
- Reduction in Hours of breakdown= 11 Hrs.

3) Increase Effectiveness of Heat Exchanger

Proper cooling is important to despite the heat from coolant. Effectiveness of cooling affects the quality and life of oil. The rate of cooling of oil depends upon the rate of heat transfer between cooling water and hot oil. Higher the rate of heat transfer, higher would be the cooling rate and hence effective cooling of oil.

The rate of heat transfer depends upon following factors:

- Cooling area in contact
- Temperature difference between two substances
- Thermal conductivity of material
- Method of cooling
- Time of cooling
- Flow rate of cooling water

The rate of heat transfer in the heat exchanger used for CFS unit is high as compared to the heat exchanger used for Kennametal machine as it has larger cooling area in contact and high flow rate of cooling water. This increased rate of heat flow in turn increases the rate of cooling of oil.

- Output Temperature of oil to old Heat Exchanger= 29°C
- Output Temperature of oil to New Heat Exchanger = 22°C

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Future Scope

Kennametal Horizontal Deployment:

Yokoten is a Japanese word meaning "horizontal deployment" and refers to thepractice of copying good results of improvement in one area to other areas.

Along with Kennametal ϕ 2.2 mm there are three more similar machine setups. Two machines of Kennametal ϕ 1.43 mm and one machine of ϕ 6 mm. The main benefit is that these machines having exactly the same setup as that of Kennametal ϕ 2.2 mm. Therefore we have scope to expand this concept on these machines without investing much time on calculations, testing, planning and other resources.

The current status is shown in table below: Table 7.2.1 Future scope

for Kennametal line

Sr. No.	Line	KM	Machine number	Date on implementation	Status
1	5	Ø 2.2	M9021-3703036523	08-11th Feb-19	Completed
2	6	Ø 1.43	M9021-3703038370		Pending
3	6	Ø 6	M9021-3703036038		Pending
4	8	Ø 1.43	M9021-3703036284		Pending

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

AMS

AMS implementation is still pending due to not approval of budget from the company. But, the whole action plan is ready. The main intention of AMS coolant circuit modification is also to reduce the energy consumption and to make system compact. There are total 42 such machines on which we can implement this project in future. The results expected from this project are tabulated below:

Table 7.2.1 Future scope for AMS line

TITLE	VALUE
Power consumed (kWh)	9.5 kWh
Running time of Pump (hr.)	48 hr.
Power consumption per hour (kW)	0.2 kW
Pump running time per day (hr.)	24 hr.
Power consumption per day	4.8 kWh
Working days per month	25 days
Power consumption per month	120 kWh
Power consumption per year	1440 kWh
Electricity Rate	7 Rs/unit
Cost of energy per month	Rs 840
Cost of energy per year	Rs 10,080
Total number of machines	42 machines
Total cost of energy	Rs 4,23,360
Investment per machine	Rs 7000
Saving per machine	**10080-7000= 3080**
Total saving for 1st year of implementation	**Rs 1,29,360**
Savings from 2nd year onwards	**Rs 4,23,360**

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

8. References

1. Poonam S. Patil et.al, „Cooling Techniques for a spindle of machine tool‟, Proc. of International Journal of Engineering and Computer Science ISSN: 2319-7242 Volume 5 Issue 12 Dec. 2016, Page No.653-656.
2. Ron Carlson et.al, 'The correct method of calculating energy saving to justify AFD on pumps‟, IEEE TRANSACTIONS ON INDUSTRY APPLICATIONS, VOL. 36, NO. 6, NOV/DEC 2000.
3. Wen-Guang Li et.al, „Effect of flow rate and viscosity on slip factor of centrifugal pump handling viscous oil‟, International Journal of Rotating Machinery Volume 4, Article ID 317473, 12 pages, Oct 2013.
4. R. A. Patil[1], V. D. Shinde[2], „„„Performance of High Pressure Coolant on Tool Wear‟, Proc. of IJRET: International Journal of Research in Engineering and Technology ISSN: 2319-1163 Volume 2 Nov. 2013, Page No. 45-56
5. Luis Norberto Lopez de Lacalle, „„„Using High Pressure Coolant in the Drilling and Turning of Low Machinability Alloys‟, International Journal of Research in Engineering and Technology ISSN: 2410-1862 Volume 9 Nov. 2010.
6. Camille Clare Sprankling Le Clair, „Oil Filtration System‟, Application April 15, 1943, Serial No. 483,158 January 24, 1942
7. Stephen R. Gardner, „Multi-Nozzle Machine Tool Cooling System‟, Provisional application No. 61/519,473, filed on May 23, 2011.
8. Gang jun Gong et.al, „Study on Control Cabinet of Automatic Filtration System for Insulating Oil of UHV Substation‟, International Conference on Computer Science and Application Engineering (CSAE 2017) ISBN: 978-1- 60595-505-6, 2017.
9. Hans-Henning Winkler et.al, „Machine Tool with Coolant Flushing System‟, Chiron-Werke GmbH & Co. KG 9/084,699 May 26, 1998
10. Turhan A. Tilev et.al, „Filtration System for Metalworking Fluids‟, Chiron- Werke GmbH & Co. 11/164,339 Nov. 18, 2005
11. Gaurav M. Gohane et.al, „Influence of Coolant in CNC Machining‟, International Journal of Advance Engineering and Research Development Volume 5, Issue 03, March -2018
12. User manual of VMC (AMS)
13. User manual of CNC Lathe (ACE)
14. User manual of CFS
15. Text book on „Fundamental of engineering heat and mass transfer‟,R.C.Sachdeva, ISBN: 978-81-224-2785-1 Page No.506-509.
16. IFM catalogue for Temperature Sensor selection
17. IFM catalogue for Pressure Sensor selection
18. IFM catalogue for Flow Sensor selection
19. Rajmane‟s catalogue for Pump selection
20. YOKOHAMA catalogue for Hoses selection