Design And Fabrication Of Multi Stage Oil Filter System

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Abstract- *Multistage oil filtration system is a system used to filter out all the metallic, non metallic particles from the cutting fluid, which is used during the machining processes. Basic procedures we are using in it are: centrifugal process, magnetic filtration, paper filtration. In centrifugal system constitutes of container, agitator, centrifugal pump attached to shaft, stainless steel mesh of fine microns .This oil is then transferred to magnetic separator with the help of pump, in this stage magnetic particles are separated out. Then this partially filtered fluid enters paper filtration stage to filter out minute non magnetic particles.*

Keywords- Centrifuge, Pumping, Filter, Frame Structure, Inlet Tank.

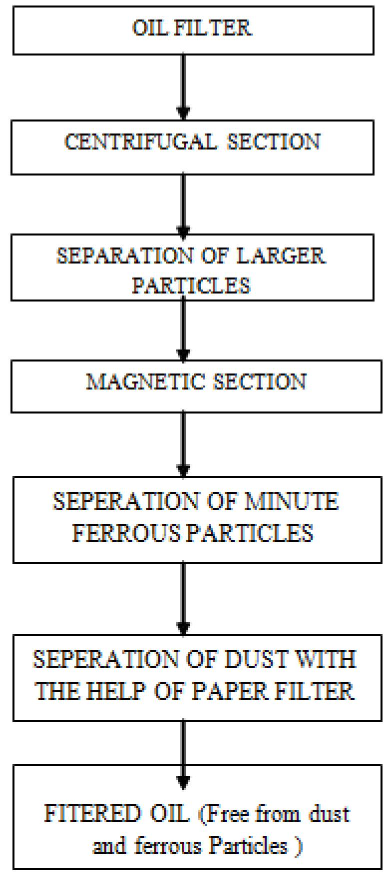
I. INTRODUCTION

In past era, in the industries, the used oil or the Cutting fluids which are used during the cutting process are filtered by Latin methods such as, delivering to sedimentation tank where all the higher density particles settle down itself into the tank and then passing it from iron mesh .but still some of the impurities remained in the fluid .so due this industry cannot use the fluid efficiently.

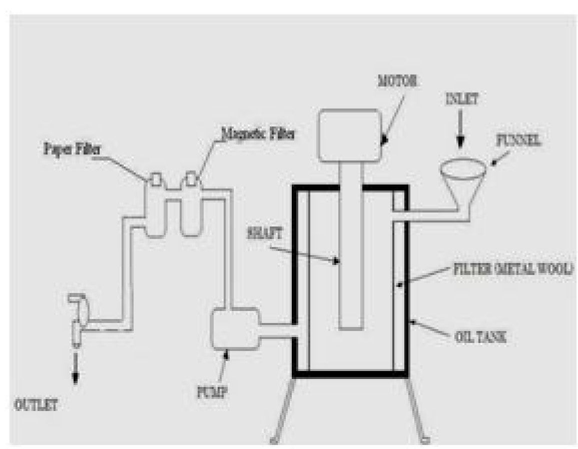
An Oil Separator is equipment which is used to separate impurities from the coolant fluid or lube oil which is mainly applicable in machines.

- It can separate out dust particle, metal particle, solid particles etc.
- The equipment helps in restoring the desirable properties of oil like viscosity index, flash point, pour point and Fire point.

The project mentioned in the given report basically combines the principle of centrifugal force along with the electromagnetism so as to obtain the optimum efficiency in the process of filtration of the magnetic particles i.e. ferrous particles and also the dust particles from the used oil. The basic idea behind the design and development of the oil separator can be explained with the help of the block diagram given below:



Working Principle:



- The centrifugal filters accelerate oil to high speed. The resulting centrifugal force throws solid particles on the wall of the rotor in a compact easy to remove mass.
- In centrifugal chamber the oil enters the centrifugal pressure and gets converted in to rotational energy producing speed of high rpm.
- The resultant centrifugal force removes metal particles from the coolant depositing it on the inner wall of the centrifugal chamber. Clean oil further forward to the filters.
- The pump is used to force oil into the filter. The bulk metal particles have removed in centrifugal filter but oil contains some minute metal particles which have further separated in the magnetic filter.
- After magnetic filtration oil fed to the paper filter where very minute particles are separated with the help of swirling motion of flow of oil or fluids.
- In this way filtration is carried out in multistage and collect at the storage tank.

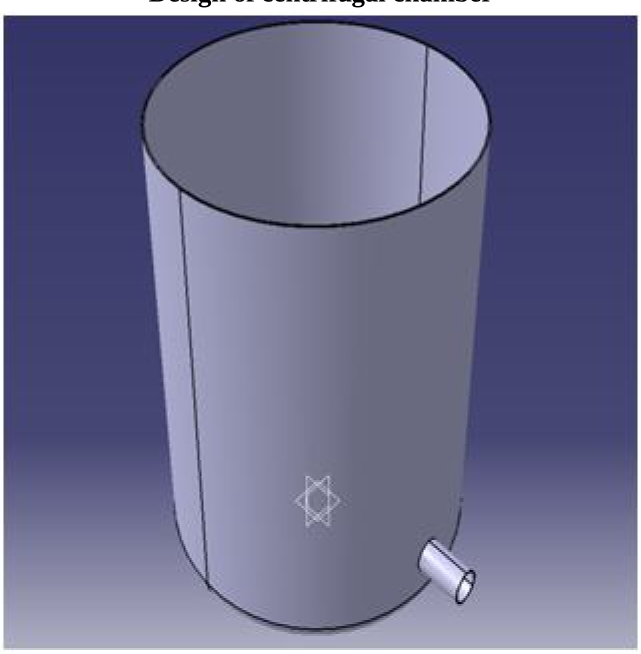
II. DESIGN PROCEDURE

i) Standard properties of cutting fluid:-

i) Viscosity at 40°C = 30 Cs
ii) Colour (Bright & clear)
iii) Specific gravity = 0.9213
iv) Density of cutting fluid = specific gravity of cutting fluid x density of water

ρc=0.9213 x 1000 =921.3 kg/m3

Design of centrifugal chamber



Select the suitable electric motor which has the following Specifications:

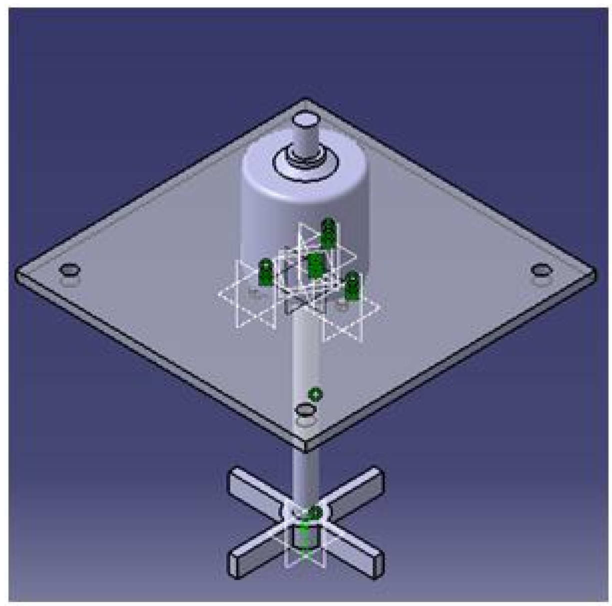
a) RPM of motor = 1400 rpm
b) Power = 45-50 Watts

We know that,

$$P= 2\pi NT/60$$

Where,

P= Power,
T= Torque developed by motor,
N= RPM of motor.
T= (P x 60)/2πN (50 x 60)/(2 x π x 1400)
= 0.341 N-m
=341 N-mm

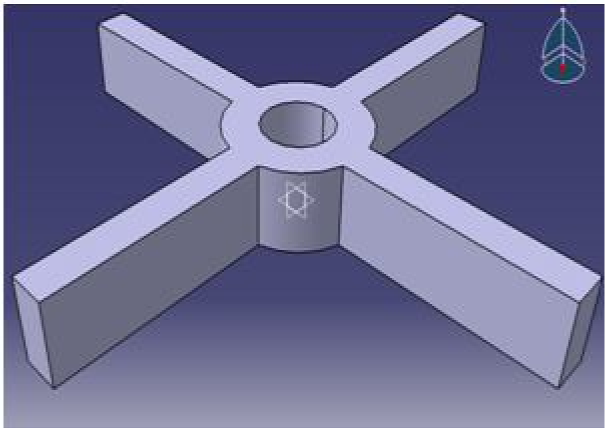


Agitator Motor and Rotors Assembly

ii) Centrifugal force due to torque:

Select a suitable size of chamber.

a) External diameter of chamber = 20 cm,
b) Height of centrifugal chamber = 22.5 cm,
c) Distance between centre of rotor to the iron wool mesh = (External diameter of chamber - thickness of iron wool mesh)/2
= (20 - (2 x 3))/2 = 7 cm
d) Fin length of agitator = 7-1
=6cm
= 0.06 m



Fin Rotor.

We know that,

Centrifugal force = Torque/(Fin lenght)

F_c = 5.68 N

iii) Mass flow rate due to centrifugal force produced by agitator (Mc):

$M_c = F_c/(\text{Fin length} \times \omega 2)$

But,

$\omega = 2\pi N/60$

ω = Angular velocity

$\omega = (2 \times \pi \times 1400)/60$

= 146.61 rad/sec.

$M_c = 5.68/(0.60 \times (146.61)2)$

$= 6.46 \times 10^{-4}$

= 0.038 kg/min

M_c = 2.32 kg/hr

iv) Total pressure developed due to centrifugal force on cutting fluid (Pt):

$P_t = F_c/A$

= $F_c/(\pi$ x Int Dia of iron wool mesh x ht of iron wool mesh)

$= 5.68/(\pi \times 0.14 \times 0.25)$

P_t =51.65 N/m²

v) Pressure Loss due to porous wall of iron wool mesh:

Porosity of iron wool mesh depends on thickness of iron wool mesh & material specification. Porosity is also depends on the usage time of filtration & contaminations present in cutting fluid.

∴ For above conditions 40% of pressure drop in centrifugal chamber due to Iron wool mesh.

$\Delta p = 0.4 \times P_t$

$= 0.4 \times 51.65$

$= 20.66$ N/m²

Δp = 20.66N/m²

Design of pump & pipe:

I) Select the smallest size of pump available in the market:

a) Power required for pump =0.35 HP
b) Head of pump =10-12 m
c) According to configuration, pump could to be delivered 1250 - 910 lit/hr volume of cutting fluid.
   Lets us assume the head of system 10m & Max discharge rate of cutting fluid, Q=1080 lit/hr
d) For this type of pump std. size of suction and delivery pipe is (d) = 8 mm

   Diameter of pipe, d = 8 mm
   i. = 0.008 m
   ii.

II) Head Loss in the pipe of due to friction:

$h_f = (4flv^2)/2gd$

Let us assume the length of pipe, l = 2m

We know that, velocity (v) = (Q)/(A)

Where A= $\pi/4$ xd2

Q = Discharge rate

= 1080 lit/hr

= 0.03 lit/sec

= 0.0003m3/sec

v =0.0003/0.000051

v=5.96 m/sec

We know that,

Reynolds number (Re) = (v x d)/ϑ

Where ϑ = kinematic viscosity

= 30 cS

= 0.03 x 10-3 m2/sec

$Re = (5.96 \times 0.008)/(0.3 \times 10^{-4})$

= 1591.55

Re < 2000

∴ Flow is viscous flow

For viscous flow,

Coefficient of friction (f) = $16/(Re) = 16/1591.55$
$= 0.01$

Head Loss,

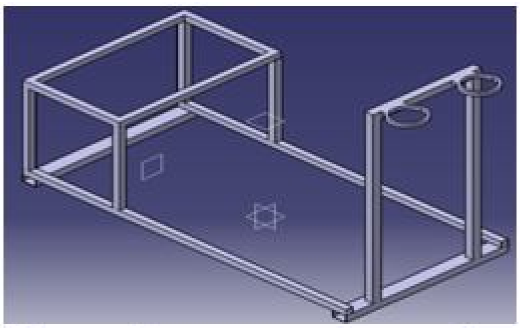
$$hf = 4flv^2/2gd$$
$$=(4 \times 0.01 \times 2 \times (5.96)^2)/(2 \times 9.81 \times 0.008)$$

hf = 18.1 m

III. PROJECT COMPONENT DRAWINGS

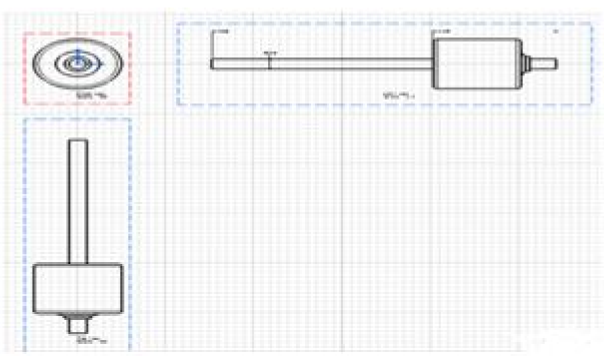
1) Frame.

Select a suitable size of frame
Length = 70 cm
Breadth = 60 cm
Height = 80 cm (of filter side)
= 37 cm (of cardboard side)



2) Inverted Motor Shaft.

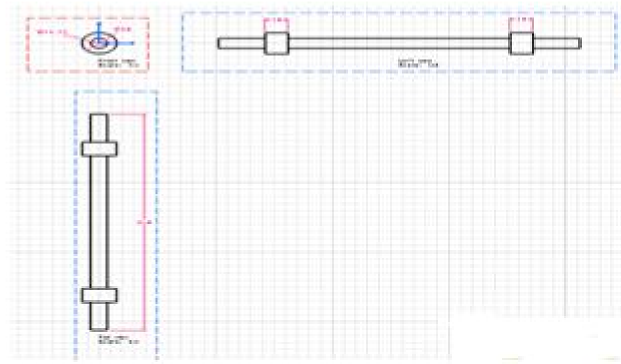
Select a suitable size or capacity of motor:
Shaft Diameter of Motor = 0.8 cm
Power of Motor = 45-50 Watt RPM of Motor = 1400 rpm.



Stud:

Select a suitable size of mild steel stud:

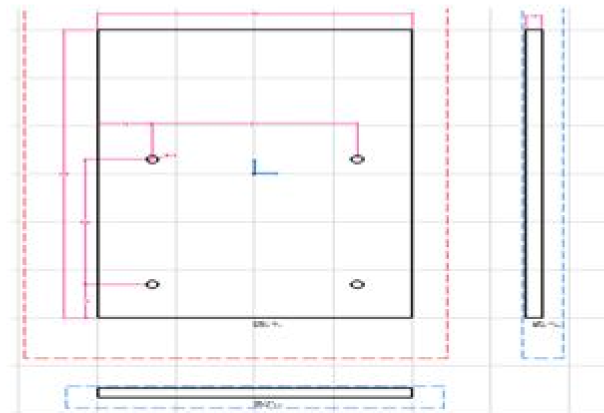
Length = 30cm
Effective diameter = 1.2cm



3) Cardboard.

Select a suitable size of cardboard:

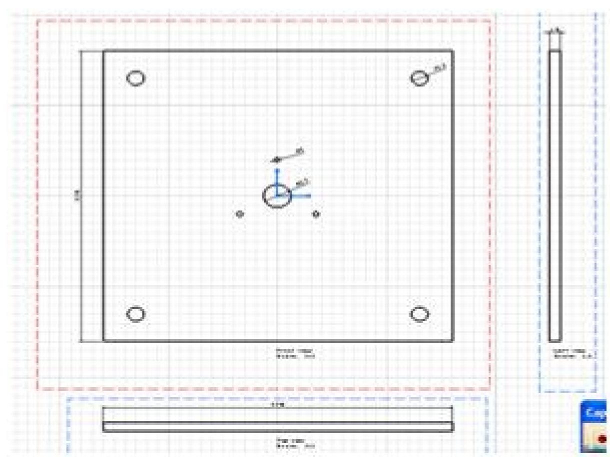
Cardboard size = 65 x 60 cm.



4) Transparent Lead Sheet:

Select suitable size of sheet:

Sheet size = 30x30cm.
Thickness = 0.8cm.



IV. RESULT / ANALYSIS

We carried out test in two phases:

A. Visualization test
B. Analytical test

A. Visualization Test

In case of our Project the coolant used which is mixed in the ratio 1:20 with the water. (1 lit cutting oil: 20 lit of water) weighs 3900 gm

The sample weighing 4000 gm (cutting oil + Water + 100 g metal particles) was then mixed with the metal particles and then the overall sample was subjected to the filtration. The overall sample was then visually analyzed with the help of metal grid.

Observation:

Few particles of ferrous impurities were observed.

B. Analytical Method

In this test we have done mathematical analysis by weight. After filtration it was observed that the overall weight of the sample collected was 3920 gm. i.e. 80 gm of metal particles were removed.

Observation Table:

SR. No.	Impurities added	Impurities removed	% of metal removal
1	100 gm	79 gm	79%
2	100 gm	80 gm	80%
3	100 gm	81 gm	81%
4	100gm	80 gm	80%
5	100gm	78 gm	78%
Average metal removal percentage			80%

V. CONCLUSION

From the study of cutting fluid, types and its usage, we concluded that cutting fluid is very important for industrial purposes, as its various advantages and its necessities. There are some disadvantages of cutting fluid related to their disposal after use to environment.

The disposal of cutting fluid getting used oil to the environment causing environment pollution.

For reducing this pollution various recycling machines are developed earlier but they are costly and not used by small industries.

The innovative idea of multistage oil separator can be used effectively. And from working of multistage oil separator we concluded that

- The oil separator can be used in various industries.
- The cost of maintenance, changing oil, servicing reduces to a great extent.
- The clean oil can be used effectively in various other industries.
- In industries they take fresh oil for each usage, but due to this project we can reuse the used oil by mixing small quantity of oil to used oil, which will ultimately lowers the usage of fresh oil which cost up to 300Rs/lit.

From the result it is clear that the filter proves to be effective in filtering the metallic & nonmetallic particles from the given sample of coolant.

Thus the multistage oil separator can be effective in the reusing of coolant at small scale and affordable price.

VI. FUTURISTIC SCOPE

The result shows 80% metal removal from the cutting oil but there is always a scope to remove the remaining 20% of the metal from the cutting oil. The 20% of metal are in the form of very small particle, but it will still hamper the surface finish of the metal being machined.

The Project can be further extended towards the complete reusing of oil. This project along with the various types of filters can be in future, used to separate the impurities such as water, sand, dust particles and other ferrous and Non-ferrous impurities from the cutting oil obtained from lathe machine or other machine.

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