Epi-Cyclic External Gear Pump for Maximum and Variable Discharge

Ravindra Maruti Kudale[1], Atish Ashok Patil[2], Rahul Pralhad Pargave[3], Siddaram Kashinath Chappalgaon[4]

[1-4]Department of Mechanical Engineering, ISB&M School of Technology, Maharashtra, India.

Abstract - *This dissertation concentrates on designing the Epi-Cyclic External Gear Pump for Maximum and Variable Discharge which can be used as cooling system for Heavy Machines. Mostly the submersible pumps are used in the machines to achieve cooling objective but these pumps get wear out and it may lead to breakage of internal parts. The repairing procedure of the submersible pumps is very complicated with high maintenance cost therefore a complete replacement of pump is preferred over the maintenance. This problem needs a better solution and here by providing an alternative to the submersible pumps we have tried to design a more efficient system.*

Key Words: Epi-Cyclic External Gear Pump, cooling system, submersible pumps, maintenance cost, solution, design.

1. INTRODUCTION

Gear is one of the popular and efficient power transmitting drives. The power transmission factors such as speed, direction and torque can be changed by using different gears with different dimensions. Comparing with belts and chains, gear is the most efficient power transmission drive. The condition of identical shapes needs to be satisfied by two gears to be called as mating gears. When the objective is to achieve number of combinations of speed, direction and torque, then the multiple gears are assembled together to form a gear train.

The count of number of gears in a motorcycle or a car such as "First Gear" is nothing but a specific gear ratio. This gear ratio is achieved by assembling the gears of different diameters mating with each other.

Torque enhancement and speed reduction in a particular motor is achieved by introducing worm and spur gears to the system which also helps to achieve regular rotational movement of the motor.

Appropriate steps in the gear ratios permit selection of driving speeds with wide ranges. Reduction in the speed and the multiplication in the torque are achieved by spur reduction gears as well as worm and worm wheel. The torque can be increased with the help of planetary gears as well.

2. WORKING PRINCIPLE

The Epi-cyclic gear pump consists of a Coolant Tank, Cooling Fluid, Shaft, External Gear Pump, Motor, Sun Gear, Planet Gear, Casing etc. The motor shaft is attached to the sun gear and sun gear is in mesh with the planet gears. The shaft is used to connect drive gears of each external gear pump with the planet gear.

The sun gear starts rotating when the respected connected motor is turned on and then the planet gears also start rotating in the opposite direction of the sun gear. The two gears in external gear pump create suction at the inlet following the discharge at outlet.

Epi-cyclic Gear Pump is rotary flow positive displacement pump. The low speed and inlet pressure requirements are highlights of this pump which results in suck in the cooling fluid from the coolant tank in each external gear pump and discharge it wherever the cooling is required.

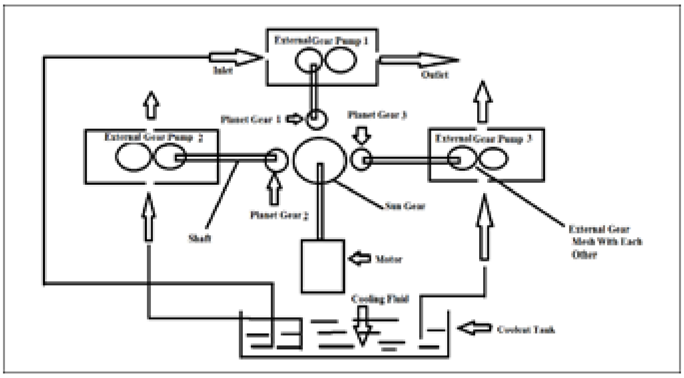

Fig – 1: External Gear Pump block diagram

Two meshing gears split the fluid and act as a seal between suction and discharge ports. The volume of the fluid is controlled by intermeshing gears by forming locked pockets in between. Formation of the seal equidistant from the suction and discharge ports is assured by complete gear teeth meshing. The target of this seal is to force the fluid out of the discharge port.

3. DESIGN & CALCULATIONS

3.1 Sun and Pinion Gear Calculations

Input data:

Sun Gear teeth	= Zg = 60
Power	= ½ HP
	= 746/2 = 373 Watt = 0.373 Kw
Motor Speed	= 6000 RPM
Driven Pulley Speed	= Ng = 1200 RPM
Gear Ratio	= 1/3
Ultimate tensile strength	= Sut = 410 N/mm^2
Material	= Plain carbon steel
Power transmission	= V-Belt

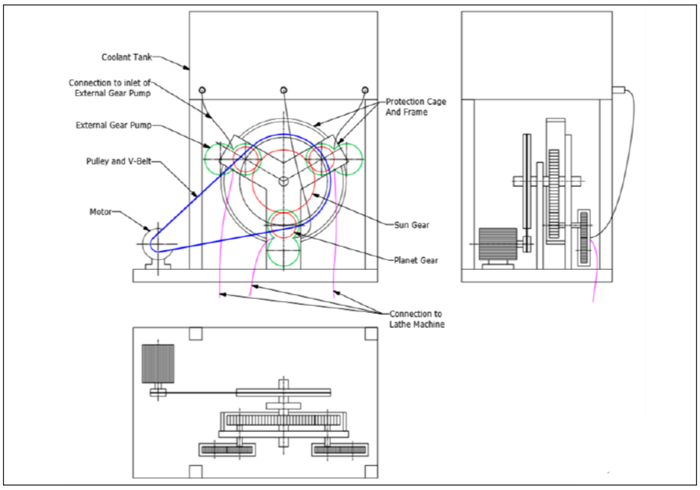

Fig – 2: Layout of Epi-Cyclic External Gear Pump

3.2 Tangential Torque

P = (2 x Π x N x T) / 60
Mt = (60 x P) / (2 x Π x N)
Mt = (60 x 0.373 x 10^6) / (2 x Π x 1200)
Mt = 2968.23 N.mm

3.3 Tangential Force

Pt = (2 x Mt) / dg
Pt = (2 x Π x 2968.23) / (m x Zg)
Pt = (2 x Π x 2968.23) / (m x 60)
Pt = (98.41/m) N

3.4 Effective Load

Peff = (Cs x Pt) / Cv   Considering V = 5 m/s
Cv = (3) / (3 + V)
= (3) / (3 + 5)
= (3) / 8
= 0.375
Considering Cs = 1.5
Cs = (Starting torque) / (Related torque)
Peff = (1.5 x 98.941) / (0.375 x m)
Peff = (395.764/m)
Sb = mb x бbY
Y = 0.421 for Zg = 60
б b = (Sut) / 3 = (410) / 3
= 136.66 N/mm^2
b = 10 m
Sb = m^2 x 10 x 136.66 x 0.421
Sb = 575.33 m^2
Peff x F.O.S = 575.33 m^2
(395.764/m) x 1.5 = 575.33 m^2
m^3 = 1.03
m = 1
For actual model, let us consider module be 2
dg = m x Zg
= 2 x 60
dg = 120 mm
dp = m x Zp
= 2 x 20
dp = 40 mm
Gear Ratio is i = 1/3
(Zp/Zg) = 1 / 3
Zp = 60 / 3
Zp = 20

3.5 Cross checking

Mt = (60 x P) / (2 x Π x N)
Mt = (60 x 0.373 x 10^6) / (2 x Π x 1200)
Mt = 2968.23 N.mm

Peff = (Cs x Pt) / Cv
Peff = (1.5 x 49.47) / 0.375
Peff = 197.88 N

Pt = (2 x Mt) / dg
Pt = (2 x 2968.23) / 120
Pt = 49.47 N

Sb = mb x бbY
Sb = 2 x 10 x 2 x (410/3) x 0.421
Sb = 2301.46

Peff x F.O.S = 2301.46 m^2
F.O.S. = 2301.46 / 197.88
F.O.S. = 11.63

3.6 Finalized Gear/Pinion Specification

Table – 1: Gear/Pinion Specification

Parameter	Formula	Value
Addendum	1m	2
Dedendum	1.25m	2.5
Working depth	2m	4
Minimum total depth	2.25m	4.5
Total Thickness	1.5708m	3.1416
Minimum Clearance	0.25m	0.5
Fillet radius at rod	0.4m	0.8

3.7 Discharge Calculations

Q = Π / 2 x b x (da^2 - a^2)
Where,
Q = Discharge in cm^3/sec
b = Width of gear in cm = 2 cm
da = Dia. Of gear in cm = 5 cm
a = Centre distance in cm = 3 cm
Q = Π / 2 x b x (da^2 - a^2)
Q = Π / 2 x 2 x (5^2 - 3^2)
Q = Π x 16
Q = 50.24 cm^3/sec
But 1cm^3/sec = 0.060 lit per min

Q = 50.24 x 0.060
Q = 3.01 lit per min

3.8 Design of Frame

Frame design for safety for 25 x 25 x 3 mm square hollow mild steel channel:

b = 25 mm
d = 25 mm
t = 3 mm

Consider the maximum load on the frame to be 50 kg.

Force = W x g
= 50 kg x 9.81
= 490.5 N

Max. Bending moment = force x perpendicular distance of Square Bar Length
= 50 x 9.81 x 450
M = 220725 N-mm

M / I = (σ x b) / y

Where,
M = Bending moment
I = Moment of Inertia about axis of bending that is; Ixx
y = Distance of the layer at which the bending stress is consider
(We take always the maximum value of y)
E = Modulus of elasticity of beam material.
I = bd^3 / 12
= 25 x 25^3 / 12
I = 32552.08 mm^4
σb = M x y / I
= (220725 x 12.5) / 32552.08
σb = 84.76 N / mm^2

The allowable shear stress for material is;
σallow = Syt / FOS
Where,
Syt = yield stress = 210 MPa = 210 N/mm^2
FOS is factor of safety = 2
So,
σ allow = 210/2
= 105 MPa
= 105 N/mm^2

Comparing above results we get,
σb < σallow
i.e 84.76 < 105 N/mm^2

Therefore the design is safe.

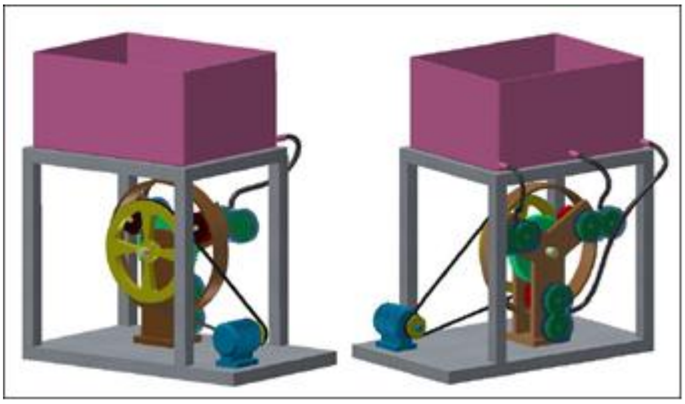

Fig – 3: 3D CAD model of Epi-Cyclic External Gear Pump

4. CONCLUSIONS

From the above results, conclusions drawn are;

1. Efficient cooling system for Heavy Machines can be designed using epi-cyclic gear train mechanism and external gear pumps.
2. Variable and maximum discharge of the fluid can be achieved by using this epi-cyclic gear train mechanism.

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