Design and fabrication of Low cost Minto wheel for Low duty industrial applications

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Abstract— In recent years usage of fuels and energy are being increased, this results in crisis for decades. Hence necessity for the invention of new alternative has been increased. The different ways proposed the ways to reduce the existing energy and to reuse the waste energy. This paper proposes a cheap and effective way of designing and fabricating of Minto wheel that may be effective to run low duty applications such as motors, compressors. Since Minto wheel has high torque it can be used in nuclear power plants for driving pumps. The design process starts by considering its top level objective and passing these criteria to its sub assembled designs. Finally the paper proposes outline of theoretical background of Minto wheel, working principle, various design parameters, innovative use of fabrication works and industrial implementation ways. The design process involves the design of chambers, selection of liquid, amount of heat addition, heat rejection, efficiency and many more. These sub design parameters helps in finding out head in which the cycle can be operated. The fabricated work involves usage of available materials in and around effectively. As a result final assembly of the engine meets the objective.

I. INTRODUCTION

Minto wheel is a heat engine developed by Minto Wally; initially Minto developed this engine with the aim of lifting entire liquid in the chamber by heating at bottom surface. Minto wheel operates at very low speed. This is normally 5 rpm. The criterion that makes the engine to use in normal environment is that wheel possesses high torque when compared to other engine. Many analyses were made over this engine to increase the speed. The high torque can be made geared up to high speed by providing higher gear ratio. The basic wheel as generally built has some limitations in which most of designs tend to heat entire liquid present in the bottom tank so that time it takes to convert the entire fluid to higher chamber is high. Modifications are to be made in the transfer tube so that the fluid can be easily transferred to higher chamber. To increase the speed of rotation the transfer tubes can be increased. Also the rate of transfer influences the speed at which it rotates. Hence greater the surface area higher is the speed of rotation.

II. WORKING PRINCIPLE

Minto wheel works on the principle of pressure difference that exists between the chambers. The heat is supplied at the bottom of the chamber where the fluid in it changes its state from liquid to vapor. During the vaporization only part of liquid gets converted in to vapor and remaining liquid due to pressure exhibited by the vapor it moves to the upper chamber. The vaporized fluid as it moves through transfer tube to the upper chamber it gets condensed in to water. The water in the upper chamber due to gravity it makes chamber to move downward causing a cyclic revolution where by heat is converted in to mechanical energy. Greater the surface area greater is the speed of rotation. Hence speed depends on the selection of chamber. The working can be clearly seen in the figure below.

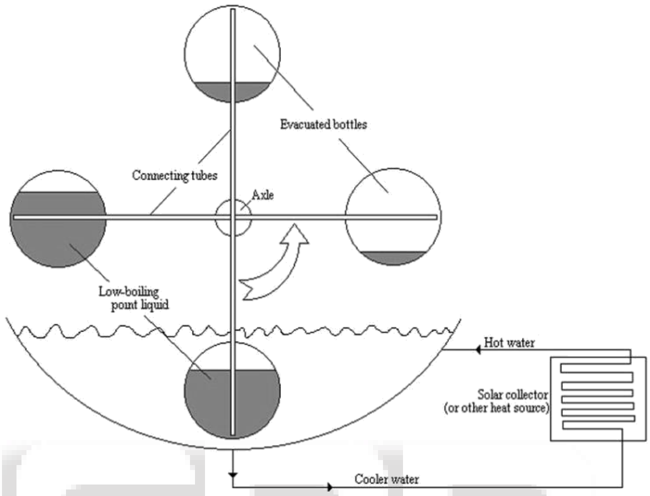

Fig. 1: Working principle of Minto wheel

III. SELECTION OF COMPONENTS

A. *Selection of fluids*

Fluids operating at the required temperature is the criteria for high efficiency of wheel hence Chambers containing the fluid should possesses properties such as low boiling point, high pouring point, easily vaporizable, easily condensable, low latent heat of vaporization. Fluid should possess low boiling point because many of the inputs to the chamber should be maintained at low temperature so as to conserve energy.

The following table gives the comparison of boiling point, cost per liter, availability of the fluids based on the survey. The fluids that are readily available are designated as good whereas lower one is designated as poor.

Liquids	Boiling point	Cost	Availability
Acetone	50.5	Medium	Good
Carbon bi sulphide	47.8	Low	Poor
Di-ethyl ether	35.7	Low	Good
Freon refrigerant R-11	23.8	High	poor
Methylene chloride	39.8	Medium	Poor
Water	100	Low	Good

Table. 1: properties of different liquids

Fluid that is to be chosen should not have a negative boiling point because heat required to convert liquid to vapor will be high, also time required for the transformation is high. Hence it is not favourable

From the above table it is clear that di ethyl ether has desired properties which suits for cycle. Even though Freon refrigerant has lower boiling point compared to di ethyl ether the availability and cost of the fluid is not desirable. Hence di-ethyl ether is chosen.

B. Selection of chamber

Properties -------------- Material	**Power loss due to weight**	**Thermal Conductivity ($W \cdot m^{-1} \cdot K^{-1}$)**	**Thermal Expansion ($\mu m \cdot m^{-1} \cdot K^{-1}$)**
Aluminium	Moderate	237	23.1
Stainless Steel	High	19	17
Glass Bulb	Very low	1.05	10.8
Copper	Moderate	401	16.5
Mild Steel	Very high	147	14

Table. 2: Properties of various materials

Selection of chamber plays a vital role in conductivity of heat from source to fluid. The properties such as thermal conductivity, thermal expansion and power loss due to weight are the important criteria in selecting the materials.

In selection of chamber material power loss plays a role. Material of less weight is to be chosen so that power loss can be minimized. Of all the materials glass has lower power loss hence it has been chosen even though its thermal conductivity is less. Though copper has a high thermal conductivity its power loss due to weight is high when compared to other materials. Also the cost associated is high. Hence glass material is chosen.

Selection of transfer tube involves same criteria as of chamber hence glass material which has low power loss due to weigh is chosen.

C. Selection of shape of chamber

Shape of chamber plays a dominant role in heat transfer. In order to have a maximum heat transfer and less power loss due to weight chamber are so chosen that it also possesses more surface to weight ratio. For the above requirement spherical shape is preferable.

IV. DESIGN CALCULATIONS

A. Calculation of working head

For Diethyl Ether

@ 20^0C Vapour Pressure of a fluid= 0.58134 bar (Calculated by Antoine equation)

@ 60^0C Vapour Pressure of a fluid= 2.157 bar (Calculated by Antoine equation)

Area= $\pi r^2 = \pi*0.01^2 = 3.1415*10^{-4}$

$F_{net} = (P_{bot}-P_{top})*Area$

$= (2.157-0.54134)10^5*3.14*10^{-4}$

$F_{net} = 50.75$N

$F_{gravity} = m*g$

= volume * density

= Head*Area*density

= $h*3.1418*10^{-4}*713.4*9.81$

$F_{gravity}= 2.1975*h$

$F_{net} = F_{gravity}$

$50.75 = 2.1975*h$

h=22m

Design conclusion

By above design calculations we conclude that the fluid operating between temperature 20^0C & 60^0C is capable of lifting the fluid to a height of 22m. But as for us economic considerations and complexity in fabrication we are planned to operate the fluid for a height of 0.6m.

B. Calculation of angle between two transfer tubes

Number of Bulbs =8

Number of Transfer tubes=4

Angle between transfer tube= 360/8 = 45^0

C. Calculation of efficiency

Efficiency $= 1-(T_2/T_1)$

$= 1-(20/60)$

Efficiency = 66.67%

D. Calculation of heat transfer

$T_m = (T_s+T_\infty)/2$

$T_m = (60+20)/2$

$T_m= 40^0C$

$Pr = (C_p*\mu)/k$

$Pr = (120.21*2.549*10^{-4})/0.01609$

Pr= 1.93

$Gr = (g\beta\Delta T L^3\rho^2)/\mu^2$

$Gr = (9.81*(1/313)*0.01^3 687.20^2)/(2.549*10^{-4})^2$

$Gr = 7.12*10^7$

$Gr*Pr= 1.37*10^8$

$Nu = c\ (GrPr)^m$

$Nu = 0.125*(1.72*10^{13})^{0.333}$

Nu = 64.132

H = Nu*k/L

h = 64.132*0.01609/0.01

h = 103.169 W/m^2K

$q=hA\Delta T$

q=103.169*0.01*40

q=41.26 W

E. Calculation of power

Torque produced = gravity force * wheel diameter

= 50.75 * 0.3

= 15.225 Nm

Speed = 5 r.p.m

Power = (2*π*N*T)/60

Power produced = 7.97KW

V. MODELING

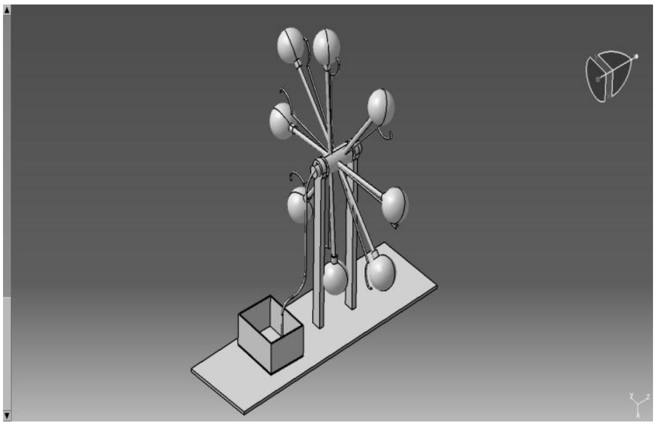

Fig. 2: Catia model of Minto wheel

The above figure represents isometric view of Minto wheel.

VI. FABRICATION TECHNIQUE

Spherical shaped glass is used as chamber. It is actually fabricated using glass blowing. Since our aim is to reduce the cost and to use the existing materials an incandescent bulb is used as an alternate for the above spherical bulb. Similarly burette tubes that are made of glass acts as transfer tubes. Four sets of transfer tubes are placed at an angle of 45° each as per calculation.

In order to reduce the cycle time the design is so modified to condensate the vapor at faster rate. The cooling tubes are to be provided over the bulb surface and water is to be circulated when bulbs are set to reach upper end

The finished model is shown in figure below

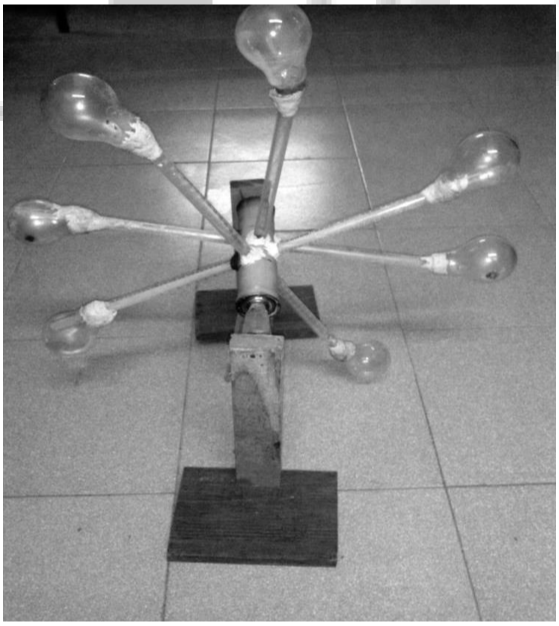

Fig. 3: Fabrication model

VII. IMPLEMENTATION OF MINTO WHEEL FOR INDUSTRIAL PROBLEMS

- Minto wheel can run directly on any available heat source, not just one produced by combustion, so they can run on heat from solar, geothermal, biological, nuclear sources or waste heat from industrial processes.
- Alternate for motors: In industries, instead of using motors the pumps, compressors and low power machines are directly run with the help of Minto wheel by utilizing waste heat as heat source.
- Further investigational study is required to find out the ways to implement the Minto wheel in high torque end applications.

VIII. COST ESTIMATION

Sr. NO	PART	MATERIAL	QUANTITY	COST (INDIAN RUPEES)
1	Chamber	Glass	8	300
2	Transfer tube	Glass	4	400
3	Supports	Wood	2	100
4	Bearing	Iron(iron plates)	2	100
5	Fluid	Di-ethyl ether	500ml	450
6	Total			1350

Table. 3: Cost Estimation

IX. CONCLUSION

Even though the speed of the Minto wheel is less it can be still used in low duty applications by using high gear ratio and convert it to nominal speed. The engine is so named for its torque hence it can be used in high torque applications. Hence the objective of designing and manufacturing of engine was successful and can be implemented as a replacement to low power motors. It's been proved that running cost of the engine is also very less this will help to minimize the usage of fuel.

ACKNOWLEDGEMENT

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