CHAPTER 1
INTRODUCTION

The report presents the design of a hybrid disc type turbine-pump; this system integrates Fluid transportation and power generation unit in a single circular system. The first phase presents, design and model of the turbine-pump using computer aided design, and in the second phase simulation of fluid flow in the system through computer fluid dynamics is summarized.

Turbine plays the major role in any power generation system; mostly in the form of impulse and reaction type. Viscous drag disc type is one of the oldest and most economical, easy to manufacture, compact type turbine available in the world, since effective nozzle design is complicated, the usage is less when compare to other types. For high viscous liquid handling disc pump is superior when compare to centrifugal type. This paper presents the integration of both type and forms a platform for further research

1.1. HISTORICAL BACKGROUND OF TESLA TURBINE

In 1913 Nikola Tesla patented a turbine without blades that uses a series of rotating discs to convert energy of fluid flow to mechanical rotation, which can be used to perform useful work. A Tesla turbine is made of a set of parallel discs with nozzles, through which gas or liquid enters toward the edge of the discs. Due to viscosity, momentum exchange takes place between fluid and discs. As fluid slows down and adds energy to the discs, it spirals to the center due to pressure and velocity, where it is exhausted. As discs commence to rotate and their speed increases, steam now travels in longer spiral paths because of larger centrifugal force. Fluid used can be steam or a mixed fluid (products of combustion). Discs and washers, that separate discs, are fitted on a sleeve, threaded at the end and nuts are used to hold thick end-plates together. The sleeve has a hole that fits tightly on the shaft. Discs are not rigidly joined, so each disc can expand or contract (due to centrifugal force and varying temperature) freely. The rotor is mounted in a casing, which is provided with two inlet nozzles, one for use in running clockwise and other anticlockwise. Openings are cut out at the central portion of the discs and these communicate directly with exhaust ports formed in the side of the casing. In a pump, centrifugal force assists in expulsion of fluid. On the contrary, in a turbine centrifugal force opposes fluid flow that moves toward canter.

1.2. HISTORICAL BACKGROUND OF TESLA PUMP

Tesla designed, built, developed and tested such machines but was not able to achieve industrial applications of them. Tesla-type turbo machinery probably cannot prove competitive in an application in which more conventional machines have adequate efficiency and performance. Thus, cannot be expected to displace conventional water pumps or conventional water turbines or gas turbines. In research author has insisted that it should be further investigated for applications to produce power from geothermal steam and particle-laden industrial gas flows. There may also be unique applications possible using ceramic discs. There is considerable evidence that multiple disc turbo machinery can be quieter in operation than is conventional machinery and that the noise is more nearly white without a prevailing

ADVANTAGES

In disc turbine pump, use of different kind of exotics fluids with particles, droplets, multiphase is possible. More stable flow and lower cavitation occurrence. It can turn at much higher speeds with total safety. Tesla disk is the double clockwise and anticlockwise direction of rotation in a single machine. It can be used for lifting highly viscous fluids, viscosities up to several 10000cP. Little wear from abrasion during pumping, slurries containing up to 80% solids by volume can be pumped without clogging the system. Cavitation will not occur so greater life for machine parts

DISADVANTAGES

The main disadvantages of disc turbine pump is high speed but low torque. Experimentally it has been found that there is many difficulties to achieve high efficiencies in nozzles and rotors of turbine pump. Proof of this pump's overall efficiency compared to conventional turbines is still questionable and needs more research. sound signature.

1.4 APPLICATION OF DISC TURBINE PUMP

Main applications include geothermal applications. In chemical, oil & petrochemical processing to pump crystal slurries, dimensioned tar, oil and sand slurry. In pulp & paper manufacturing to pump black liquor soap, paper coatings, fly ash. Another application is waste water treatment & disposal applications such as to pump lime sludge, sand slurry, carbon black slurry. It is inevitable in food & sanitary applications to pump sugar slurries, crystal shell slurries, and chicken processing waste. It is used in mining & environmental cleanup to pump borax, diatomaceous earth, steel, slag, drilling mud etc.… also it has an important application in medical field as multiple disc centrifugal blood pump to pump blood.

CHAPTER 2

PROBLEM DESCRIPTION

Tesla pumps have great application in lifting highly viscous fluids. Ordinary pumps like reciprocating pumps, centrifugal pumps, and gear pumps lack many advantages than tesla pumps.

Some of the disadvantages of these pumps over tesla pumps are listed below:

1. Difficulty in pumping highly viscous fluids consisting of solid particles cannot be pumped by positive displacement pumps.
2. Difficulty in pumping highly abrasive slurries, viscous slurries, slurries with high solid contents, fluids with entrained air, fluids with shear sensitive or delicate products.
3. High maintenance.

But hybridisation of tesla pump with tesla tesla turbine is more advantageous than tesla pumps because it overcomes the below mentioned disadvantages of the tesla pump.

1. Decreased pressure at outlet.
2. Decreased outlet head and efficiency.

CHAPTER 3

LITERATURE REVIEW

The disc turbine-pump is operating under the principle of boundary layer effect, since there is no straight forward design system for disc components, it is very important to refer many research works developed over the century for design, and still the design is open for selection and experiment. One good method is design of experiment based numerical simulation, but it is time consuming for the present scenario, so based on the evaluation of many research papers the design is arrived and experiment for study.

P. Lampart & L.Jedrzejewski (1) We have learn about, The compressor draws the air into a recuperator which acts as an air-to-air heat exchanger, recovering the heat from exhaust gas. Developed it while trying to make an engine that was light enough to power his ultimate goal of building a “flying machine”

Dr. SMG. Akela (2) We have learnt about, Turbines work by converting the kinetic energy of a fluid into another form of energy. The blades in turn rotate a generator, which converts the rotational energy into electricity.

D. Amal Raju (3) We have learnt about, both pump and turbine are operand purely on the hain of boundary layer effect and viscos drag the und layer closer to the inner disc surfaces in the inter spacing are almost stationary from the external peint of view, but they are a higher velocity.

Borate H.P &Missal N.D(4) We have learnt about, “An Effect of Surface Finish and Spacing between discs on the Performance of Disc. but it is time consuming for the present scenario, so based on the evaluation of many research papers the design is arrived and experiment for study.

D.Sturge, D.Sobotta,(5) We have learnt about, “A new technique of extracting the data collected from the actuator disc method and applying it upstream of a high fidelity turbine. The actuator disc method will be used to replicate the far wake region of a turbine.

CHAPTER 4

SYSTEM DESIGN

4.1 DESIGN

The hybrid design incorporates a disc pack made up off circular discs, placed with uniform gap between them in tandem and fitted to a circular flange by means of bolts. The flange is coupled with a shaft which passes through a sealing and bearing to a mechanical coupling. The coupling can be used to connect the hybrid disc turbine to an AC electric and DC drive respectively for pumping and turbine operation.

4.2 CONFIGURATION DETAILS

The discs are made of mild steel, with 90 mm outside diameter and 2 mm thickness with a hole in their centre for fluid passage, which is equal to the diameter of the inlet. Discs are packed in tandem with a gap of 1 mm between them through aluminium spacer and fastened with a circular flange through three bolts angularly spaced in 120° each. A mild steel shaft is coupled with flange and fitted into bearing block. This shaft is then coupled with AC or DC drives for pump and turbine operation respectively. This prototype consists of an AC 0.25 HP electric motor and a 36 watts DC drive. Theses drives can be coupled to the hybrid system according to their operation.25 mm inlet and 15 mm outlet is given for pump, the same outlet is used for turbine and the inlets of the turbine are placed tangentially and diagonally to each other in the top and bottom of the system.

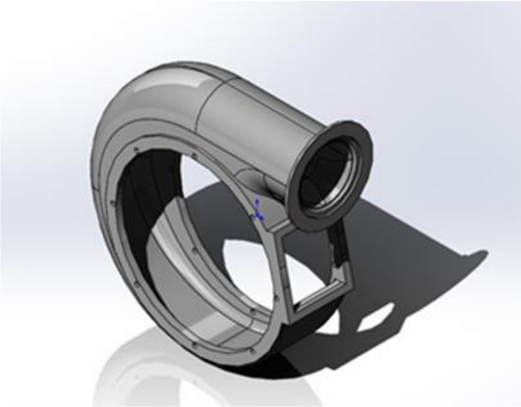

Fig 4.1Scroll Casing

The above figure show the casing with inlet in the front face and outlet at the top for pump and in the side face on the inlet for the turbine.

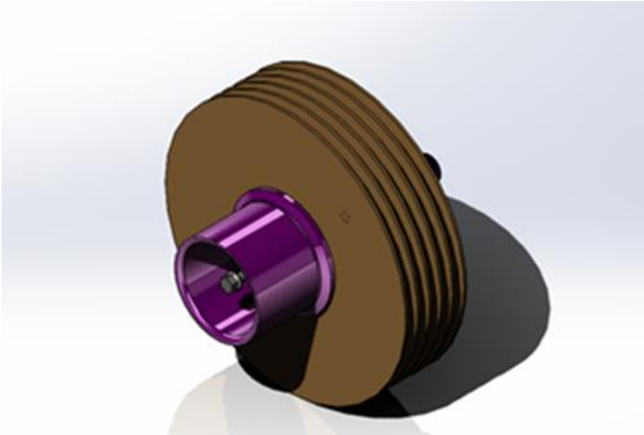

Fig 4.2 Disc Pack

The above figure shows the disc pack assembly with drive shaft.

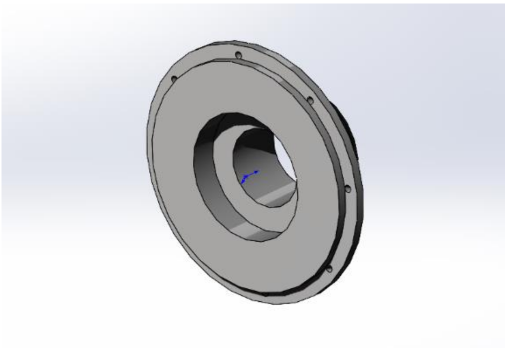

Fig 4.3 Bearing block

The above figure show the bearing block for the system and it also provide the spaced for the mechanical sealing.

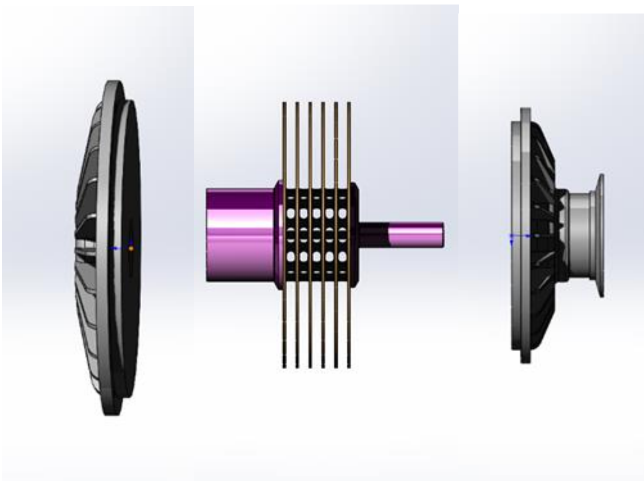

Fig 4.4 Turbine pump exploded and assembled views

The above figures show the exploded and actual assembly of the hybrid turbine pump.

CHAPTER 5

WORKING PRINCIPLE

Both pump and turbine are operated purely on the basis of boundary layer effect and viscous drag. The fluid layer closer to the inner disc surfaces in the inter disc spacing are almost stationary from the external point of view, but they are at highest velocity, the energy is transferred to the adjacent layers and the middle layer between the two disc is having the maximum velocity by viscous drag principle.

The fluids contained between the discs are the volume that is transfer to the outlet and means the actual pumping. Turbine operates on the same principle and depends on the velocity of the impinging fluid on the disc periphery surface. The operative fluid of the turbine enters into the two inlets and rotates the turbine and then leaves through the inlet of the pump. The outlet of the pump is closed to entertain more fluid in that location by the top turbine inlet.

CHAPTER 6

EXPERIMENTAL TESTING AND RESULT

6.1 TESTING OF PUMP

Pump is tested to variable head from 1to 10m. Head against discharge is observed and the result is plotted. A one-meter suction lift is used in the testing; the discharge head is the total head minus the suction head. Pipe friction losses are taken into account and it is 1 meter per 10 meter for the selected pipe system. The observed values are tabulated and plotted down here.

Table 6.1 Experimental (Q vs H) values

Head (m)	Q (lpm)
1	59.478
2	50.024
3	41.033
4	32.535
5	25.263
6	18.434
7	12.105
8	6.733
9	2.839
10	1.890

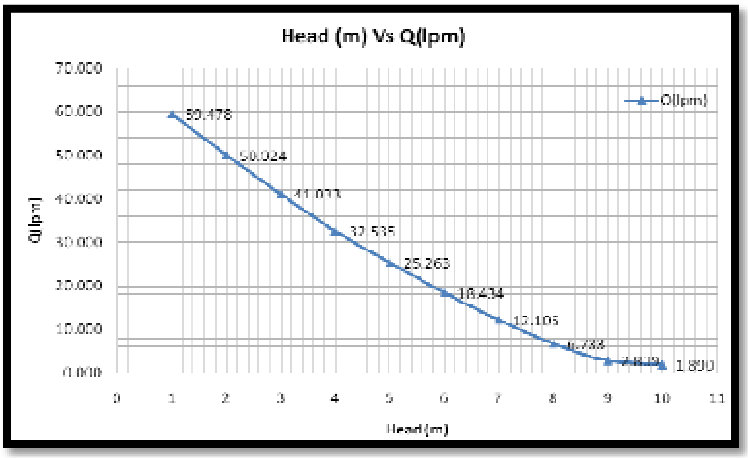

Fig 6.1 Head (m) vs Q (lpm)

The pump shut off at 10.2 m, the performance curve forms a base for further investigation on the pump.

6.2 TESTING OF TURBINE

A flow control valve is used to get the required air flow rate; theoretically the required angular velocity can be achieved by the following manner and the same is achieved with the flow control valve. At maximum RPM a DC motor will produce its maximum power. For example, a 3 ampere 12-volt DC motor running at 1440 RPM. This motor will produce 36 watts maximum. The RPM at different flow rate is obtained and plotted.

Table 6.2 Q vs RPM

Q(m^3/s)	RPM
0.00833	167.64
0.0166	335.29
0.025	502.93
0.033	670.57
0.04166	838.22
0.05	1005.86
0.0583	1173.50
0.066	1341.15
0.075	1440.06

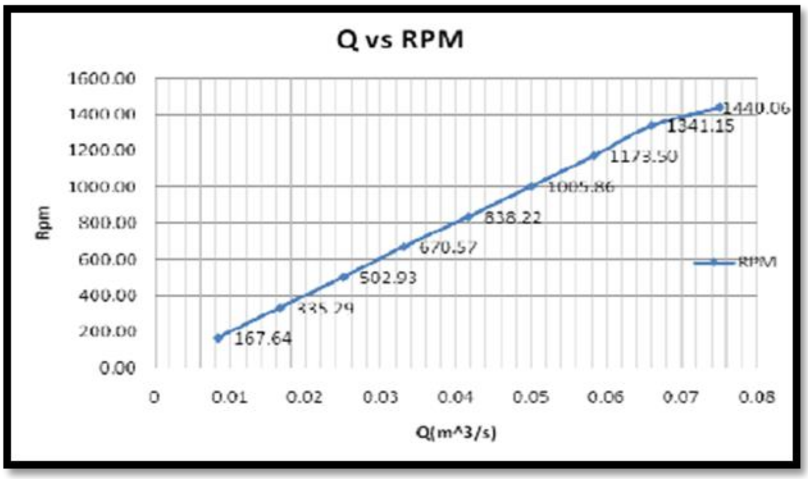

Fig 6.2 Q vs RPM

By controlling the mass flow, the velocity is adjusted at the outlet and the desired angular velocity of the turbine is achieved. This is a reverse operation to obtain the required speed for the DC motor or drive to get the required power or suit to the available DC system.

CHAPTER 7

SIMULATION

7.1 OVERVIEW

Flow simulation using Cosmos flow is presented in this section. Simplified model of the pump system is taken for the flow analysis for the pump system. The pump is simulated for head range of 2 to10 m with 1 m interval, the head versus discharge is plotted and various key parameters at specific locations were studied to understand the flow characters of the pump. The simulation configurations are shown in the flowing figures.

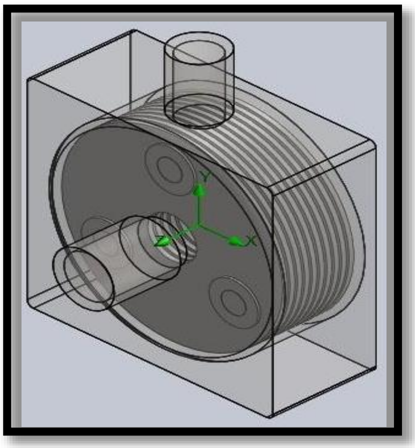

Figure 7.1 Simulation Model

The above shows the simulation model of the pump. The model consists of casing, inlet, outlet and disc pack with simplified fastener model.

7.2 SIMULATION CONFIGURATION

No. of discs: 10

Inlet Pressure: Environmental Pressure

Outlet Pressure: 20000 to 100000 Pa

RPM: 1440

Flow simulation doesn’t account the leakage losses, frictional losses and actual manufacturing accuracy of the hybrid turbine pump system. The simulation results will vary to the experimental by the effect of the above-mentioned parameters. This forms a foundation to make factors for parameters in further simulation-based research works. The below figure shows the boundary condition for the flow simulation.

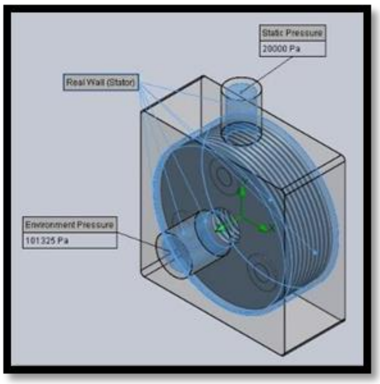

Fig 7.2.Boundary Conditions

7.3 SIMULATION RESULTS AND FINDINGS

Simulation is conducted in the head range of 2m to 10 m and a detailed study of pump flow character is given in the following section.

7.3.1. HEAD vs DISCHARGE

The flow simulation conducted in the range of 2m head to 10m head. For each head the discharge is obtained. The results are plotted to get an understanding of the pump performance. Since the losses on the actual system are unaccountable in the simulation it is clear that the obtained result is the maximum in the flow simulation. The percentage difference to the experimental will produce the head losses due to mechanical, piping, sealing and other factors.

Table 7.1 Head (m) vs Q (lpm)

Head (m)	Q(lpm)
1	66.09
2	62.53
3	58.62
4	54.22
5	50.53
6	46.09
7	40.35
8	33.66
9	28.39
10	21.46

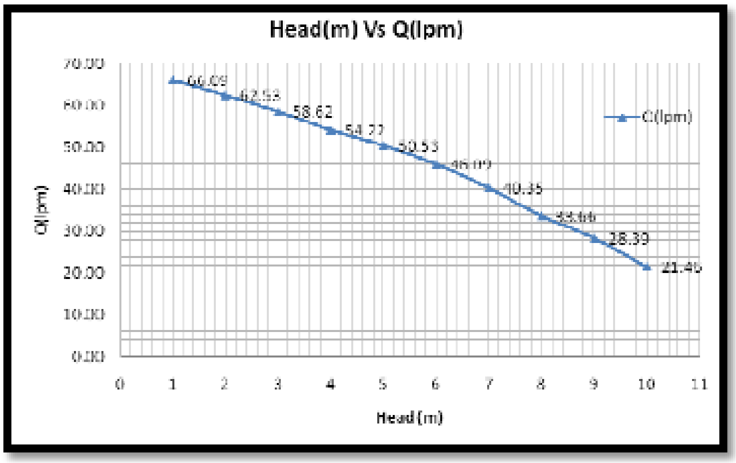

Fig 7.3 Head (m) vs Q(lpm)

7.3.2. STUDY OF VELOCITY

The velocity at the outlet is shown in the following figure, the flow produces a vortex in the outlet, it is evident that the pressure is formed by the boundary layer effect and it is important to make a design that collects the pressure effectively to produce more head effectively. And a volute casing design would ease out this problem and is proposed for the further research.

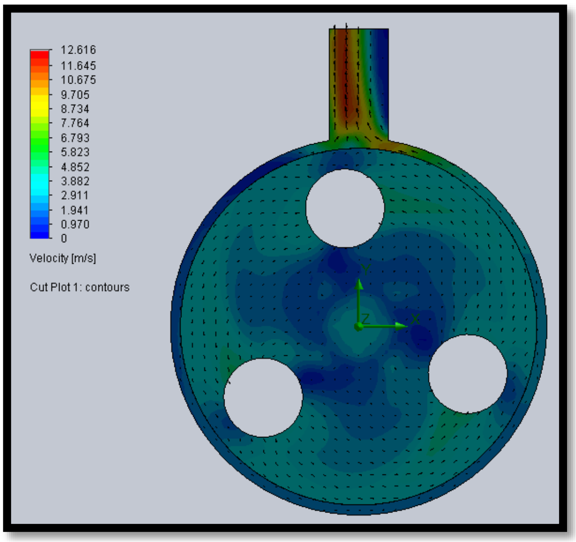

Fig 7.4 Velocity Plot

7.3.3. STUDY OF PRESSURE

The pressure in the casing is higher, the centrifugal force by the disc to the fluid produce high pressure inside the casing and it should be effectively transferred to make a higher head of delivery by the pump.

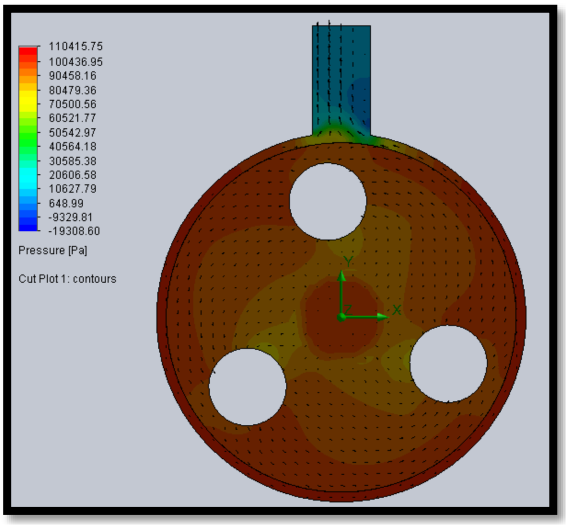

Figure 7.5 Pressure Plot

7.3.4. TURBINE OUTPUT RPM- THEORETICAL

The following table and charts shows the theoretical maximum RPM of the turbine with respect to air flow rate.

Table 7.2 Flow Rate (Q) vs RPM

Q(m^3/s)	Rpm
0.00833	184.41
0.0166	385.58
0.025	603.52
0.033	838.22
0.04166	1089.68
0.05	1357.91
0.0583	1642.90
0.066	1944.66
0.075	2160.08

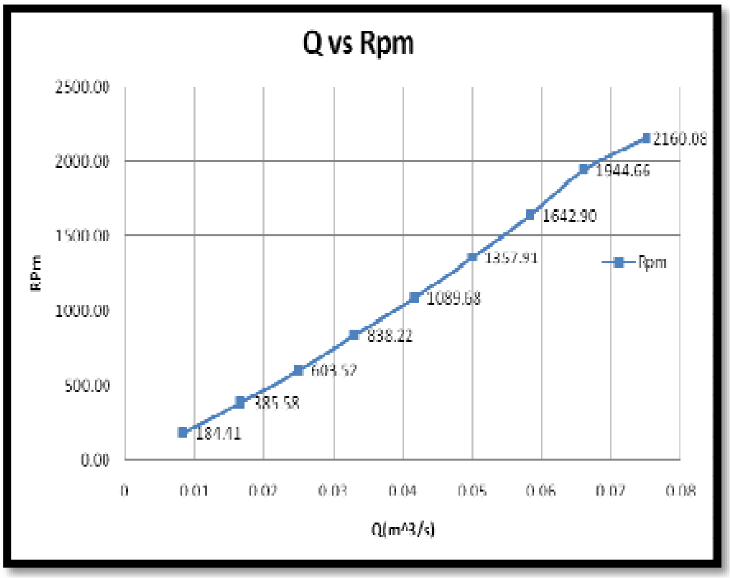

Fig 7.6 Q vs RPM

CHAPTER 8

RESULT COMPARISON

The experimental and simulation results are compared and presented in this session. The discharge decline in a linear manner and shows that the losses due to the friction, pumping, sealing in the actual model plays the key role in between these two. The location of the pump outlet decides the head in this case, so it is recommended to make the casing as volute to collect the pressure built up by the disc. The turbine also requires effective nozzle design to make the flow in an efficient way to produce best power output.

Table 8.1 Comparison Table

Head (m)	Simulation Results - Discharge (lpm)	Experimental Results - Discharge (lpm)	Percent. Decline in Discharge
1	66.09	59.478	10.00
2	62.53	50.024	20.00
3	58.62	41.033	30.00
4	54.22	32.535	40.00
5	50.53	25.263	50.00
6	46.09	18.434	60.00
7	40.35	12.105	70.00
8	33.66	6.733	80.00
9	28.39	2.839	90.00
10	21.46	1.890	91.19

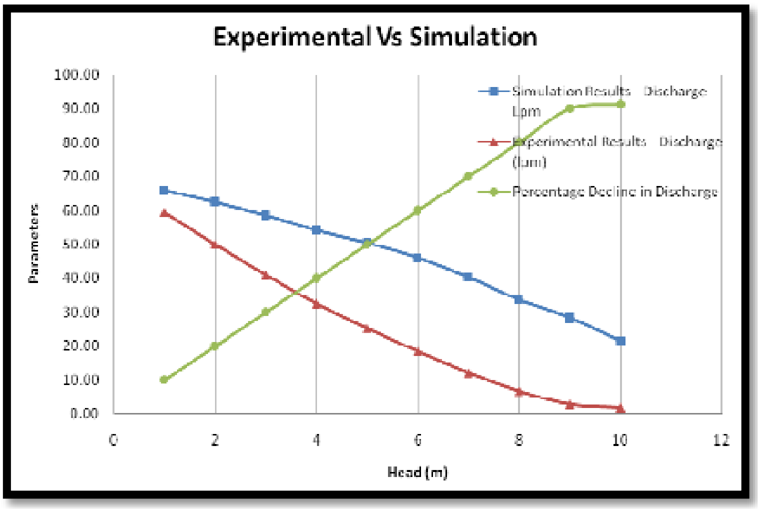

Figure 8.1 Experimental vs Simulation

CHAPTERS 9

PART MODELING OF MAIN COMPONENTS & EXPLANATION

9.1. Scroll

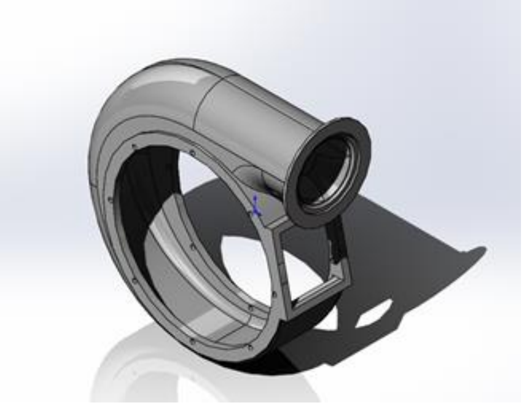

Fig 9.1

The spiral casing around the runner of the turbine is known as the volute casing or scroll case. Throughout its length, it has numerous openings at regular intervals to allow the working fluid to impinge on the blades of the runner. ... Runner blades: Runner blades are the heart of any turbine

9.2. Disk set

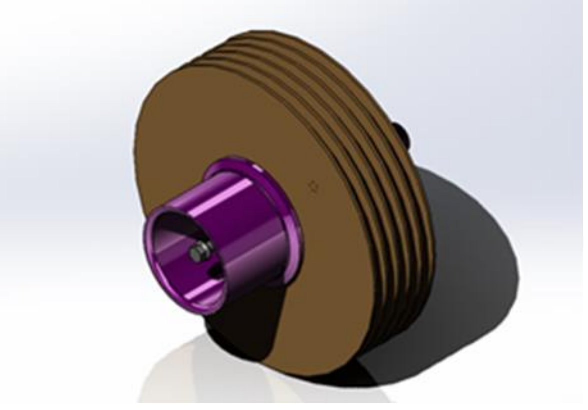

Fig 9.2

The drum or the disc to which the turbine blades are attached. It is forged and then machined with an integral shaft or flange onto which the shaft may be bolted. To limit the effect of heat conduction from the turbine blades to the disc, a flow of cooling air is passed across both sides of each disc.

9.3. Intake spindle

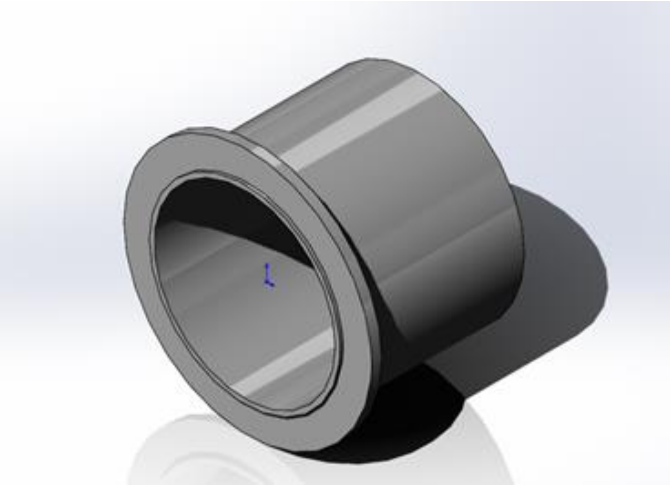

Fig 9.3

Turbine Spindles maintain high speed and torque under load using a patented turbine governor. At governed 25,000 - 90,000 rpm to 1.40 hp (1.04 kW), these powerful spindles have only 2 moving parts – patented turbines and ceramic bearings cooled by airflow.

9.4. Ring

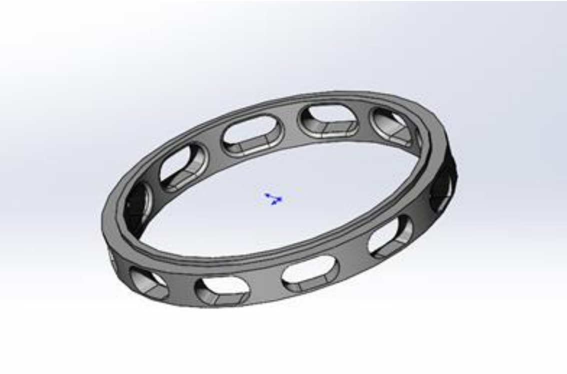

Fig 9.4

When an electric pitch system is used the slip ring is providing power to the motors that pitch the blades and also allowing communication to the hub. In the turbines that use a hydraulic pitch system, the slip ring is providing signals to the hub to control the hydraulic valves along with data transfer.

9.5. Thrust bearing

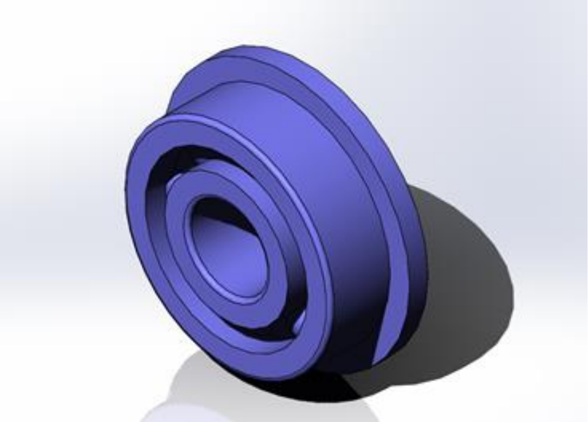

Fig 9.5

It is an axial bearing that permits rotation between parts. Thrust bearings support the axial thrust of both horizontal and vertical shafts. The functions are to prevent the shaft from drifting in the axial direction and to transfer thrust loads applied on the shaft.

9.6. Disk Type Hybrid Turbine Pump Assembly

Fig 9.6

. Turbine operates on the same principle and depends on the velocity of the impinging fluid on the disc periphery surface. The operative fluid of the turbine enters into the two inlets and rotates the turbine and then leaves through the inlet of the pump. The outlet of the pump is closed to entertain more fluid in that location by the top turbine inlet.

CHAPTER 11

CONCLUSION

The comparative study of experimental and simulation results show that the disc pump is more suitable for high viscous liquids than low incompressible liquids. Since this works on the principle of boundary layer effect, it is more suitable for high viscous fluids. For turbine, it requires effective nozzle design to produce more efficient output, this is an innovative prototype to integrate two different type of hydraulic machines. This forms a base for new application levels and researches.

CHAPTER 12

REFERENCE

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2. **Danny Blanchard, Phil Ligroin, Bruce Gale.** “Single-disc and double- disc viscous, Micro pumps” -volume 122,Issue 1,29 july 2005.

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