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Design and Analysis of in-pipe Water Generation from Spherical Turbine

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ABSTRACT: This generation requires an environmentally friendly electrical power producing technology. This project is about a novel way to generate electricity by using the flow of sewage waste liquid as the energy source for running turbines, which then drive electrical power generators. The goal is to construct a self-sustaining system that generates electricity using the kinetic and pressure energy of water flowing through turbine assemblies that include spherical turbines linked to generators that are sequentially situated in each water channel.Fast-growing cities, particularly in emerging nations, provide a problem for present energy consumption. Micro-turbines, rather than lowering pressure valves in urban water pipes, might help with energy delivery to the electrical grid. Understanding turbine design and operational parameters can aid in energy harvesting efficiency in these cities. We will investigate the needed process parameters, design requirements, operating parameters, implementation cost, and power producing capacity of a spherical turbine in-pipe water power generator in this research activity.

KEYWORDS: n-pipesystem,energy harvesting,turbine system.

I. INTRODUCTION

Thewaterflowingthroughpipe,especiallyverticallydownwards,possesses alotofenergyin form of kinetic and pressure energy. The flow rate inside the pipe always remainsconstant.Andinmanycases,theend-userrequirementisjustflow-rateandnotthepressure.Hence, a part of the pressure energy can be extracted and stored in the form of electricalenergy. The turbines available till now occupied a large amount of cross-sectional area inpipe. Hence as the area reduces the pressure energy gets converted into kinetic energy.Hence velocity increases. And the spherical turbine is the most efficient way to extractpressure energyfromthepipe-flow.

The great variety in the size of hydropower plants allows this technology to adapt to bothlarge centralized and small-scale urbans distributed energy model needs. Recently, thanksto the development of small hydro turbines, compact and specified for urban use, it ispossible to harness water power for on-site energy generation or domestic production orindustrial and agricultural districts. Water possess a lot of energy which is in the form ofkineticandpressureenergyflowingverticallythroughpipe.Thetur-binesworkingtilldateoccupies a large amount of cross-sectional area in pipe. When the area reduces, it convertspressure energy into kinetic energy which results in increase of velocity-ty. This velocityofwaterisutilizedinin-pipeturbineandusedforgeneratingelectricity.

Hydropowerisconsideredasadevelopedandacost-competitiverenewableenergysource,in which energy and water are linked strongly together. Indeed, significant energy is usedto deliver the water to the consumers throughout the distribution system. This excessiveenergy might damage the transporting pipes at some points due to the extra pressure.Therefore, pressure valves are used to reduce the pressure in these pipes to proper levels.The excess pressure points can be exploited by generating clean energy that suppliesdifferent loads near to these points. The inclusion of the turbines in the distribution pipewillreducethesystemcostsignificantlyduetonotusingpressurevalves.Inthistechnology, the pipe is equipped with a turbine, which is connected to a generator, whichis mounted on top of the pipe. The generated energy from the in-pipe system is known intheliteratureby in-pipehydropower.

As India is progressing its power needs are increasing day by day. With uncontrolledelectricity shortages in outlying villages and remote areas, it would be ideal to exploit themicro-hydro potential of water pipes to produce electricity. However, the use of compactturbinesgeneratinghalf½to1kWpowerisdesiredandsuchaturbineneedstobedesignedand put

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to practical use. This alternate source of power would be available all the time.Water Pipe line network is vast and extensive in areas where farming is done. Pipes areused in conveying water from reservoirs and dams to different parts of the country. Thissetup aims at using the force of the moving water in pipes to generate electricity that canbe either stored or immediately used in nearby areas. This paper shows the technique usedforthesame

II. LITERATURE SERVEY

Hani Muhsen, Mariam Ibrahim, Ahmad Alsheikh, Mohammed Qanadilo, and Abdallah Karadsheh Turbine Design and Its Impact on Energy Harvesting from In- Pipe Hydro Systems International Journal of Mechanical Engineering and Robotics Research Vol. 8, No. 5, September 2019

Inrecentyearswirelesssensorsarebecomingmorewidelyusedtomonitorwaterdistributionsystemsinthewatersupplyindustry.Whensensorsareinstalledinareaswhereelectricpowersupplyislackingand/orbatteryreplacementisdifficult,harvestingrenewable energy from the water distribution systems or the environment would be anattractiveoption.Thisworkstudiesthefeasibilityofenergyharvestinginwaterdistributionsystems from hydraulic energy in bypass water pipes, thermal energy in the water-airtemperature gradient, and kinetic energy in the water pressure fluctuation. The energyharvestingsystems aremodelledand thenanalysedbyusingsimulateddataandrealdata.

Harvesting energy from in-pipe hydro systems at urban and building scale Marco Casini International Journal of Smart Grid and Clean Energy DOI: 10.12720/sgce.4.4.316-327

In addition to photovoltaic and wind systems, nowadays in-pipe water to wire powersystems are becoming particularly interesting for the integration of renewable resources aturbanandbuildingscale becauseofthepotentialtoharnesscleanenergyfromexcessheadpressureinurbananddomesticwaterpipelines.Abletooperate acrossawiderangeofheadand flow conditions, these particular micro hydro power systems can be deployed inmunicipalities, energy-intensive industries and agricultural irrigation districts providing aconsistentamountofcleanandcontinuousenergywithoutthetypicalintermittencyofwindand solar and at the same time helping in pipelines management and maintenance. Thearticlepresentsanoverviewofthedifferenttypesofin-pipehydrosystemsavailableonthemarket and illustrates their possible applications at the urban and building scale and thebenefits achievable in terms of energy production compared to other renewable such asphotovoltaicandwind systems.

Computational Fluid Dynamics Study on Water Flow in a Hollow Helical Pipe Ebrahim Ahmadloo1*, Najmeh Sobhanifar2, Fatemeh Sadat Hosseini3 Received 1 April 2014; revised 1 May 2014; accepted 8 May 2014

Although curved pipes are used in a wide range of applications, flow in curved pipes isrelatively less well known than that in straight ducts. This paper presents a computationalfluid dynamics study of isothermal laminar single-phase flow of water in a hollow helicalpipeatvariousReynoldsnumbers.TherangingofReynoldsnumbersoffluidwasfrom 703.2to1687.7.Thethree-dimensionalgoverningequationsformassandmomentumhavebeensolved.ItwasfoundthatwithincreasingReynoldsnumberandcreationofcentrifugalforces, a high velocity and pressure region occurs between two tubes, at the outer side ofthe hollow helical pipe walls. Friction factor decreases as the tendency for turbulenceincreases.

III. PART IMPLEMENTATION

Construction:

The spherical turbine Power System is a water-to-wire system that generates clean, renewable energy fromexcessheadpressureingravity-fedwaterpipelines.Spherical turbine converts water pressure to energy using aunique, lift based, vertical axis turbine installed within apipeline.Asingleunitcanproduce20–100kWofrenewable,zero-emissionselectricity,dependingontheflow and head pressure conditions at a given site. Multipleunits can be aggregated for a system that can produce morethanaMW.TheSphericalTurbinerotatesthesamedirection regardless of the direction of the water flow andcan accommodate flows in any direction through a pipeline.This means gravity fed water can pass through the system togenerate power, while when the pipeline is used to conveypumped water in the opposite direction, the system can bestoppedandtheimpactis virtually unnoticed.Typically,SphericalTurbinesystemsaredesignedtogenerate240volts,3-phaseACpower.Otherconfigurationsarepossible.

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SphericalTurbine:

A spherical turbine for any fluid type at anydepthorelevation,whichiscapableofunidirectionalrotation under reversible flow conditions, is disclosed. Asphericalturbineisadvantageousbecause,bydesign,italways remains symmetrical to flow, which is particularlyusefulinurbanareaswithtallbuildingsandinplanarregions where winds are unstable, e.g. Patagonia. Moreover,in the field of mechanical engineering, a spherical frame ispotentially the strongest and most reliable three-dimensionalframe.

The turbine includes a rotatable shaft that isadapted to rotate about an axis of rotation and turbine bladesupport members that are fixedly attached to the rotatableshaftandtoapluralityofmeridianturbineblades.Geographically,ameridianisanimaginaryarcontheEarth's surface that extends from the North Pole to the SouthPole.Inthisinvention,ameridianbladeisanarcedsectionlying on the surface of a non-solid sphere, extending from a“north”pointto adiametrically-opposite “south”point.

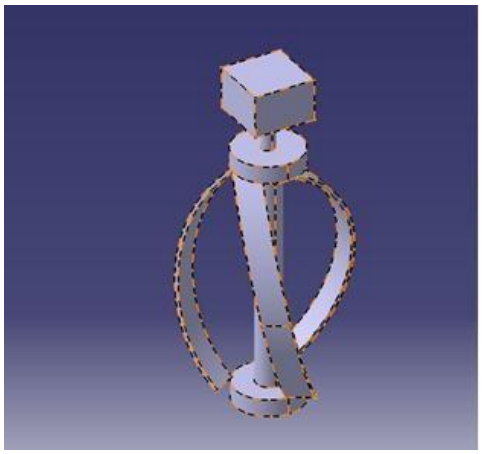

Fig. Spherical Turbine

Flow Velocity:
Water velocity is the most important indicator fordetermining the energy generating capacity of a pipeline.The power generated by the Pipe is proportional to the cubeof the water velocity. Water velocity helps determine theoptimal size of the Pipe system that can be operated in apipeline. Also factored in are the pipeline diameter, headpressurethatisavailableforextractionandthecapacityfactor(frequencyand duration ofwaterflow).

Flowwith Full Head:
Waterflowingwithfullpieisthebasicrequirementfortherotationofthesphericalturbineandgaining the maximum rotation possible. Ultimately it helpsinextractingmore energy.

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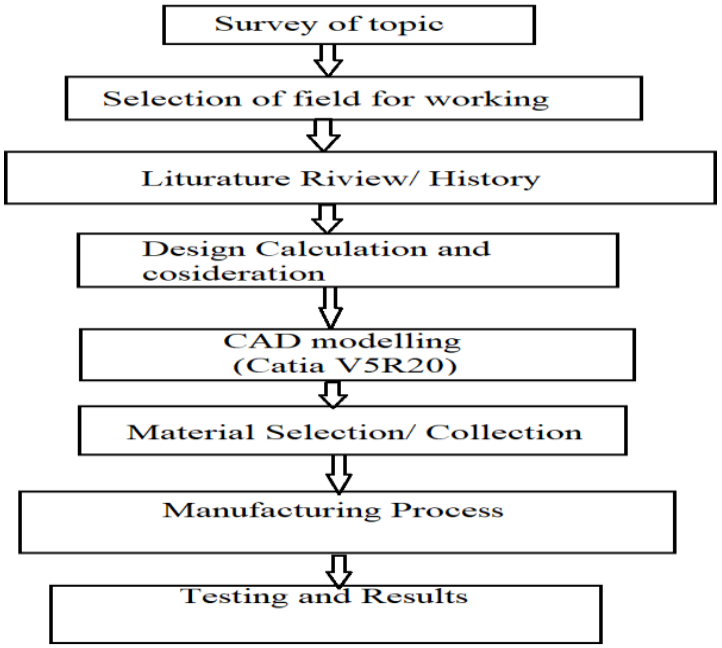
IV. METHODOLOGY



Methodology Flow Chart

HYDROPOWERCLASSIFICATIONBYCAPACITY:

Hydro Power plants capacities range from several watt (W) for the smallest individualinstallations, to tens of gigawatt (GW) for the largest. Depending on the installedcapacity,hydropower systems are classified into "large hydro" (over 10 MW) or "small hydro" (upto10MW).Smallsystemsareinturndividedin"mini-hydro"(upto1MW),"micro-hydro"(up to 100 kW) and "pico-hydro" (up to 5 kW). HPP with capacity lower than 10 MW areestimatedtorepresentabout10%oftheglobalHPPcapacity.Thesesize-basedsubdivisionsrepresent an average size reference as there is no global agreement between differentcountries on the classification of hydro systems according to the installed power, with theconsequencethatthedefinitionofsmall-scalehydrospansaverywiderangeofplantssizes.As shown in Table 1, various countries, or groups of countries, define ‘small hydro’differently,from below 1.5 MWinSwedento below50 MWinChina. This broad spectrum in definitions of size categories is motivated by local energy andresource management needs of different countries such as national licensing rules todeterminewhichauthorityisresponsibleforthe process.

Due to their ease of construction and integration into local environments, the deploymentofsmallhydropowersystemsisincreasinginmanypartsoftheworld,especiallyinremoteareas where other energy sources are not viable or not economically attractive. Amongsystems with power up to 100 kW (micro hydro), particularly interesting for the potentialof integration at urban and building scale are in-pipe hydro power systems. Designed forgravity fed and pressurized transmission and distribution lines as well as effluent outfallsand other pipe conveyance systems, these particular micro hydro systems may be locatedin municipal water or waste water systems, industrial water systems, or irrigation systems.In-pipe hydro systems can operate across a wide range of head and flow conditions insidemostcommonpipingmaterialssuchassteel,ductileiron,concrete,oranymaterialthatcanbe mated with steel pipe, providing clean, baseload energy without the intermittency ofwindandsolarandwithoutenvironmentalrepercussion.Sincemostofpipingrunsunderground, such systems are also protected from vandalism, theft or weather accidentsandare compatibleevenwithhistoricalcitiesorlocationswithstrictvisualregulations.

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IN-PIPEWATERPOWERGENERATION:

Water possess a lot of energy which is in the form of kinetic and pressure energy flowingvertically through pipe. The tur-bines working till date occupies a large amount of crosssec-tonal area in pipe. When the area reduces, it converts pressure energy into kineticenergy which results in increase of velocity-ty. This velocity of water is utilized in in-pipeturbine and used for generating electricity. The in-pipe water generator is an electricalpower generating pipeline which can produce renewable energy completely clean, reliablelow-cost electricity. The in-pipe turbine is setup in the pipe, the flowing water strikes thesphericalbladesoftheturbineandleadstotherotationofit.Theverticalshaftoftheturbineiscoupledtothegeneratorwhichgenerateselectricityandstoresinbatteries.

INPIPE HYDRO POWERSYSTEMS:

In pipehydropowersystemscanbedividedintwomaindesigns:

- Internal systems, where the runner is wholly inside the pipe section and only thegeneratorprotrudesfromtheconduit.
- Externalsystems, wheretherunneriscontainedinasecondaryconduitthatbypassesthemain on.

V. WORKING

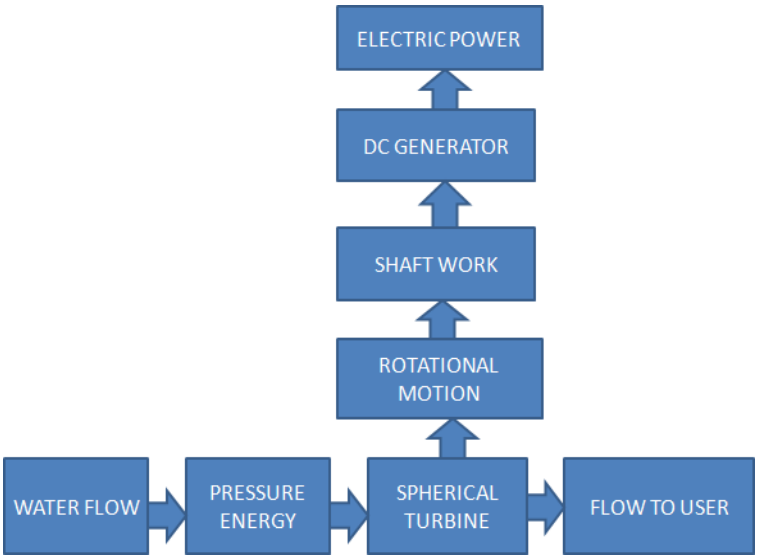

Fig. Basic Flow Chart

Water possess a lot of energy which is in the formof kinetic and pressure energy flowing vertically throughpipe. The turbines working till date occupies a large amountof cross sectional area in pipe. When the area reduces, itconverts pressure energy into kinetic energy which results inincrease of velocity. This velocity of water is utilized in in-pipe turbine and used for generating electricity. The in-pipewater generator is an electrical power generating pipelinewhichcanproducerenewableenergycompletelyclean,reliable low cost electricity. The in-pipe turbine is setup inthe pipe, the flowing water strikes the spherical blades of theturbine and leads to the rotation of it. The vertical shaft oftheturbineiscoupledtothegeneratorwhichgenerateselectricityandstoresinbatteries.

Advantages:

- The modular pipe system to be placed on series,whileallowingforuninterruptedwaterflow.
- Pipedoesnotneedtobeplacedinapressuretransientzoneorwhereextremedifferentialpressuresare needed.
- Produceclean,low-costelectricity.

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- Itisreliable,cost-effectiveelectricity.
- Tomaximizeelectricitygeneration,severalpipesystemscanbeinstalled into asinglepipeline.

Applications:

- Green electricity applications include wind turbinesand water turbines used in applications for windpower andtidal power.
- Alsoitapplicableinthevillageorcitywatersupplylines.
- Damoutletpipe isthe bigsourceofthisproject.
- Farming water supply through the pipe is the greatapplication for installation of this project becauseIndiaisthefarmingcountry.

Limitations:

- Requiredaperfectdesigningofsphericalturbineotherwiseitgoesto backflow thewater.
- Initialcostisrequired.

VI. FUTURE WORK

- On the hilly areas the higher pressure head is easilyobtained due to the altitude. And the velocity of thefluidismoreduetothegravitationalacceleration.
- The multi-store building, where the water almostflowsconstantlytheoverheadtankisfilledandemptied very frequently in the buildings and theapartments. Hence we get almost continuous flow,whichcanbeagreathelpingeneratingtheelectricity.Thegeneralpurposelightingsofthebuildingcanbe litupbythe stored energy.
- Thegovernmentwaterdistributionpipesforthedifferent areas of a country Big pipe lines, used inthe government projects for supplying the water tothedryareasofacountryhavealsoalargepotentialfor thisapplication.
- Agriculture and industries the water is the primaryneedoftheagricultureandtheindustries.Theturbinescanbeinstalledinthepipelineswithsufficientdiameters inthesefields.

VII. CONCLUSION

Alltheconceptofthetheoryandmathematicalequationsthatrelatedwiththisstudyhave been applied in this project. The design and specifications of the turbine havebeendiscussed in thisreportbriefly.Based on the results shown in above chapter, it can be conclude that the higherpower output can be generated when the high velocity of water is present. This isduetothepressureofwaterwhichincreasedthevelocityofflowinsidethepipelines. Moreover, due to high velocity of the water, it made the rotor of the turbine rotatefasterattheshorterlengthand itcangeneratemore outputpower.The technical potential for hydropower development around the world is muchgreater than theactualproduction.Selectionofin-pipeturbinetogeneratepowerformtheflowingwaterisaninnovativeapproach towardsrenewableenergy.Thisnewschemehasprovideduswithalow-costelectricitygenerationwhichisbigassistancein helpingtheworld.Using thisexperiment,thewaste energyfromthe flowingwaterinsidethepipecanbeextracted,whichhelps fulfillingsmallscaleelectricityrequirements.Thisisan eco-friendlymethodandhaslessinstallationandmaintenancecost.

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