Design of a Micro Hydroelectric generator

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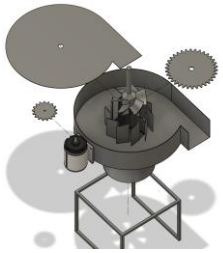
Introduction

Hydroelectric energy is a popular renewable energy source that is often utilized by landowners as a method of producing free electricity. This design of a hydroelectric generator was requested by the client to provide him with off-the grid power, capable of powering a few small devices. Most hydroelectric generation happens on a large industrial scale, so the challenge faced by the group was to construct a micro-generator without losing too much efficiency. This design was built with the parameters of a low head, high volume flow, and is oriented as a battery design, instead of a traditional generator build. The turbine spins an alternator, which in turn powers the battery, before sending the power through an inverter for client use.

Left: Housing of Turbine

Right: Battery/Inverter/ Controller System

Right: Exploded 3D Model View of Turbine Housing and Gear System, with Alternator attached to the side of the Frame

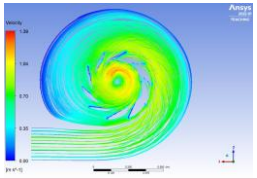


Preliminary Analysis

For our micro hydroelectric generator project, we've combined Computational Fluid Dynamics (C.F.D.) analysis, hand calculations, and Fusion 360 modeling to ensure success. Hand calculations provide basic estimates and insights, while C.F.D. analysis allows us to visualize water flow through our turbine design. This ensures our generator produces maximum energy while maintaining strength and reliability. By integrating these methods, we're confident our project will work as intended.

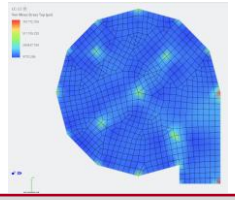
Head (m)	Draft Tube Diameter (m)	Flow rate (m^3/s)	Runner Speed (rpm)	Guide Vane Angle	Shaft Power Output (W)	Torque (Nm)
0.5	0.542475771	0.182904848	263.095724	65.33618529	901.1225341	32.70705508
0.75		0.224011774	322.2251387	65.33618529	1655.467803	49.06058263
1		0.258666516	372.0735411	65.33618529	2548.759418	65.41411017
1.25		0.289197957	415.9908653	65.33618529	3561.999573	81.76763771
1.5		0.316800489	455.6951613	65.33618529	4682.370039	98.12116525

Hand Calculations showing flowrate, rpm, shaft power output, and torque at different head heights (Green values are optimal)

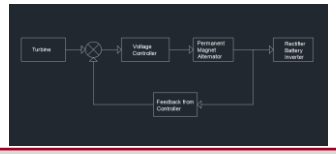


C.F.D. Analysis showing velocity streamlines (Left)

SkyCIV analysis detailing the von mises stress on the base of the system (Right)



Electric circuit diagram for the system and its components

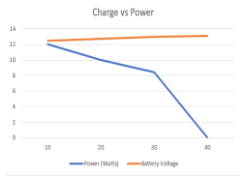


Block diagram showing how the system will work electrically.

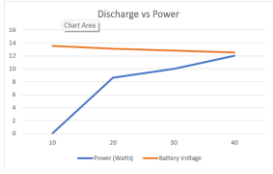
Results

Testing was done with the help of the Canyon Fire Department. A few firefighters, with the permission of the fire chief, shot water into the entrance of the turbine at varying flow rates, to provide the group with data with which to perform analysis and further optimization of the design. Most important result was that of Excitation/RPM, which was essential to the client's needs.

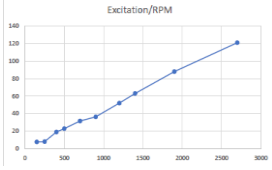
Voltage controller working as turbine and alternator are being spun.



Battery being charged when connected to various loads over 40 seconds.



Battery discharging when connected to various loads over 40 seconds.



Expected range of excitation (watts) when the alternator is spun at certain RPMs.

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Trey McAnally for providing metal and advice
Daniel for 3D printing

Recommendations

- Testing: "natural" flow resembling client's water source for more realistic results was preferable, but not possible due to landscape
- Add bearings for main shaft to prevent energy loss
- Allow lots of time for testing and research to avoid buildup of efficiency losses