AIDG
Appropriate Infrastructure Development Group

Deflector Modification Journal

Nueva Alianza Microhydro System

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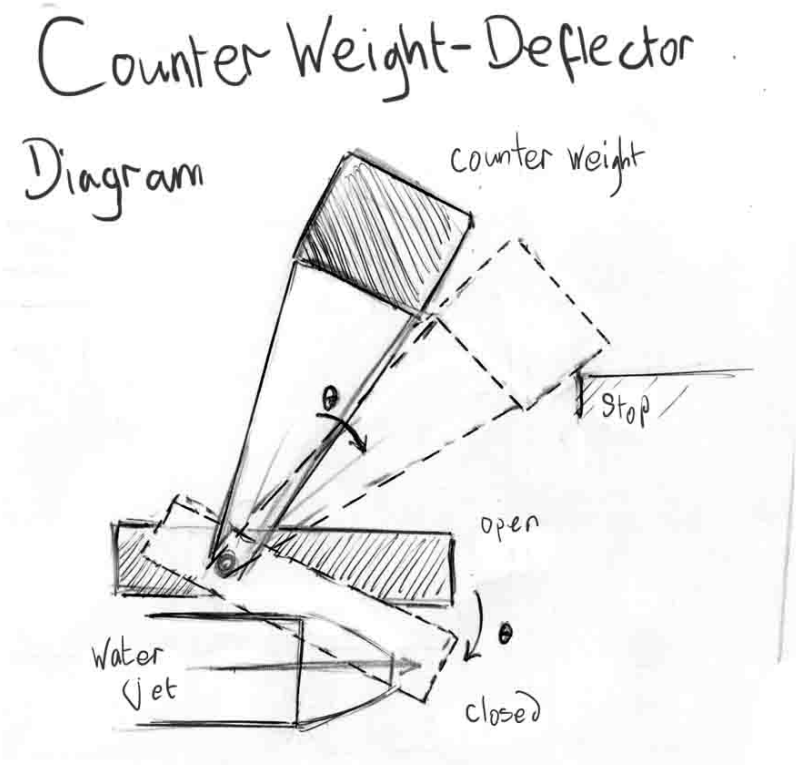
Deflector Installations.

Purpose: 1) To install the new deflector design and ensure that it is working properly.

Deflector Background

The deflectors were put in place in the Pelton turbine housings to protect the turbine generators from overspeeding. In the case that the electrical load is dropped and the turbines spin freely without electrical resistance, they will turn the generators at speeds which will damage the windings. In order to prevent this, a solenoid actuator activated by sensing a given higher rpm pulls a pin from two deadweights (counterweights) which are located to fall a certain distance before hitting a stop. In turn these counterweights turn an axis which is attached to a metal shield. When the counterweights hit their respective stops, the shields (deflectors) are covering the nozzles which eject water towards the turbine, thus preventing water from turning the turbine, and possibly damaging the generators.

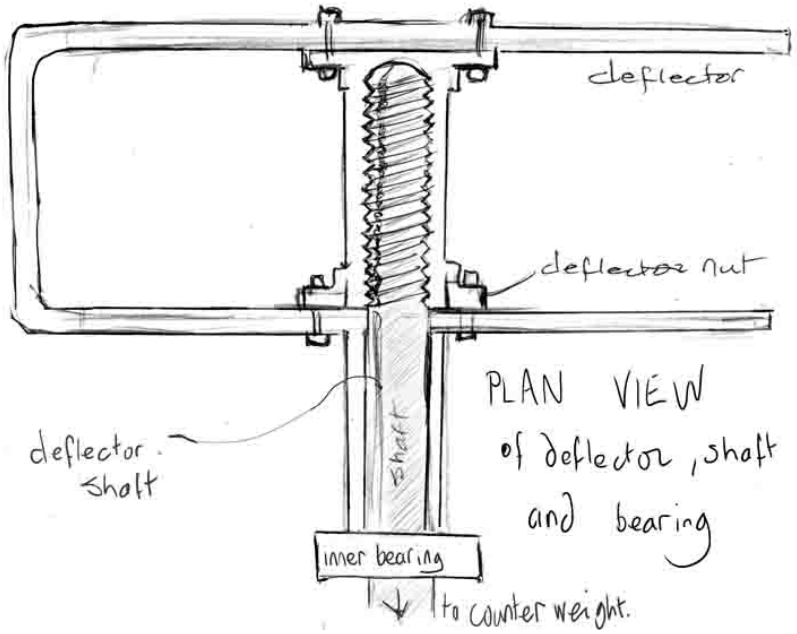


The problem with the past generators was that the shaft that holds both the counterweight and the deflector, was too small to support the counterweight (which not only moves back and forth in its plane of rotation but wobbles to the sides as well, causing extra unwanted stress).
The counterweight was attached to this shaft using a cotter pin, which slipped through a hole drilled in the shaft which took out about half the already very small shaft, so eventually the cotter pin tore through the hole and detached the dead weight.

Changing the shaft size is desirable, but is very labour intensive, as it requires replacing the bearings and therefore the bearing housings with those of a larger size. It is recommended that for future systems a larger shaft size be included from the beginning. Also a way of constraining the motion of the counterweight to one plane would greatly reduce the load on the shaft.
The bearing housings are welded in with a welder that needs to be carried down a mountain slope to weld and posed much difficulty locating the correct position on the first install.
So, keeping the shaft size the same, we focused on a solution that would enable attachment of both the counter weight and the deflector, (on opposite sides of the housing walls and bearings) that would not put holes or any sort of weakening to our shaft.

The current solution has been to weld the shaft to the counter weight on one side of the shaft. The other side must be detachable as the shaft must slide through the bearing to be removable for trouble shooting or maintenance of any sort. On the deflector side, the deflectors are bolted to a nut which threads on to a threaded portion of the shaft. The nut has a long unthreaded portion so that it butts up against the bearing's inner race (to prevent back and forth play) of the shaft through the bearings.

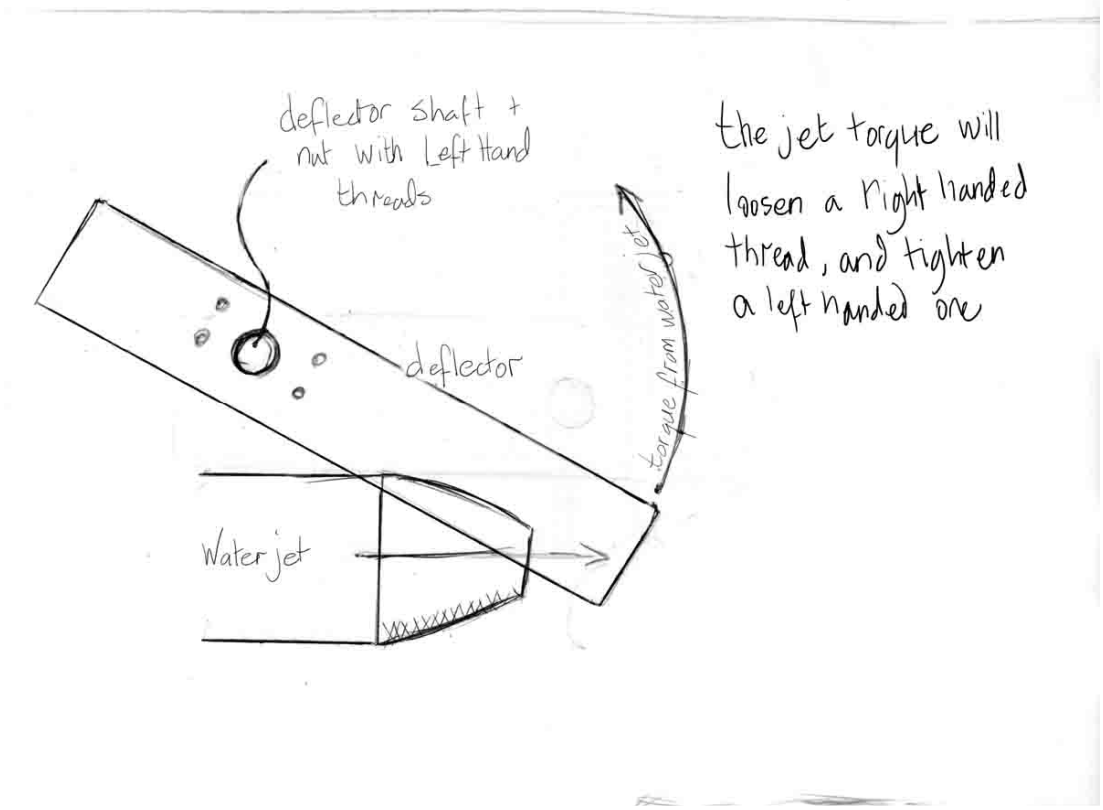
Deflector Redesign



The threaded portion is either threaded left or threaded right, depending on which turbine it is located, as one turbine is the mirror image of the other. The idea behind this is that as the water exits the nozzle and hits the deflector, it will push the deflector in such a way that the deflector will want to rotate and either loosen or tighten the attached

nut onto the shaft. Obviously, it is desirable that the water tighten the deflector over time, and so the direction of the threads was dependent on this.

Side View of Deflector, and Thread Orientation Diagram



Construction of the new deflector design, and other details:

The new deflectors consisted of a strip of 1 1/4“ wide, 1/16“ thick steel flat bar, which was bent in to shape according and had holes drilled in it to allow for the insertion of the shaft. The shaft and the mating nut were contracted out to Tornos Rosario’s who cut left and right handed threads on the 10mm stainless steel shafts and cut long mating 16mm OD nuts to thread on to them. Small L shaped brackets were welded to nuts, with holes in them to attach them to the deflectors. This was so that the nut could spin freely over the shaft until it was located and then the deflector would be attached. Otherwise the deflector would have to spin with the nut and would hit the jet nozzle.

Lessons learnt in this construction were:

- Don’t weld the brackets onto the nut with the shaft inserted. We did this in order to prevent the nut from deforming under the heat and losing its shape, but of course we

found that it just fused to the threaded portion of the shaft quite easily as the surfaces were tightly pressed together. Some lengths of thread were quite badly deformed after we finally separated the shaft from the nuts. Only the last nut was welded without the shaft in it, and it did not deform, and was the best of the four. The deformed threads added later to much of the resistance in the process of installing the deflectors and presented the fear of fully stripping the damaged threads if too much torque was placed on them.

- Also holes drilled in the brackets on the drill press were oddly located and not uniform. For this reason every time the deflector was removed and replaced the correct orientation had to be found for the brackets on the threads (the sides could not be swapped) as nut and deflector holes were customized for each other. This seemed to be of small concern during construction, but on site after clearance problems with wrenches in the small space and aforementioned resistance from the damaged threads already impeded the process, the many removals and re-installments of the deflectors made it apparent that time taken to make uniform parts would have been worth the effort.

Install Visit 1

- The four inner bearings were replaced, and some of the bearing housings were found to be cracked.
- The four deflectors were installed and found to be too large, hitting the turbine and the jet nozzle. This was expected as measurements had been taken loosely months earlier in Nueva Alianza before the actual redesign of the deflectors was fully addressed. The deflectors were cut and rewelded to fit their allotted space. However further problems arose with the design.

First, this plan depends on locating the orientation of the deflector of the shaft before welding it to the counterweight, so that once the deflector is screwed on all the way (and the nut butts up against the bearing and prevents lateral movement of the deflector along the shaft) the deflector is oriented so that it is blocking the water jet. This location is very temperamental and sensitive, and only a few degrees shift of the shaft will knock the deflector out of its useful range. Once we had welded the shafts onto the counterweights, after marking their necessary welding position, and screwed and bolted on the deflectors, the deflectors were actually loose. This will not be good as the water will then tighten them and push them out of deflecting range and they will be useless.

- The four deflectors were left in a fairly unsatisfactory state at the end of this visit.

Install Visit 2

- The solution to the problem of the loose deflectors was to use shim washers, and as these could not be located quickly in a hardware store, I made them out of aluminum pop can foil using a sharpened punch to punch out the diameter.

They were delicate but were sandwiched between two well fitting surfaces and I believe they would have lasted as long as they were held this way. Steel ones however would definitely have been a better choice. These shim washers would essentially shorten the travel of the nut on the shaft so that it bottoms out sooner and at an earlier angle. Thus by trial and error (as everything compresses somewhat variably once I tighten everything with a wrench) the correct angle can be achieved with the correct tightness for the deflectors. This works, but is a little unreliable, since if a deflector gets tightened a little more (maybe someone comes in and plays around with it, while detaching the nozzles for cleaning) , then returning the deflector to its original position leaves it looser than it was before. I believe this is because all the pressure from cranking the nuts on the shaft tightly is going on the bearing surfaces, which so far are not compressing so much that they squeeze the rollers too tight, but they still compress a little more each time. So I suspect something is deforming every time I retighten a nut to get it back to its snug fitting position. Of course compressing and deforming either bearings or housing is bad, but also, now the angle is no longer correct and needs another disassembly and insertion of more washers. This is a somewhat painful procedure.

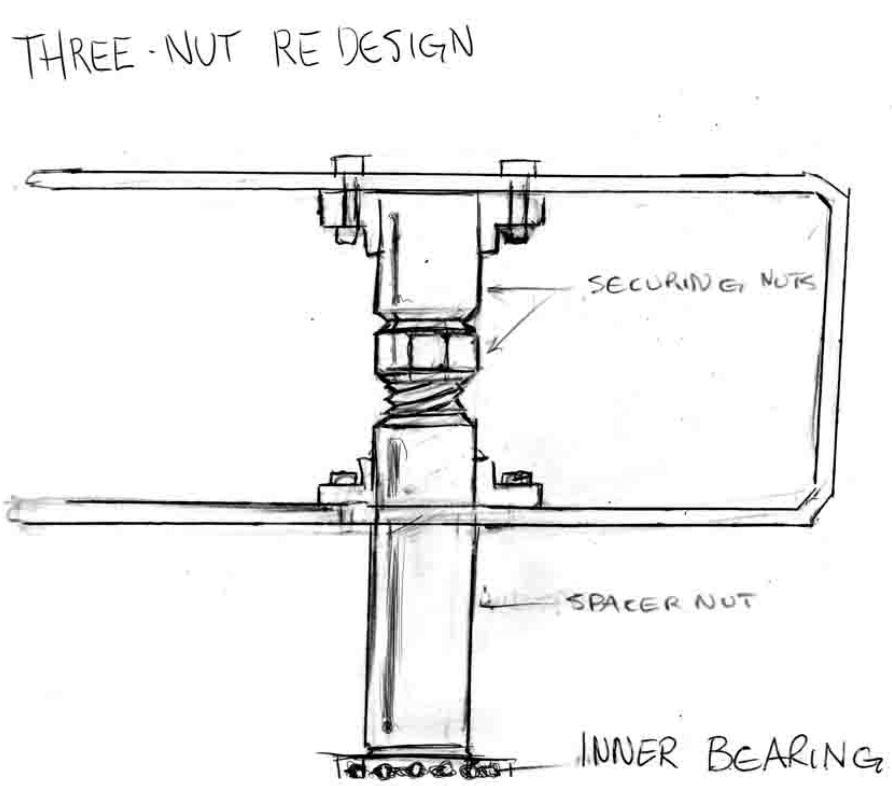
One other problem is that inadvertent loosening of the deflectors can occur if the counter weight is brought back past its open position by about 30 °. If the deflector is loosened, it will have to be retightened which as mentioned above is an awkward procedure, and may even require more shim washers, which are unlikely to be available to whichever Nueva Alianza local has the task of maintaining the deflectors.

- The deflectors were left in a more satisfactory state than the previous visit, however still not reliable. One of them could not be tightened and it was thought that the cracked bearing housing was responsible for this as it allowed for play in the shaft and bearings.

Install Visit 3:

- The cracked bearing housings were rewelded.
- Four holes were drilled just before each of the four jet inlets and 1/4 NPT nipples were welded to each and plugged. These will serve as ports for a pressure gauge for efficiency testing.
- Some preliminary testing was done and the static pressure of each of the inlets was found to be 72 psi.
- The deflectors underwent a minor design change.

The solution to the problem would take care of the compression of the bearings and housing and also of the locating the angle with washers. However the mechanism is made more complicated and poses some difficulty for anyone wishing to remove the deflectors for maintenance, who is not already familiar with the design. The inner nut was cut into three parts. The back third of the nut was used to butt up against the inner bearing and stop the shaft from sliding back and forth through the bearings. The middle portion of the nut was thrown away and replaced with a commercial nut (two left hand threaded nuts were found for the left shafts). This middle nut twisted against the front portion of the nut to hold the deflector at the correct angle, and keep the mechanism tight. Shim washers to adjust the angle were therefore no longer needed and were removed. This solution is nice as now the pressure is on the nuts and the shaft and not on the bearings.



There was some concern with installing this three part nut deflector with the deflector frame and bolting it all together in place. However the process proved not to be too difficult or finicky once the procedure was understood. One of the left nuts however was over tightened and stripped. I used the middle part of the long nut and ground down some flats on it for the use of a wrench, in place of the stripped standard nut. I am debating whether or not to replace this with a standard nut on the next visit, in order to make them all the same. Since the original long nuts seem to be made of a better steel than the store bought nut, it may be better to leave it as is. One other down side to this design is that the aforementioned over travel of the counterweight will now no longer loosen the deflector, but more likely strip the nuts or shaft threads.

- Holes were drilled to be fitted with bolts to stop over travel of the counter weights. The process was finished by Carlos on his fourth solo visit. This is another point that would be good to inform the locals of.
- The aforementioned very loose deflector was found to need a new outer bearing as well as rewelding the bearing housing. The bearing was replaced with an available spare.
- The other outer bearings were examined and found to require replacement soon as well.