CHAPTER 6

CONCLUSION AND FUTURE SCOPE OF RESEARCH

The research work on “ANALYSIS & REDESIGNING OF WATERMILLS FOR SUSTAINABLE DEVELOPMENT OF RURAL AREAS OF UTTARAKHAND” started with understanding the need of work by analyzing the power scenario of the country and than more importantly that of Uttarakhand. This also helped in understanding the importance of energy over power and in absence of which lots of socio economic problems are originating. Than existing watermills were analyzed on various identified parameters which ranged from geographical, hydrological to operational. This analysis was done for watermills all across the state and it the foundation work of the research as it highlighted the problems, issues and other parameters which are of importance for further work. Than traditional and existing improved watermills are tested to identify the gap and scope of improvement over existing improved watermills. This also gave the design improvement basis. Design is than carried out based on above improvements and more importantly the entire watermill system was redesigned rather than only the mill turbine as it was in previous cases. The design also identifies the importance of specific speed in watermill efficiency and proposes the discharge control method to get higher efficiency during low discharge periods. It also suggests power generating method for locations where hydrology is not sufficient for proper power generation. At the end proper installation, operation and maintenance aspects are presented.

Analysis of existing system was important to understand the deficiency in the system which can be improved upon to make the system efficient and user friendly. This chapter covered the approach to identify such parameters of the existing system and methodology used to gather the information on those parameters. Further, it covered the analysis of those parameters and other observations identified in the process. The outline of this analysis goes with understanding the existing water mill.

After carrying out the survey of various watermills on identified parameters as compiled based on inputs of concerned stakeholders following important observations were made.

10% of watermills were surveyed across the state to cover entire geographical and ecological variance of the region. Some other available relevant information from the stake holders was also included. That covered the information on almost all the watermills.

The survey revealed some interesting facts. In spite of huge efforts made by the UREDA and other NGOs only 3% of total watermills amounting to 499 numbers could be upgraded so far and still 14882 watermills are traditional.

Only 1% of total watermills are used for electricity generation also and majority of watermills i.e. 77% are used for grinding purpose whereas 22% are used for other applications such as cotton combing, fish farming, rice husking and bee keeping etc.

The water mills work year round as well as seasonal depending on rain, flooding, boulders coming in channel, land slides damaging the channel or mill itself or even damaging the approach to the mill. 57% mills operate round the year. Data is available district wise.

Similarly 55% of the total water mills are defunct. Maintenance has been identified as the main cause of water mills not functioning. This problem has been identified even in upgraded watermills also. Maintenance problems become even more severe as many of the water mills are very remotely located.

After analyzing the site and feed back from various stake holders it was established that approx. 55% of water mills can be upgraded to improve their efficiency and further approx 68% water mill owners are willing to upgrade their water mills.

Distance of water mills from the village and road head has been observed as a astonishing fact causing maintenance problems and utilisation of full potential of water mills. 7% of total water mills are as far as more than 20 kms from the village and 32% water mills are in the range of 5 to 20 Kms. Similarly approx. 5% water mills are beyond 10 Kms from nearest road head and about 11.7% water mills are between 5 – 10 Kms from road head. This statistics itself depicts the hard fought life rural habitants have in the hills and the fact that technology up gradation for water mills should be based on local resources and almost maintenance free. This also leads to the fact that successful up gradation water mill in such condition will be that which requires less maintenance even if some efficiency has to be compromised for that.

Other very important parameters governing the selection of water mills, improvement criterion for them were identified as the hydrological parameters of the site. Discharge and head have been analysed for various sites.

At all the total discharge ranges from 0 to 0.6 cumec. However at 90% locations the average annual discharge is only 0 to 0.2 cumec, whereas 8% locations have 0.2 to 0.4 cumec discharge and only 2% locations have 0.4 to 0.6 cumec discharge.

Almost all the locations in Chamoli, Uttarkashi and Tehri Garhwal district have 0 to 0.2 cumec discharge, whereas Almora has 27% locations having discharge of 0.2 to 0.4 cumec and 10% locations with 0.4 to 0.6 cumec discharge. District wise locations have been identified with respective average annual discharge.

Similarly, available head at various locations has also been recorded. It is found that 14% locations have head as low as 0 – 2 mtr and at 55% locations head is from 2 – 4 mtrs. And 23% locations have head in the range of 4 – 5 mtrs. Only 10% locations have more than 5 mtrs head. Location wise and district wise data of head is identified. These data are very important input for upgrading the watermills.

Further to these parameters some other important points are observed which can be crucial for identifying the areas of performance improvement for watermills.

- Majority of watermills are defunct due to maintenance problems.
- The distance of watermill from village and the road head make the owner disinterested in operating and maintaining the watermill.
- Heavy weight of wooden turbine causes low RPM and hence low output per hour.
- Mis-match by fabricating heavy turbine vis-a-vis available hydro power potential (head, flow etc).
- Wooden runner and blades get damaged quite frequently. Blades come out of runner.
- Use of open channel made up of stones as penstock causing loss of head due to friction, spillage of water.
- Unavailability of screen at entrance of channel causing trash and boulders to be carried up to turbine.
- Deposition of elegy and growth of plants in channel causes loss of head.

- Improper angle of penstock nozzle, causing imperfect strike of water on turbine blade.
- Damaged penstock nozzle causing water to spill all over
- There is no provision of controlling the water.
- During rainy seasons the water become violent and carries lots of sediment & boulders with it. These boulders and sediment effect the turbines hence the watermill has to be closed during the seasons of high discharge.
- There was breaching of the open channel just before the fore bay tank which reduced the discharge
- The channel is situated just downhill the road, so the slope lead to the direct dropping of leaves and other waste materials in the channel.
- This garbage material was blocking the way of penstock
- The screening of materials has the temporary adjustments with wooden trap which was not efficient
- Flour dripping in bearing causes its frequent failure/ jamming.

Above points have also been considered while improving the watermill system.

Analyzing the existing improved watermills was also important to understand further scope of improvement. Next the performance of existing improved watermills was analyzed based on lab testing. Presently cross flow, axial flow, pelton turbines are used. A number of each of these turbines were tested in lab and their performance is analysed as effect of flow and load on efficiency. Cross flow turbines are found to be most efficient with efficiency close to 50% for medium and high flow i.e. at above 100 lps flow while pelton turbine is found to be most efficient in low flow condition i.e. close to 40% at about 20 - 40 lps flow. As revealed in survey majority of locations have low annual average flow, therefore our design was based on pelton turbine. Further field testing of existing improved watermill and working traditional watermill was also done to see the impact of practical conditions on the efficiency. It is found that while efficiency of traditional watermill is only 5 – 13% the efficiency of existing improved watermill is 10 – 37% under similar site conditions. This also revealed that under site condition the efficiency of improved watermill has dropped by approx. 15-20% from controlled lab environment.

This work has suggested the design criterion, hydrological parameters and equipment selection criterion for new design.

Watermill efficiency depends on its hydraulic efficiency, mechanical efficiency and volumetric efficiency which in turn depend on net head, flow, watermill components like bearing, runner, it's material and amount of water striking the runner blades. Nozzle is a component which converts potential energy of water in kinetic energy at outlet of penstock and also helps in properly directing the water stream so that most of the water strikes the runner. Therefore in this chapter penstock, runner and nozzle have been designed to minimize losses and optimizing the overall efficiency keeping economic considerations in mind. Further it is observed to select a turbine of higher specific speed because higher specific speed of a turbine result in reduction of runner diameter as well as the overall size of the runner, due to which weight and cost of runner is reduced. If we are able to change to diameter of nozzle/ jet, we will be able to get almost constant efficiency even at varying discharge.

To start with standardizing the design as above to achieve optimum efficiency, channel or penstock material, smoothness and it's condition has direct bearing on head loss. Therefore closed conduit of a material with least friction coefficient under economic consideration and i.e. PVC has been selected. Its internal diameter and wall thickness has been calculated for the right sizing and strength. These parameters have been calculated for other probable materials like cast iron and steel etc. Penstock support is also designed for its proper erection over the ground.

Nozzles are frequently used to control the rate of flow, speed, direction, mass, shape, and/or the pressure of the stream that emerges from them. In case of hydraulic turbine jet nozzle is mainly used. A hydro jet is a nozzle intended to eject fluid in a coherent stream into a surrounding medium. Nozzle is a device used for converting the pressure energy of jet into kinetic energy of jet. Nozzle is designed for different head and discharge values.

As per the previous work done by IIT Roorkee, the power output from watermills at above 7 meter head can be used for cereal grinding, cereal grinding plus electricity generation and agro work plus electricity generation respectively. Whereas, at sites with lower heads the application can be grinding only. Based on these suggestions turbine runner is designed. Runner diameter, rim width and number of blades are calculated for different head and flow parameters.

Importance of specific speed for different head and discharge values is identified also its effect on efficiency. Then a rack and pinion arrangement connected with spear valve arrangement to control the jet diameter is designed to maintain the efficiency even at varying discharges. Controlling arrangement to movement of spear is given above the ground so that according to requirement jet diameter can be controlled manually. Efficiency with and without jet control are also compared.

It is found that with jet control almost steady efficiency is possible at various discharge values. Also with the design as suggested in this work overall efficiency improves to over 40% as compared to the efficiency by existing improved watermills of around 30 - 35%. It is about 15 – 20% more than the efficiency of existing improved watermill. Further, design software is developed to bring in consistency in performance of watermills, which is missing in existing scenario as observed in turbine testing. Further it is expected that trash rack, silt tank and self lubricating bearing will also reduce the severe maintenance problems caused by boulders, mud & twigs and dripping flour etc as these have been identified as major cause of concern amongst the millers. A further improvisation is also suggested for generating and storing electricity in batteries to be carried back home and light few CFLs. This can be very useful for low hydrological sites (which are the case in most of the locations) where proper electricity generation is not viable.

To have 360^0 coverage of performance improvement of watermill, installation, operation and maintenance guidelines have also been suggested.

Based on the design calculations a software package has been developed which can be used to find out all manufacturing parameters and drawings for the given hydrological inputs. This software can be used to bring uniformity in design and the efficiency.

Further future scope of research has also been identified as follows:

1. Effect of alignment of nozzle with respect to turbine blades. More specifically establishing a relation between efficiency and angle of nozzle with respect to turbine blades for different discharge values. This can be done at site by experimentation.
2. Importance of distance of nozzle from blades can also be established for effect on efficiency.
3. For power generation, along with battery an inverter system can be designed in such a way that composite unit can be carried on shoulder by miller on his way back to home.