Opportunity for research and manufacturing of pump in Nepal

N. Pokharel¹, A. Ghimire¹, B. S. Thapa¹, B. Thapa*¹
¹Turbine Testing Lab, Kathmandu University
*Corresponding author (bhola@ku.edu.np)

Abstract. Pumps are the mechanical device used to increase the pressure energy of fluids. Pumps of different types and size are being used in Nepal, for different applications. Despite the widespread applications of pumps not much have been done to manufacture pumps in Nepal. This study investigates the opportunity of manufacturing pumps in Nepal. It shows the history of usage of pumps in Nepal and also depicts the problems faced by the pumps used in different projects. It discusses about the current market trend related to the import of pumps from foreign countries and develops an argument to start a new business for manufacturing pumps. Role of research institutes like Turbine Testing Laboratory in design of pumps has been discussed as a future prospect for Nepalese academia and industry.

Keywords: Pump, Manufacturing, market, opportunity, Nepal

1. Introduction
Nepal is an agricultural country with over 2.7 million hectares of agricultural land, of which 1.4 million hectares have access to irrigation facilities [1]. Of the irrigated land, a large portion of land is being irrigated with the help of lift irrigation projects, which require large pumps for their operation. Nepal is also a developing country, which is focusing their investment in domestic industries. Depending upon the type of product being manufactured, industries tend to use a large quantity of pumps, which require continuous maintenance and replacement. It is not just the manufacturing industries that use pumps for their operation. Technology inspired construction companies have started using pumps to transport the cement mixtures. There are numerous other instances where pumps are the integral part of the system in Nepal.

Pump is a machine that converts the mechanical energy, supplied to it through its shaft, into kinetic and pressure energy by moving the fluids. Pumps are usually operated by either a reciprocating or rotating mechanism, which can be done using any form of energy that can be transferred to it. There are different types based upon various categories. Broadly, they are divided into two categories: positive pressure pumps and dynamic pressure pumps. Positive pressure pumps are designed to displace a more or less fixed volume of fluid during each cycle of operation. The volumetric flow rate is determined by the displacement per cycle of the moving member (either rotating or reciprocating) times the cycle rate (e.g. rpm). They are further divided into two types reciprocating pumps and rotary pumps. In reciprocating pumps, pumping takes place by to and fro motion of the piston or diaphragm in the cylinder. Where as in rotary pumps relative movement between rotating elements and the stationary element of the pump cause the pumping action. Piston or diaphragm pump are commonly available reciprocating pumps whereas gear, lobe, screw, vane are some types of rotary pumps.[2]

In dynamic pressure pumps, during pumping action, tangential force is imparted which accelerates the fluid normally by rotation of impeller. They are further classified into centrifugal pump, propeller pump, and turbine pump. A centrifugal pump use a rotating impeller to increase the pressure of a fluid. A
problems and successfully made use. Establishment of

s

Journal of Physics: Conference Series

1608 (2020) 012018
doi:10.1088/1742-6596/1608/1/012018

propeller pump is a high flow; low lift impeller type, which function by drawing water up an outer casing and out of a discharge outlet via a propeller bladed impeller head. Turbine pumps are centrifugal pumps that use pressure and flow in combination with a rotary mechanism to transfer fluid.

Among all the types of pump discussed, centrifugal pump are the most common types of pump available in market. They have long history of use with proven technology. Another fact is that they are very similar in appearance and working principle to reaction turbines. A centrifugal pump absorbs useful energy and converts it to kinetic energy and gives it to a fluid stream whereas the reaction turbine does the exact opposite as it absorbs energy from a fluid stream and converts it to work [3]. Unlike the method of operation, the components of centrifugal pumps and reaction turbines are quite similar. The basic component for both are runner volute, pressure pipe and draft tube which are both in common for pumps and turbines although their names may be different.

Some devices are even designed to be operated as pump as well as turbines when rotated in reverse direction[4]. The small centrifugal pumps can be These reversible pump turbines are for pumped storage hydropower, which is more feasible for countries like Nepal where most of the flow in river occur during certain months in a year [5]. Most of the hydropower in Nepal are runoff type projects, which lose their production during the dry seasons. This often causes lack of electricity during those seasons. In addition to that, ever-increasing consumption of electricity during the peak hours of the day tends to cause lack of electricity for that period. European countries have faced these problems and successfully made use of pumped storage projects to fulfil the extra demand during the peak hour. Nepal can make use of this technology to fulfil the demand during peak hours and dry seasons. There has already been few studies done to identify the potential locations of such projects. Chilime corridor and Rupa Begnas lake are often mentioned in different studies for potential pumped storage projects in Nepal[5][6]. Pumps are also available in a range of sizes varying from microscopic pumps to extremely large sized pumps. The largest pumps in Nepal are used in irrigation and water supply systems while there are other numerous other applications in which pumps are being used. In this study, the status of pumps that are being used in Nepal have been described taking some field studies. It also depicts the economic impacts pump have had over the years in Nepal using fiscal year reports published by government. Similarly, problems associated with existing pumps are highlighted taking some reference of irrigation projects and operating industries. The opportunities available for a pump manufacturing and maintaining industry in Nepal have been analysed. The future prospects for design and development of pumps in Nepal has been discussed too.

2. History of pumps in Nepal

It is difficult to trace the documented history to mark the first use of pumps in Nepal. However, it can be anticipated that there were diesel powered centrifugal pumps being used in Nepal. Although an exact date is unknown, some projects established during 20th century give a good picture of history of using pumps in Nepal. One of the oldest irrigation project in Nepal, Narayani Lift irrigation project, started its operation in 2040 B.S. The project utilized electric driven axial pumps and was established to irrigate 47000 Hectares of land in Chitwan district[7]. Bhairahawa Lumbini Ground Water Irrigation Project is another example of irrigation project making use of multistage turbine pumps to irrigate more than 7600 Hectares of land, in Rupandehi district of Nepal, through 63 tube well schemes [8]. Apart from irrigation and drinking water projects, pumps were found being used in industries transporting fluids at some stage of their processes. Industries like Bhrikuti paper mill, established in 2040 B.S., MK paper mills, Lumbini sugar mill, Indusankar Sugar Mills use pumps at some stages of their industrial processes. Generally, centrifugal pumps with closed impeller and semi open impeller are used in these types of industries. Based on the properties of the fluids involved, lighter fluid mixtures require closed impellers while dense fluid mixtures require semi open impellers. Industrialization and urbanization in Nepal grew the use of pumps with other modern technologies. After the establishment of Department of Water Supply and Sewerage (DWSS) in 1972 A.D. responsibility of providing water facilities and sanitation services for
people living in rural areas free of charge pumps were used in boring systems and overhead tanks as well [9]. The DWSS was given the management and maintenance responsibilities. For the urban sector, Nepal Water Supply Corporation is to provide and maintain drinking water supply system with nominal charges. Prior to that, Ministry of Panchayat was primarily responsible for providing piped water facilities in the rural communities. In addition to drinking water supply system, after the establishment of Nepal Water Supply and Sewerage Corporation in 1985 with two major water treatment plants constructed at Balkumari known as Kodku now and Sundarighat now known as Dhobighat, sewage pumps has also been used equally in this areas [10]. Various other water treatment plant in Nepal now days uses such sewage pumps [11]. Pumps have now become integral part individual households in most part of Nepal. Nepal Water Supply Corporation was also responsible for municipal wastewater treatment and they have installed several sewage pumps.

3. Current Market of Pumps

Pumps have a huge market in Nepal. According to the foreign trade import report in record of government of Nepal recorded for the past eight years, import of pumps has increased significantly. Different types of pumps have been imported during this period. Import of hand pumps have dipped considerably. An amount spent on the import of various types of pump on an annual basis have been shown in the Figure 1 below. Amongst different types of pumps, centrifugal pumps are the most widely used type of pumps. Construction of new project using modern technologies have uplifted the import of concrete pumps in the recent days. The fiscal year report of recent past seven years showed that the import of pumps have increased from NRs. 950 Millions to well over NRs. 4 Billions as shown in Figure 2 [12].

Figure 1. Market of Pumps in Nepal in Last Eight Fiscal Years
4. Problems faced by pumps

Pumps face various problems after certain time of operation. The general problem associated in continuously operating hydraulic machinery like pumps as well as turbines includes corrosion, erosion, cavitation, fracture, fatigue. The failure like fracture and fatigue are not very often, because it may be somehow solved by use of high strength steels. However, the problem like erosion is unavoidable. Even small size sediments will be enough to destroy hydraulic machines rotating at high speed [13]. As this size of sediment particles are difficult to control to enter in the impeller, it is necessary to change the hydraulic design as in case of Francis turbine exposed to sediments [14]. Even metal of high strength like nickel chromium steels are being eroded in short time. It is not always that pumps operates in clean water and sometimes it has to operate in slurry environment too. Due to this, the well-designed pump may not operate efficiently in such environment. Rigorous worldwide research has been carried out for this.

Palgrave classified three types of erosion mechanisms in the case of pump as impact, grinding and turbulence [15]. The rotational speed, impeller and casing geometry, flow velocity and material are the factors affecting erosion of pump components. The erosion of pump impeller is analogous to the runner of reaction turbine. The velocity vectors of impeller blade are important in case of erosion of pumps. Possible areas of erosions of pump impeller is shown in figure 3. Thapa, mentioned different areas of erosion of pumps with their possible cause [16]. At blade inlet, both side will be affected by erosion due to impact of particle at high impingement angle. The erosion at leading edge of impeller is dependent on inlet velocity vector and it should be kept minimum to avoid erosion. The shape of blade is another factor of erosion. The local concentration of sediment particles is created along the concave side of wall of blade due to difference in relative velocity. Impact of particles in smaller angles also cause erosion in their areas. Further, the large gradient of relative velocity at the trailing edge of the blade causes high erosion rate. Erosion at the trailing edge is due to both low impingement angle and high turbulence. The tip vortex may cause erosion of blade tip at outlet. Apart from the blades of the impeller, the hub surface will also face erosion problem due to change in flow direction. Similarly, the tongue of the volute casing faces due to high impingement angle.
In recent days combination of both numerical and experimental technique are being used to find the erosion in pumps. During actual field operation, wear of the components affects the pump hydraulics and also the wear rate\cite{17}. The study done by Dong et al. suggested that the sediment erosion around pump impeller in slurry environment is mainly due to the change in relative velocity around the blade and this can be minimized by inducing swirling flows around the bionic convex domes.\cite{18}

The erosion areas are more in that area where the relative velocity is high as shown in figure 4. The experiment done by Shen et al showed that the erosion in double suction centrifugal pump showed that deep pits combined with micro cracks were observed near the leading edge, and grooving scratches were found in the direction of the mainstream near the trailing edge as shown in Figure 5. \cite{19}
Another phenomenon and common problem faces is cavitation. Any time a flowing liquid falls below its vapor pressure, vapor bubbles can form. If the flowing liquid is then subjected to pressures above the vapor pressure, these bubbles can implode causing damage [20]. The pressure that changes around the pump impeller may cause this effect and reduces performance and life significantly. Many researcher has done the cavitation study to design the pumps. Although the impeller is designed, free from cavitation the operation phenomenon, so times due improper knowledge regarding pump installation may also cause cavitation effect. The cavitation effect is governed by fluid pressure and sometimes selection of suction pipe diameter very small, long distance of suction pipe, too may fittings on suction pipe, causes abrupt change in pressure there by causing cavitation [3]. Also keeping the pump at too large height from fluid source or sump also causes cavitation. The cavitation phenomenon is also dependent on rotational speed of pump. Rotating pump at too high speed also cause cavitation [21]. Therefore, a well-designed pump may also suffer the problem of cavitation if it is not installed properly. The other common problem in pumps is corrosion due to formation on metal surface as the metal, fluid and atmosphere comes in contact. This erodes the layer of impeller causing failure as shown in figure 6.

Sometime the pump faces problem of combined erosion corrosion and cavitation, which has been most challenging topic of research. The synergy between erosion and corrosion can be either erosion enhanced corrosion or corrosion enhanced erosion whichever is dominant but the research regarding the relation for erosion and cavitation is difficult to find in literature [16].

In the context of Nepal, no research have been done to identify the status of pumps used in Nepal. Depending on the use of pumps in industries with highly erosive fluids, we can be sure that the pumps would require continuous maintenance. In addition to that, import of pumps every year for the same industries would also imply that the pumps are being replaced continuously. It could be because of the lack of pumps manufacturing and maintaining companies in Nepal. Thus, we can also state that the pumps maintenance can be a prospect for the investors. The annul market for spare parts of pump in Nepal can be seen in Figure 7 which is around 250 million Nepalese Rupees.
One of the largest pumps being used in Nepal, the axial pump used in Narayani Lift irrigation system, is facing severe slit erosion problems as shown in figure 8a, 8b. The impeller of the pumps are maintained regularly. As on June 2019, just one unit, out of the four, was in operation due to breakdown of the other three.

Pumps used in the industries do not give the same performance after certain time of operation. Depending on the nature of fluid transported, the pumps are often found with damaged after certain cycles of operation. Paper mills use pumps to transport the slurry of raw materials used to make paper. In a typical recycling paper mill, where used papers are used to make slurry, the raw materials are often contaminated by metal pins and other unwanted chemical. This contamination and the paper itself have been eroding and corroding the impellers of pumps as shown in figure 9. In addition to that, these pumps also suffer cavitation problems as these pumps are used from a standard market and are not designed for the specific characteristics as demanded by the process. They often replace impellers instead of maintaining it. Similarly, pumps used in Sugar Mills to transport the sugar cane juice and much thicker molasses. As discussed in different studies, sugar canes are found to contain silica in some forms, which are highly erosive in nature [23]. Thus, the pump impellers in these industries face problem of erosion as well.
5. Future Prospects

The current study shows that Nepal has a quite a good market for pumps and it is increasing day by day. With ever increasing urbanization and understanding of technology, almost every household in the country’s major cities and towns have started using pumps for water supply. The growth in production of electricity in the next few years will promote industrialization in the country. Most of the industries producing essential daily agro based products like paper mill, sugar mill, oil industry, etc will demand more pumping technology for their productions. Similarly, being agricultural country, the next use will be in agricultural fields. The growth in production of electricity in the next few years will promote agriculture in the country where use of diesel power will be replaced by electricity in agriculture [24]. The last fiscal year report of the NEA suggested that 94% of its consumers are from domestic, 3% in irrigation, 1% in industrial and 1% in commercial sector [25]. In order to increase the agricultural production, the primitive technology should be replaced by modern one. A modern technology for agriculture being followed in some developed countries like USA, European countries and best example for Nepal is agriculture technology used by its neighboring country China where pumps are one crucial component for such mechanization. Nepal has also somehow started modernization in agriculture technology. Some pilot projects in solar water pumping initiated by AEPC is good indication of future for this. The drip irrigation project initiated by some recent industries is another example for modernization in agriculture. All these modern technology in agriculture has one thing common that is pumps. Also as per the NEA load forecast report, almost 34% of electricity will be used in industrial sector in coming next year’s [26]. Most of the industries demands pumps at some instance of process producing essential daily agro based products like paper mill, sugar mill, oil industry. So looking all the trends in agriculture, domestic use, industries it indicated that for the energy consumption scenario for future years in Nepal, one place is always occupied by pumps.

Despite having such potential market, no manufacturer have initiated the manufacturing of pumps in Nepal. As discussed earlier, pumps and turbines are very similar in working principle as well as structure. Any manufacturer working on turbines should be able to manufacture the pumps as well. However, due to lack of knowledge on the design and development of Francis turbine as well pumps Nepalese turbine manufacturers have not been able to step into that market. One of the reasons for this could be abundance of market for Cross flow and pelton wheels during their inception in the 20th century, however in the recent times, the market of micro hydro has gone done by many folds and the micro hydro turbine manufacturers are being reluctant to step into a new market [27]. Manufacturing pumps and Francis turbines can be a way out of this deadlock for the manufacturers. And they can do so without having to invest too much on machinery or manpower as most of the machinery and skills required are the same. The initiation taken by Turbine Testing Lab (TTL) at Kathmandu University for establishing research Centre in hydropower in contributing to society in the country has taken greater achievements in past years in Nepal. The design techniques for hydraulic machinery has been disseminated repeatedly to industry. One successful story of this is in growing the capability of Nepalese manufactures in developing micro Francis turbine for first time in Nepal [28]. Designing turbines for handling national geographic conditions, especially sediment-laden waters is one of the key achievements of turbine testing lab which is appreciated worldwide. TTL has now started doing research on pumps, which will make things easier for the manufacturers willing to invest on the manufacturing of pumps. As TTL have been known to develop hydraulic machines with the latest design methods and verify the design using Numerical simulations. TTL as an academic body can also have access to design software available in the market or developed themselves for the design of well-optimized pumps specific to the site.

TTL has been cooperating with international partners for the development of turbine technology in the past. Even now there are numerous projects undergoing in cooperation with the prestigious universities
like Norwegian University of Science and Technology, Norway, Korea Maritime and Ocean University, South Korea, Wuhan University, China, etc [29]. All these universities are pioneer in the field of hydraulic machines as they have a long history of working on high-end research in hydraulic machines. NTNU leads the race in turbine technology throughout the world, in developing new and highly efficient technologies. They also have experience working in Reversible pump turbines and their laboratory test [30]. The research conducted by Wuhan University on sediment erosion in double suction centrifugal pumps used in irrigation is considered to be a pioneer both in sediment erosion as well as pump technology[19]. They have extensive research experience in optimization of pumps using reverse engineering. Korean Maritime and Ocean University has also been continuously working in close collaboration TTL for designing sediment friendly hydraulic machines.

6. Conclusion

Nepal has huge potential for applications of pumps as well as their manufacturing. Nepal is importing all of its pumps from the foreign countries, which is sending the hard-earned remittance back out of the country. While the Nepalese turbine manufacturers are looking for a possible ways to sustain under the circumstances that market of micro hydro is almost nonexistent in the country, pump manufacturing can be a possible way out of the deadlock and a way to bloom their business once again. Turbine Testing Laboratory has successfully conducted research to design Francis turbines in Nepal and are now transferring knowledge to the Nepalese turbine industries. Similarly, initiating new research to develop pumps locally, TTL is trying to broaden their research area initiating research in pumps, after realizing the need for pump manufacturing in Nepal. Therefore, in near future, the role from academic institution, industries and government, plays an important role to jump in pump technology in Nepal. Being agricultural country, the existing market of pump could motivate the industries in manufacturing in coming years and also the existing problem in pump could be opportunity for research and development for academic institution.

References

[1] Pradhan P and Belbase M 2018 Institutional Reforms in Irrigation Sector for Sustainable Agriculture Water Management including Water Users Associations in Nepal Hydro Nepal J. Water, Energy Environ. 23 58–70
[2] RK Rajput 2011 A TEXTBOOK OF FLUID MECHANICS AND HYDRAULIC MACHINE (New Delhi: S Chand and Compaly Ltd.)
[3] Dale Conway Pump Motor Drives www.flowcontrolnetwork.com
[4] Derakhshan S and Nourbakhsh A 2008 Experimental study of characteristic curves of centrifugal pumps working as turbines in different specific speeds Exp. Therm. Fluid Sci. 32 800–7
[5] Maharjan N, Chitrakar S and Koirala R 2014 Design of Reversible Pump Turbine for its prospective application in Nepal Int. J. Sci. Res. Publ. 4 2250–3153
[6] Sah N K, Uprety M, Bhandari S, Kharel P, Suman S and Maskey R K 2014 Prospects of Storage and Pumped-Storage Hydropower for Enhancing Integrated Nepal Power Systems Hydro Nepal J. Water, Energy Environ. 15 37–41
[7] Pande P R, Paudel R and Pradhan A B 2016 Nepal: Water Resources Project Preparatory Facility Pre-Feasibility Study Report of Mid-Hill Lift Irrigation Project (Package 6) (Kathmandu)
[8] World Bank 1984 PROJECT PERFORMANCE AUDIT REPORT NEPAL BRAIRAWA-LUMBINI GROUNDWATER PROJECT
[9] S.Upadhaya 2018 Water Nepal : A Historical Perspective
[10] Kathmandu Upatyaka Khanepani Limited 2013 Resettlement Plan Nepal: Kathmandu Valley Wastewater Management Project
[11] Kumar Jha A and Ratna Bajracharya T 2014 Wastewater Treatment Technologies in Nepal
Acknowledgments
Authors would like to thank all government authorities from Narayani Lift Irrigation project for allowing visiting pump house and providing information about project. Similarly, they would like to thank Dhurba Pokharel from MK paper mill for allowing the visit industry and providing impellers for research purpose.