



GUJARAT TECHNOLOGICAL UNIVERSITY

(Established by Government of Gujarat under Gujarat Act No. : 20 of 2007)

ગુજરાત ટેકનોલોજીકલ યુનિવર્સિટી

(ગુજરાત સરકારના ગુજરાત અધિનિયમ ક્રમાંક : ૨૦/૨૦૦૭ દ્વારા સ્થાપિત)

Accredited with A++ Grade by NAAC

Abstract of the Thesis



Name: **Mehta Amit Umeshbhai**

Enrollment No.: **189999919026**

Faculty: **Engineering**

Discipline/Branch: **Mechanical Engineering**

Title of the Thesis: **EXPERIMENTAL AND NUMERICAL STUDY OF
MODULAR HYDRO TURBINE BASED ON CANAL FLOW**

Abstract

The hydrokinetic turbine (HKT), which generates electricity from open water channels, is the most cost-effective solution for meeting these locations' power needs. Using the potential of rivers, canals, and oceans to generate electricity is also a clean, sustainable, and practical solution. In the first stage of this research work, for identifying a potential HKT study site, a comparative numerical assessment of various turbulence models was carried out at trapezoidal open canal situated on Tapi River, Surat, Gujarat, India. Various flow parameters like longitudinal velocity along the depth and width as well as secondary vectors were discussed with different turbulence models such as $k - \varepsilon$ Standard, $k - \varepsilon$ Renormalization group (RNG), $k - \varepsilon$ Realizable, $k - \omega$ Standard and $k - \omega$ shear stress transport (SST). For predicting the potential HKT installation and understanding the flow physics phenomena, velocity vectors as well as water power density were analysed. The simulation results were validated using the experiments performed at the site. Based on the results, the $k - \omega$ SST model found to be more accurate providing the potential site for HKT installation. The potential site is capable enough to provide the flow velocity (U_m) of 0.42 m/s, with estimated power generation of 1.2 kW.

Based on the obtained canal flow, in the second stage comparative analysis of Savonius HKT (SHKT) and Michell-Banki HKT (MBHKT) was carried out in a canal. These HKTs are most viable for ease at fabrication and maintenance too. Additionally, they are suitable for low magnitude velocity of flow. For numerical analysis, the $k - \omega$ SST turbulence model has been selected to the Reynolds-Averaged Navier-Stokes (RANS) solver with two different inlet U_m of 0.42 m/s and 1.06 m/s for a wide range of 0.1 to 1.8 tip speed ratio (TSR). Based on the investigation, the maximum power coefficient ($C_{p,max}$) obtained was 0.0648 and 0.0721 at 0.6 TSR for SHKT and; 0.1121 and 0.1249 at 0.4 TSR for MBHKT, at 0.42 m/s and 1.06 m/s velocity, respectively. Additionally, the fluid flow visualisations surrounding the rotors have been examined and discussed for comparing the performance of HKTs. Because of



GUJARAT TECHNOLOGICAL UNIVERSITY

(Established by Government of Gujarat under Gujarat Act No. : 20 of 2007)

ગુજરાત ટેકનોલોજીકલ યુનિવર્સિટી

(ગુજરાત સરકારના ગુજરાત અધિનિયમ ક્રમાંક : ૨૦/૨૦૦૭ દ્વારા સ્થાપિત)

Accredited with A++ Grade by NAAC

these characteristics, the MBHKT provides a straightforward, reliable, and clog resistant cross-flow option for decentralized zero-head hydrokinetic power generation.

In the next stage, an experimental study of MBHKT was performed at state-of-the-art open channel testing facility established at Fluid Mechanics and Fluid Machine Laboratory, Sardar Vallabhbhai National Institute of Technology, Surat, Gujarat, India. The numerical simulation was validated with the experimental results for MBHKT fully submerged (100% immersion) and partially submerged (75% and 50% immersion) at different velocities. Based on the experimental study, the $C_{p,max}$ obtained was 0.2608 at 1.0 TSR; 0.1330 at 0.8 TSR; and 0.2478 at 0.5 TSR, of 100%, 75% and 50% immersion, respectively. Similarly, during the numerical simulation the $C_{p,max}$ found was 0.4599 at 1.0 TSR; 0.1267 at 0.8 TSR; and 0.3387 at 0.5 TSR, of 100%, 75% and 50% immersion, respectively.

In the final stage of the present investigation, the numerical optimization of three different blade profiles (profile 1 – flat, profile 2 – round and profile 3 – sharp edged) was performed for open channel testing facility established at Fluid Mechanics and Fluid Machine Laboratory, Sardar Vallabhbhai National Institute of Technology, Surat, Gujarat, India. Moreover, based on the optimum blade profile obtained the various augmentations combining the nozzle and diffuser were also numerically simulated to find out the optimum design of augmentation. The results show that the blade profile-3 (sharp-edged) provided the superior performance across the different U_m , achieving the $C_{p,max}$ of 0.2517 at 1.0 TSR. Furthermore, the $C_{p,max}$ of blade profile-1 (flat) and blade profile-2 (round) were 0.1915 and 0.1050 at 1.0 TSR. The augmentation systems can accelerate the water flow in open channels, especially in low-velocity regions. Based on the numerical investigation, performance of the augmentation system-3 was found better than other three augmentation systems. The $C_{p,max}$ of augmentation system-3 with sharp-edged blade profile was found 0.5520 at 1.0 TSR. Comparing, the $C_{p,max}$ of augmentation system-1, augmentation system-2 and augmentation system-4 was found to be 0.4180, 0.5252 and 0.5314 at 1.0 TSR. Also, performance of the MBHKT with augmentation system-3 was 2.2 times higher that of the without augmentation.

- List of Publication(s):
- 1) **Amit U. Mehta** and Pankaj P. Gohil (2026). "A comparative study of turbulence models in a trapezoidal open channel for potential turbine installation site selection.", ISH Journal of Hydraulic Engineering, 1–26.
 - 2) **Amit U. Mehta** and Pankaj P. Gohil (2026). "Performance analysis of Savonius Hydrokinetic Turbine in Open Channel", Multidisciplinary, Scientific Work and Management Journal, Volume 36 (1), pp. 4650-4655.
 - 3) **Amit U. Mehta** and Pankaj P. Gohil (2026). "Survey of India's Small Hydro Power Plants Using Hydro Turbines", Journal of Research in Engineering and Applied Sciences, Volume 11 (01), pp. 1-9.