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Modeling of Human Power Flywheel Motor through Artificial Neural Network- A Novel Approach

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Abstract

Some of the authors of this paper had already established a pedal operated human powered flywheel motor (HPFM) which justifies the energy requirements for process units. The different types of process units designed and tested so far intestinally suits to rural areas such as brick making machine, Low head water lifting, Wood turning, Wood strips cutting, electricity generation etc. This machine system includes three sub systems namely (i) HPFM (ii) Torsionally Flexible Clutch (TFC) (iii) A Process Unit.

ANN modeling has been used to model the experimental findings for human powered flywheel motor. It has been observed that neuron size, transfer function, training function plays important role in performance of the network. The optimal selection of parametric values of each ANN parameter is carried through observation of performance, regression plots. This paper illustrates a unique method of selecting optimal ANN network configuration for fitting function approximation problem. We also found that reliability of the derived ANN model is 97%.

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Keywords: Artificial Neural Network (ANN), Modelling, Human Power Flywheel Motor (HPFM), Reliability analysis;

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1. Overview

Dr. J. P. Modak and his associates have developed Human Powered Process Machines driven by Human Powered Flywheel Motor [1, 2 and3] for rural population to fulfill the production activities such as low level water lifting [4, 12], bricks making (rectangular as well as keyed cross section) for various combinations of raw materials, algae formation process [4], wood turning, wood strips cutting [12], smiths hammer (drop forged/ cam type) electricity generation etc.

The evolved machine system [11] contained of three subsystems namely (1) Energy Unit : Comprising of a suitable peddling mechanism, speed rise gear pair and Flywheel abstracted as Human Powered Flywheel Motor (HPFM) (2) Suitable torsionally flexible clutch [13] and torque amplification gear pair and (3) a process unit. Though human capacity is 0.1 HP continuous duty, the processes needing power even up to 6.0 HP can be energized by such a machine concept.

The basis of this development is generation of design data of these subsystems through establishing Generalized Experimental Data Based Models through executed necessary research projects.

1.1. Empirical Modelling for HPFM:

The experiments for human powered flywheel motor involved large numbers of variables hence dimensionless pi terms were evaluated to model this experimental database.

The dependent pi variable (ωT) for HPFM is function of independent pi terms (I/RT^2), (ME and (G). Where ω is Angular Velocity of flywheel in rad/sec reached after time interval T sec, I is moment of inertia of flywheel, Kg-m^2, R is energy input by rider, Kgf-m, ME is effectiveness of mechanism 'M', G is the speed increasing gear ratio and T is peddling time in second. The complete data comprises of 199 observations. The mathematical model derived for HPFM [9] is

$$WT = 1.288\,(I/RT^2)^{-0.46}\,(ME)^{-0.87}\,(G)^{0.40} \quad (1)$$

The prediction of experimental findings through above empirical model was tabulated for HPFM. It is been observed that the percentage error in prediction of experimental findings is in the range of 10% to 80% [10].

The present research work develops a unique methodology of optimizing ANN prediction of ANN model through methodical amendment of ANN paradigm. The work also derives the mathematical model of the optimized ANN model for HPFM.

The performance of the ANN model is validated through reliability analysis and compared with experimental findings and previously derived mathematical model.

2. Review on Human Powered Flywheel Motor

2.1. Basic Concept of Machine

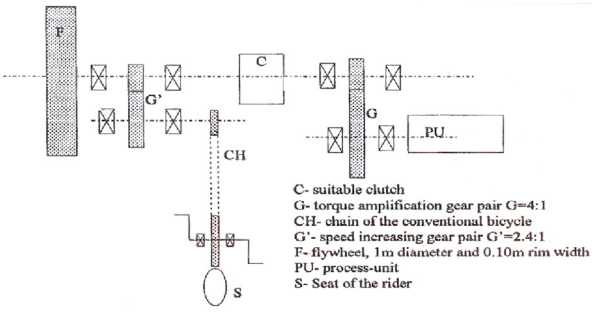

Fig. 1. Plain view of schematic arrangement of machine [9]

On an average, the power produced by a human being is approximately 75W (0.10hp) [9], if he works