SRI KRISHNA COLLEGE OF ENGINEERING AND TECHNOLOGY,

COIMBATORE - 641008

DEPARTMENT OF MECHANICAL ENGINEERING

SCHLUMBERGER - INNOVAY 19

Team : Mechanizers

Title of the Project Proposal

Digitization of Swing Check Valve

Name of the Students

K.Sathishkumar
N.Jayasuriya
R.G.Girish Vishnu
B.Guruprassad

Name of the faculty mentor

Dr.R.Soundararajan

Digitization of Swing Check Valve

K.Sathishkumar[1], N.Jayasuriya[2], R.G.Girish Vishnu[2], B.Guruprassad[2]

[1] Final Year M.E., Mechanical Engineering, Sri Krishna College of Engineering and Technology, Coimbatore.

[2] Final Year B.E., Mechanical Engineering, Sri Krishna College of Engineering and Technology, Coimbatore.

Faculty Mentor

Dr.R.Soundararajan

Associate Professor, Sri Krishna College of Engineering and Technology, Coimbatore.

Email: soundararajan.mtech@gmail.com, **Mobile: 9894534879.**

1. Introduction about Swing Check Valve

A Swing Check Valve (SCV) is mounted with a disc that swings on a hinge or shaft. The disc swings off the seat to allow forward flow and when the flow is stopped, the disc swings back onto the seat to block reverse flow. The weight of the disc and the return flow has an impact on the shut-off characteristics of the valve. Often a lever and weight or a lever and spring are mounted to achieve optimum performance. Swing check valves with lever and weight are appropriate for installations with an increased risk of water hammer at standard velocities. Swing check valves with lever and external spring are suitable for high pressure, insufficient backpressure, and high flow velocities. Used in power plants, oil and gas sectors, hydraulic press, drills, and many hydraulic circuits.

Fig 1. Swing Check Valve

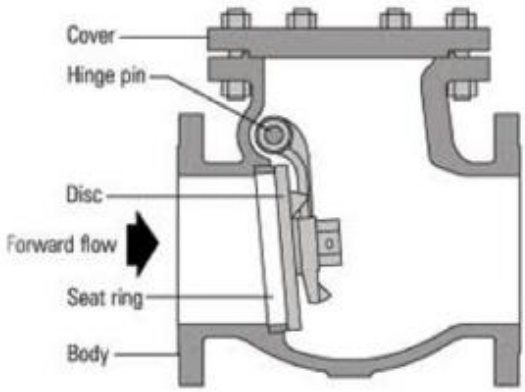


Fig 2. Cut section of Swing Check Valve

2. Problem Statement

- Prediction of Clapper position.
- Measuring of the Pressure, Valve coefficient, and Discharge of the flowing fluid in the swing check valve.
- Clapper chattering verification.
- Sand erosion on the critical regions of the check valve.

3. Solution Proposed

- To measure the flow rate (valve coefficient), the pressure at inlet and outlet during the flow of fluids using relevant sensors.
- To predict the clapper position for corresponding flow.
- To transfer the collected data from the local node to cloud storage and to a computer using a suitable communication protocol.
- To develop a computational model based on pre-experimental data's and analyse using machine learning technique to predict the clapper position and wear behavior of the SCV.
- Also perform alert predictive maintenance of SCV by developed computation ANN model.

4. Brief explanation of Components used for proposed solution

The following Designing of Swing Check Valve, sensors and other accessories were used for the proposed work they are; Flow sensor, Pressure sensor, Microcontroller and Router

4.1 3D Modelling of Swing check Valve with sensors

The 3D Model of the SCV is designed by using Solidworks 2019. The following fig 3&4 will shows the 3D view of the SCV, the cut section view of the SCV shows the position of the flow and pressure sensors placed at the inlet and outlet areas of SCV. The fig 5 shows the cut section view of the SCV.

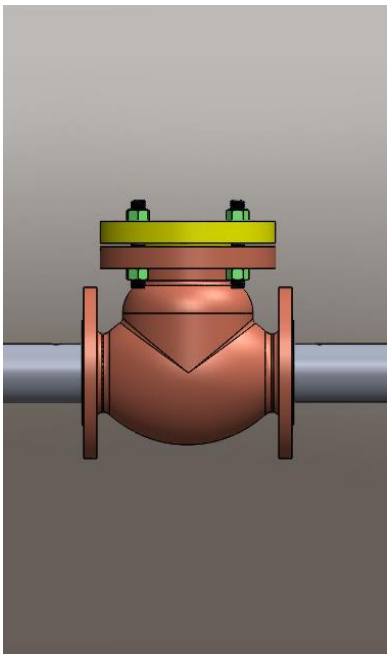


Fig 3. Front view of SCV

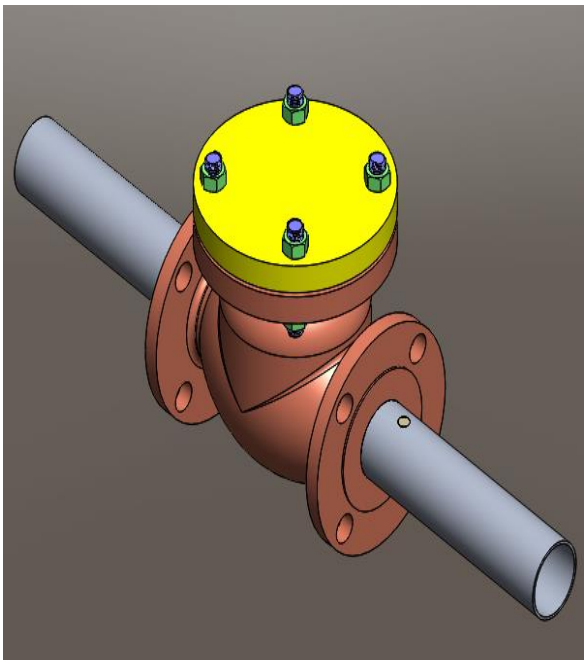


Fig 4. Isometric View of SCV

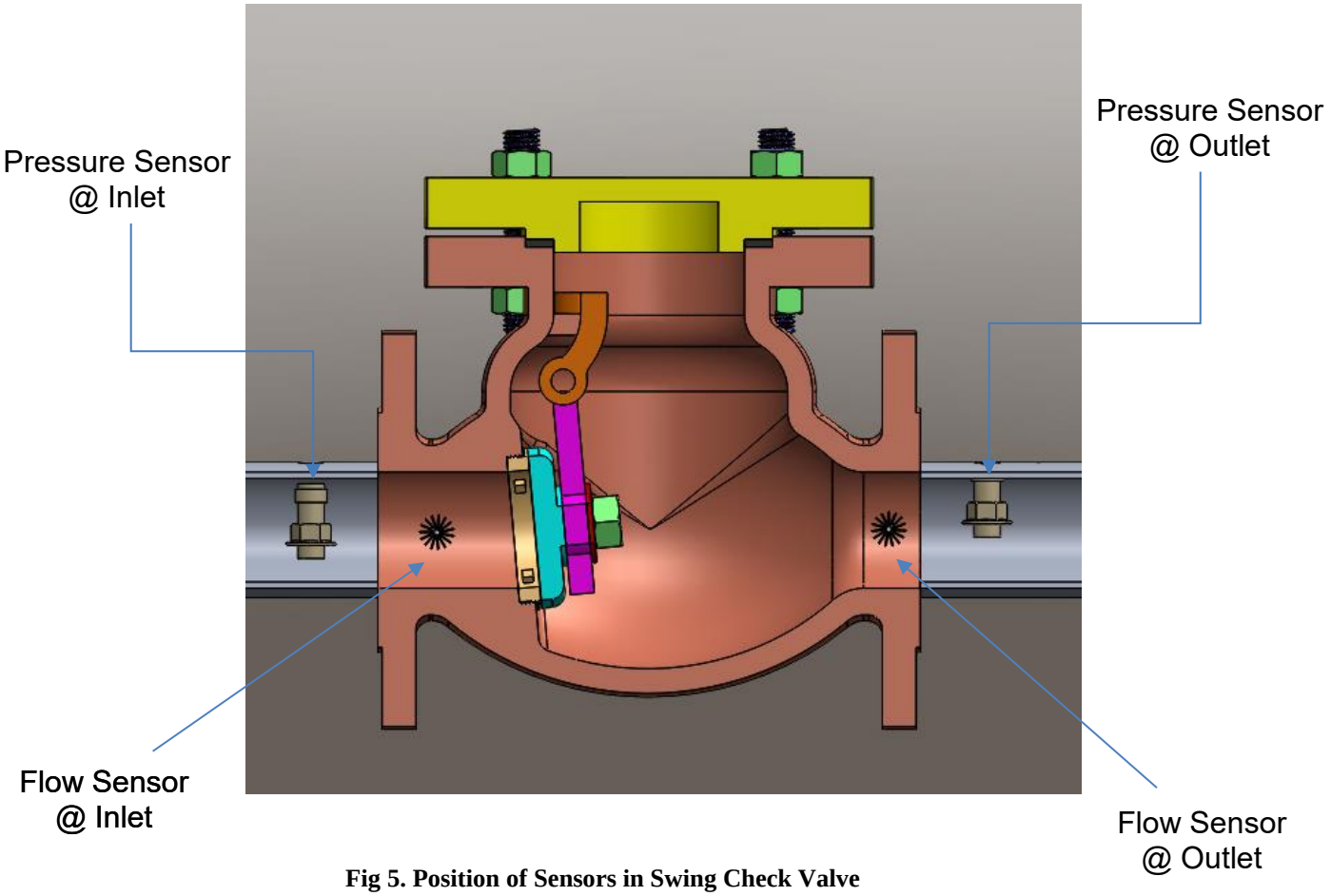


Fig 5. Position of Sensors in Swing Check Valve

4.2 Flow sensor

Fig 6. Honeywell Flow Sensor

Table1. Specifications of Honeywell Flow Sensor

Parameters	Description/ Range
Make	Honey well
Type	Flow Measurement
Flow Range	±300 SLPM
Excitation voltage	5 Vdc ±0.01 Vdc
Power supply	9.0 Vdc min./16.0 Vdc max
Power consumption	60 mW
Operating Temperature	5 °C to 60 °C [41 °F to 140 °F]
Warmup time	5 Sec

The Honeywell flow range sensor provides accurate measurement of mass flow, density, volumetric flow rate and temperature for gases, liquids with low viscosity and applications where users are unwilling or unable to cut into the process measurement line to install an in-line meter.

4.3 Pressure Sensor

Fig 7. Honeywell Pressure Sensor

Table2. Specifications of Honeywell Pressure Sensor

Parameters	Description/ Range
Make	Honey well
Type	Pressure Measurement
Pressure Range	Up to 150,000 psi
Supply current	5mA
Accuracy	±0.25 %
Response Time	<2 ms
Operating Temperature	-40 °C to 125 °C [-40 °F to 257 °F]
Life	min. of 10 million cycles to operating pressure

Honeywell's absolute, gage and true gage pressure and miniature pressure sensors are manufactured from the start to meet the most demanding test and measurement specifications in some of the world's most rugged environments, from a general industrial process, needs up to highly specialized pressure sensors used in hazardous locations. Specialties include high pressure, high temperature and flush diaphragm models in both regular, miniature sizes and subminiature sizes to fit in spaces with tight clearances.

4.4 Microcontroller - Raspberry Pi

Fig 8. Microcontroller Raspberry Pi

The Raspberry Pi is a series of small single-board computers developed in the United Kingdom by the Raspberry Pi Foundation. Several generations of Raspberry Pis have been released. All models feature a Broadcom system on a chip (SoC) with an integrated ARM-compatible central processing unit (CPU) and on-chip graphics processing unit (GPU).

Processor speed ranges from 700 MHz to 1.4 GHz for the Pi 3 Model B+ or 1.5 GHz for the Pi 4; on-board memory ranges from 256 MB to 1 GB with up to 4 GB available on the Pi 4 random-access memory (RAM). Secure Digital (SD) cards in Micro SDHC form factor (SDHC on early models) are used to store the operating system and program memory. The boards have one to five USB ports. For video output, HDMI and composite video are supported, with a standard 3.5 mm tip-ring-sleeve jack for audio output. The lower-level output is provided by a number of GPIO pins, which support common protocols like I²C. The B-models have an 8P8C Ethernet port and the Pi 3 and Pi Zero W have on-board Wi-Fi 802.11n and Bluetooth.

4.5 Communication Protocol – WIFI Module and Router

- The ESP8266 Wi-Fi Module is a self-contained SOC with integrated TCP/IP protocol stack that can give any microcontroller access to the Wi-Fi network.
- The ESP8266 is capable of either hosting an application or offloading all Wi-Fi networking functions from another application processor.
- If long-range data transfer is required then RS232 module is preferred
- A Wi-Fi module is connected to each node's Microcontroller(Arduino)
- All wifi's connected to the local node is connected to a common Router
- All the SCV's are in the same network
- From the common gateway, the data's are stored in Cloud storage and Local Server

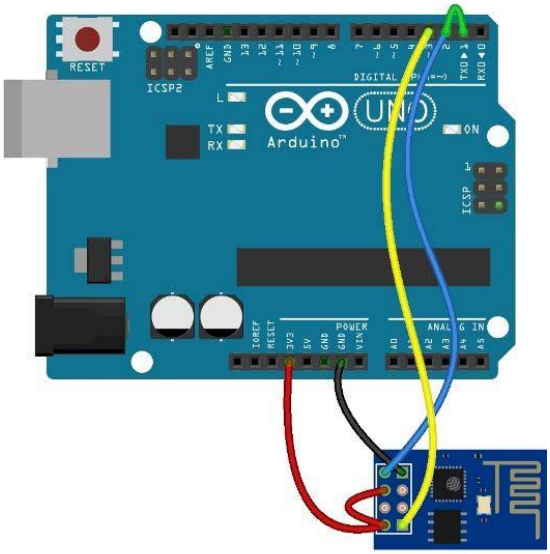


Fig 9. Wi-Fi Module Connected to Microcontroller

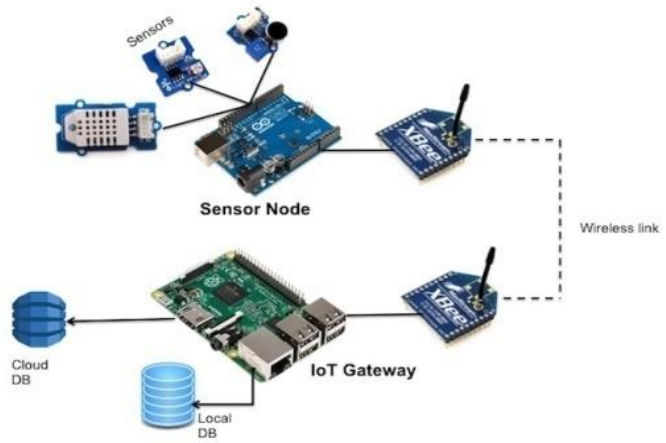


Fig 10. Systematic view of local Wi-Fi network

5. Brief Working procedure of IOT based SCV

5.1 Block diagram of Local Node at SCV

- This block diagram focuses on the above structure which provides a high-level overview of major system components, key process participants, and important working relationships.
- All the sensors are connected to the MC.
- A battery is placed with MC, the MC distributes the required power for working of sensors
- The datum from the sensors are transmitted to the MC and from MC it is directed towards the router.

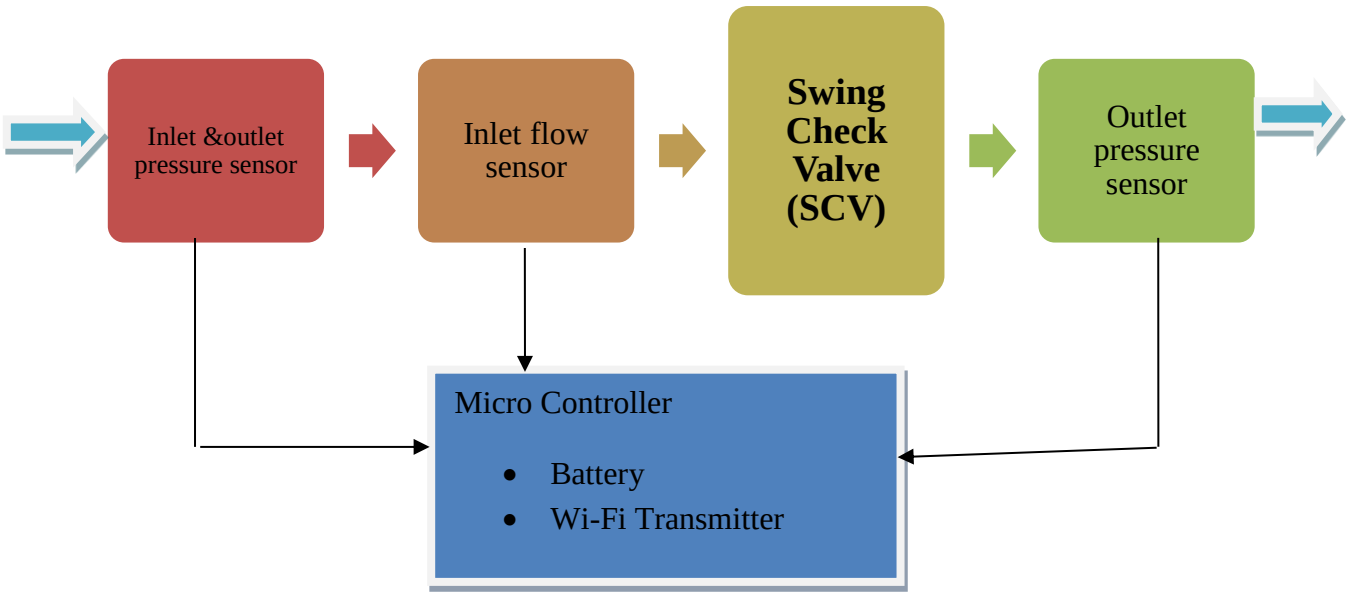


Fig 11. Block diagram of local node

5.2 Life cycle of data generated – Cloud storage

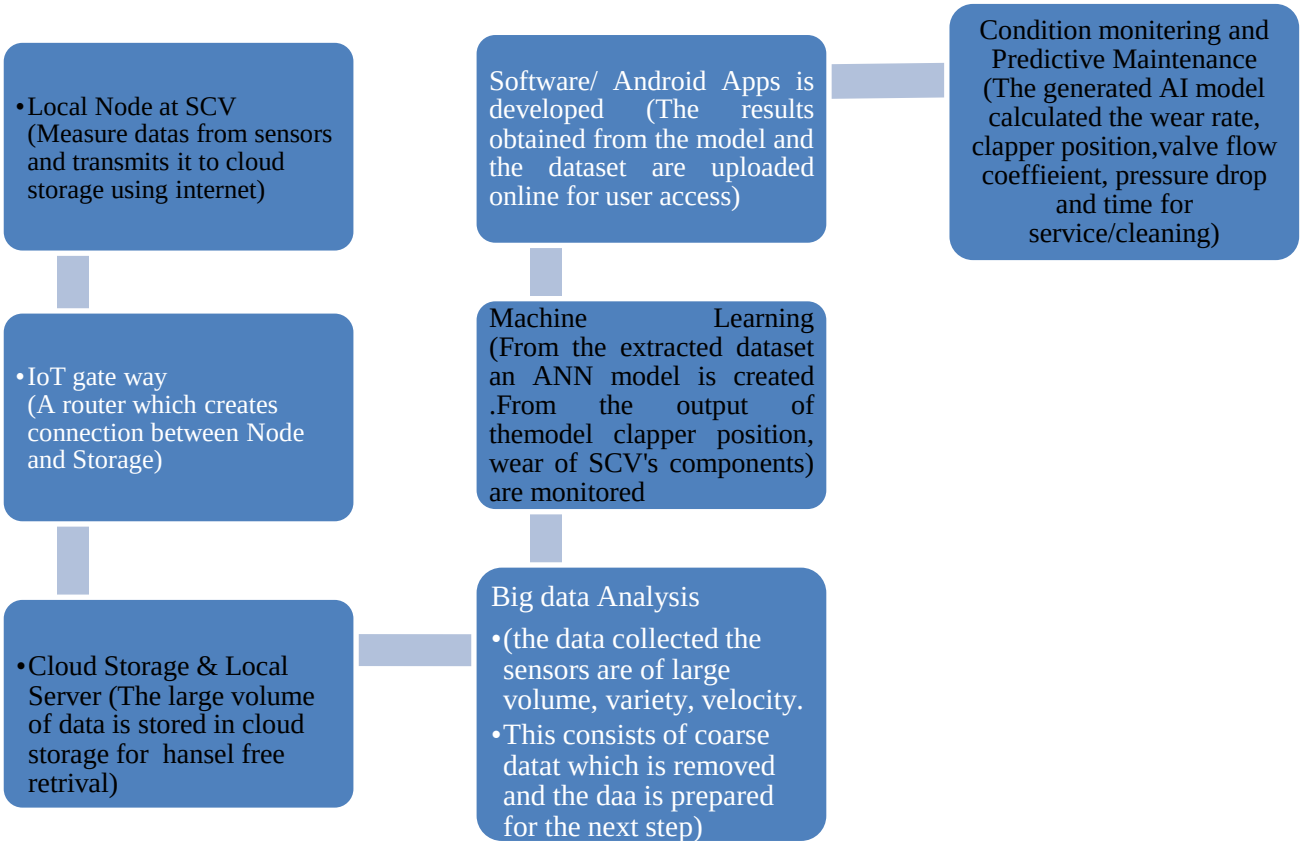


Fig 12. Block diagram of data generated

6. Analytical model and analysis

From the local node at SCV the following three parameters were taken and measured for sensors for further processing;

- Inlet Flow – Variable 1
- Inlet pressure – Variable 2
- Outlet pressure- Variable 3

6.1 Clapper position prediction

- The angular position of clapper is determined by the flow rate.
- From the dataset given by the manufacturer, the clapper position can be predicted using computational ANN model.
- The data set consisting of flow rate data and its relative clapper position values were split into test ($2/3^{rd}$ of data) and train ($1/3^{rd}$ of data) data series
- From the formulae and training set data a multiple linear regression model is developed using Python to predict the clapper position.
- The test set data will be used to check the accuracy of the model by comparing the actual clapper potion value for a particular flow with the predicted value for the corresponding flow and the error percentage is calculated to evaluate the model accuracy.
- From the inlet pressure and outlet pressure, the valve flow coefficient and pressure drop values are calculated.

6.2 Predicting the wear and friction

- The wear rate of the hinge pin, clapper seal will be determined by testing the same material in a Pin on disc Tribometer.
- The influenced input parameters for the pin on disc machine are; Load, Sliding distance, sliding Velocity, Time duration, Type of fluid used were fixed and observed wear and friction values. The test setup was shown in fig 13.

Fig 13. Pin on disc setup

- The data framework consisting of the above-mentioned parameters and wear rate and COF, Frictional Fore are the collected responses.
- Artificial Neural Network (ANN) model has been developed based on feed-forward backpropagation to map the tribological test with different architectures. The optimal model shows appropriate results that can be estimated rather than measured, thereby reducing the testing time and cost.

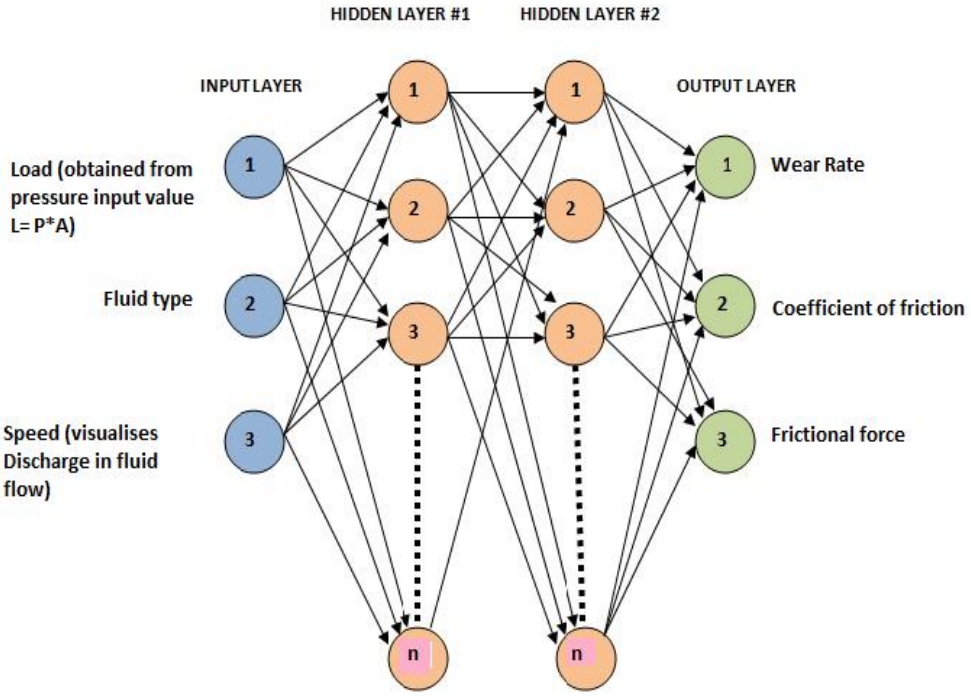


Fig 14. ANN Model

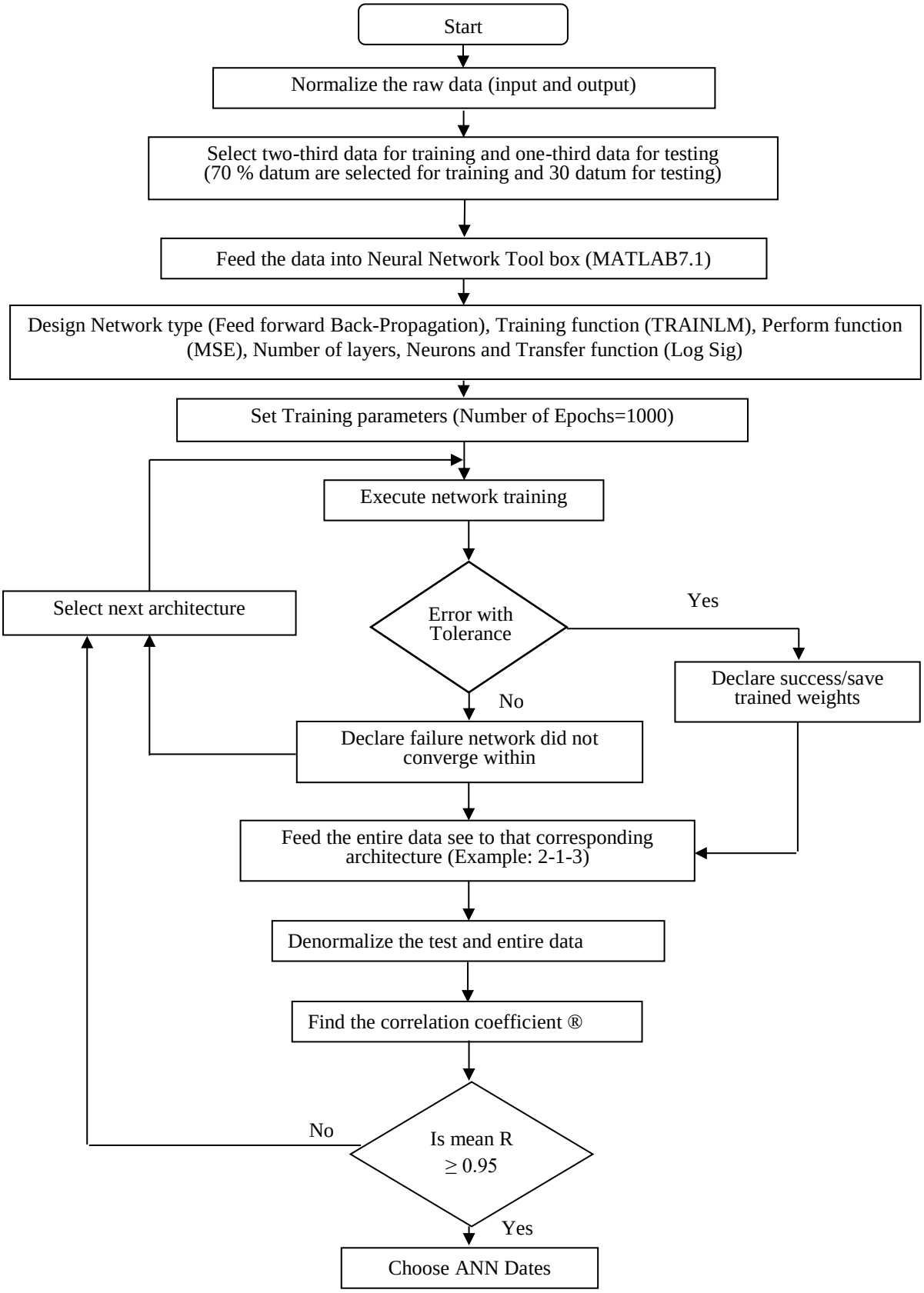


Fig 15. Flow Chart of developed ANN model

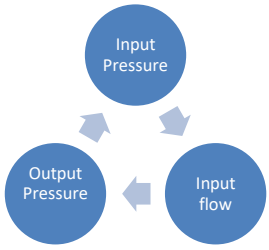
7. Conclusion

We can conclude that by using IoT based check valve,

- The pressure drop and valve flow coefficient is measured for the flow by using sensors to continuous monitoring and permanent data storage for further processing.
- The clapper movement is monitored regularly based on the respective flow rate data from the sensors and recorded in the local node.
- Through data accuquation from sensors, the values can be stored in the local node as well cloud data and it can be retracted any time at any place without any complexity.
- The Failure of the check valve and its sub components (clapper seal, Hinge pin etc.,) by wear (erosion) can be predicted earlier. In this predictive maintenance of each check valve can be done easily through developed ANN model from the stored data.

8. Extended work

- There will be an app for iPhones and Android-based systems. The user interface will be designed as part of the project. There will also be a web application where in authorized personnel will be able to use the app to log in, overview the functioning, safety inspections and audits. Each of these will have a built-in checklist for wear & efficiency.
- It notifies to do service for wear rate and slum in swing check valve
- In order to predict whether service is required or not.
- A correlations between the measured three variables will be created which will help in solving the above problem.



- Correlation is a statistical measure that indicates the extent towards two or more variables fluctuates together. A positive correlation indicates that these variables vary in parallel and vice versa.
- Benchmarking values for three parameters and the expected clapper position will be set from the collection of datum, if the real-time values of these parameters exceed the working range then a notification will be sent to the authorized personals.
- The model developed using the variables predict the wear rate percentage, slump created amount in the valve.