Design and Implement Intelligent System in Water Distribution Network through Fuzzy Logic Using MATLAB 2020

[1] Neeraj,[2] Meenakshi Nawal,[3] Mahesh Bundele,[4] P.K. Suri

[1] Research Scholar
Department of Computer Science Engineering
Poornima University, Jaipur, India
Email: neeraj.bhardwaj789@gmail.com

[2]Associate Professor
Department of Computer Science Engineering
Poornima University, Jaipur, India

[3]Principal and Director
Department of Computer Science Engineering
Poornima College of Engineering, Jaipur, India

[4]Professor
Department of Computer Science Engineering
Kurukshetra University, Haryana, India

Abstract:*Water distribution network (WDN) design of hydraulic model Gurthali, NARWANA-JIND, HARYANA. The objective of this paper to detecting the leakage in water supply system.I have built an intelligent system means fuzzy logic system which take the correct decision about the leakage is present or not in pipeline network which follow the continuous monitoring enhancement of discrete monitoring. Spectral monitoring to take decision with variation of set of data with in a particular time. The objective of this work to detect the leakage in pipeline with correct decision. Intelligent system extension of discrete monitoring system.*

Keywords:*Fuzzy, Leakage, Spectral*

I. INTRODUCTION

In the previous implemented base paper define a discrete monitoring system which take the decision in a particular time at the basis of one coefficient. Today's all monitoring approach take the decision at the discrete components. This is the first decision making approach. Whatever which type of leakage detection available they all operate on discrete values for making decision but in discrete system all values vary to the external and other leakage factors then alarming system or monitoring system will give wrong decision. In discrete monitoring can't classify it is real leakage or external disorder leakage because they don't have a decision approach. They are unable to take a correct decision.
Existing system take the decision through threshold but to overcome and to take a correct decision we built intelligent system means fuzzy logic intelligent system that improve the capability to take a correct decision.
We take real leakage data with measured parameters pressure, flow, leakage value and demand. To observed all parameters and identify the leakage in pipeline network. Discrete monitoring has two conditions without leakage and with leakage.

II. Literature Review

This chapter includes the literature review of the to detect leak detection and categorical review on the different technology.

[Ezeofor et al, 2016] proposed work to find out complete simulationon SMS based robotic system which detect the leakage in pipelines. In given pipe lines to use the GPS/GSM/GPRS technology. In industry to design a system which are based on the robotic system and using different GPS technology. In water supply distribution network welding is a not the proper solution for leakage. In industries today, using the internet of things-based on hardware devices like Arduino.

[Swathi et al, 2018] Presented paper to use the monitoring and controlling the leakage in water pipeline. There are leakage of water at large scale and more water waste. Many industries continue monitor the leakage in water supply system to using on off control algorithm. To detect the value man power use manually methods. To control leakage and monitoring create a Lab view based sensors and hardware includes flow sensor, solenoid value, relay and Arduino.

[J. Vinoj et al, 2018] Presented work to represent the water leak and theft detection system with internet of things in smart city. Water leak detect by remote network sensor which create with Arduino uno microcontroller board and gathered information in details. Smart city mission of India works on this project to improve the economic growth. Message queuing telemetry transport very simple and lightweight messaging protocol, design for high latency, low bandwidth, and reliable network. In future to create an application for water leakage and water theft. Automatically, alarm start whenever water theft. This method can be applying for other area and using android application.

Table1. Comparison table

Author name	Year	Methodology	Objective	Hardware includes	Software includes	Technology	Result
Prasanna	2018	Block chain on –off algorithm	Monitoring & Leak detection	Flow sensor, relay, Arduino,	LabVIEW, VIPM		flow rate = Frequency/7.5
J.Vinoj	2018	IOT	Monitoring & Leak detection	c Flow sensor	MQTT	GSM, GPRS	Output sensor value 98% no leakage
Cithara	2018	IOT (ZigBee module)	Leak detection	Ultrasonic, Gas sensor, RPM sensor, sensor	Programmed embedded in c language	GSM, GPRS	
Rahamat	2017	Experiment set up	Monitoring & Leak detection	Arduino Ethernet shield flow meter sensor,	Web server		Detect leak with avg flow rate 10 litre per minute
Ezofor	2016	SMS based robotic system	Leak detection	Arduino uno micro controller, ultra sonic sensor		GSM, GPRS, GPS	Detect holes in pipeline

III. METHODOLOGY

3.1 Objectives of Fuzzy logic method

- To monitor and detect the leakage in water supply network.
- Detect the leakage with spectral technique.

- Design and implement algorithm with automatic fuzzy rules which based on Mamdani approach.
- Apply the fuzzy rules on a real data.

3.1.2 Spectral Feature

The monitoring input to the fuzzy system is given by the spectral feature developed by sub band decomposition. A successive integration of filter banks results in a decomposition of signal into finer frequency band. For the realization of such filtration a wavelet-based filtration is used. In the process of spectral decomposition approach, successive filter bank architecture is used as shown,

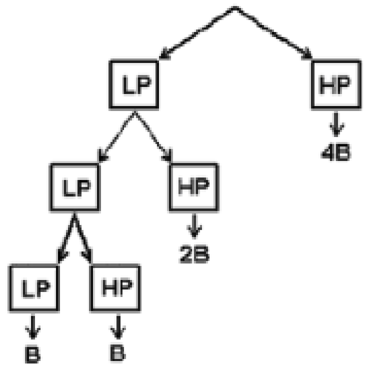


Figure1: Filter bank Architecture

For each of the decompose band mean spectral density (MSD) is computed given by,

$$MSD = \frac{\sum_{i=1}^{n} |B^2|}{n}$$

B is the decomposed band for a signal P(t) which reflect the measured parameter for a period ‘t’. given by,

B = conv (P,F)

Conv. is the convolution operation between the observed parameter with a filter coefficient (F). the High pass (HP) and low pass (LP) filter are developed as FIR filter giving the spectral variation of the observing parameter.

3.2 Fuzzy System

In Fuzzification process, the measured value from sensors is transformed into linguistic variables (LV). Each LV is graded by membership functions (MF) with the values between NORMAL, HIGH and LOW and whose values are based on process knowledge as shown,

Table2.Linguistic variable (LV) for fuzzy system

Parameter input	**NORMAL**	**LOW**	**HIGH**
Pressure	45	43	47
Flow	270	230	300
Demand	300	250	350

The triangular membership functions always varies between 0 and 1.

$$L = \begin{cases} 0, & if x \leq a \\ \dfrac{x-a}{m-a}, & if a \leq x \leq m \\ \dfrac{b-x}{b-m}, & if m \leq x \leq b \\ 1, & if x \geq b \end{cases}$$

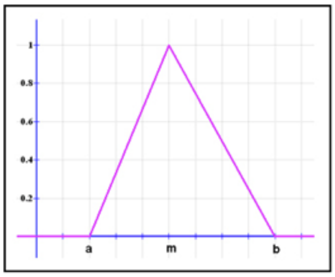


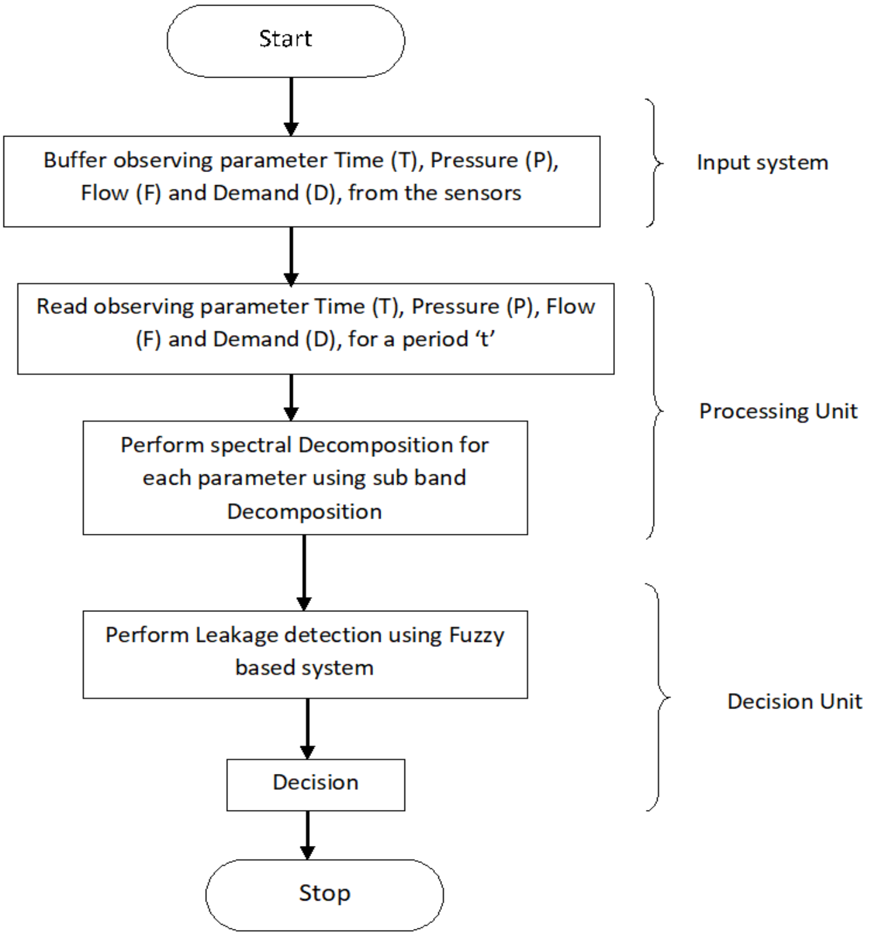
Figure2: Triangular membership function

Where x is the input value, m – Normal, a – Low, and b – high
The fuzzifier based on membership function which consist of fuzzy rules. The Mamdani type fuzzy inference system, which adapts if then rules are used.
Defuzzification is the last step in fuzzification which use the mean of Maximum (MoM) technique.
The rule developed for the fuzzy interface and the decision is given in table below.

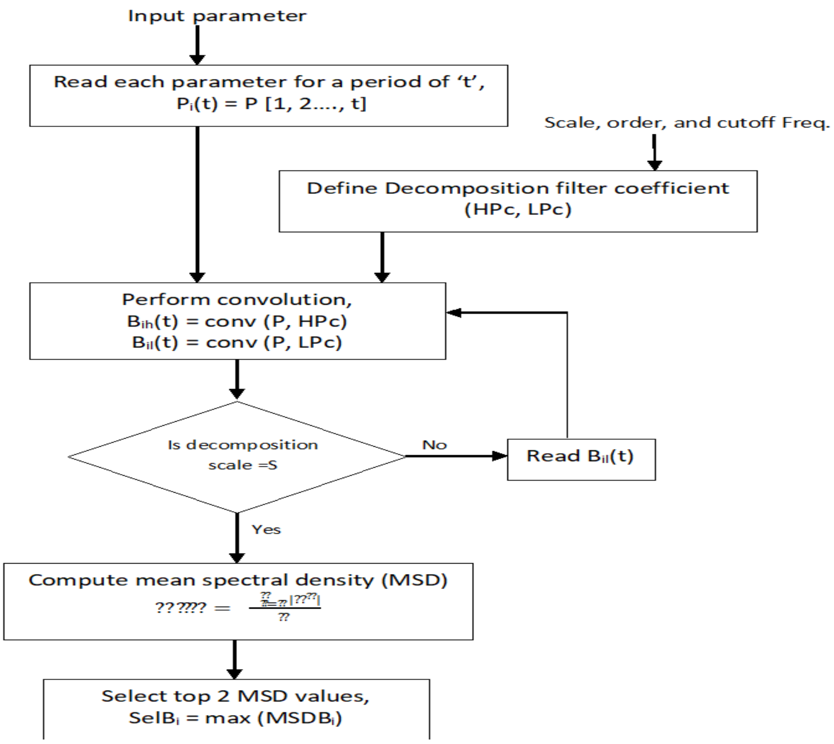
Table3.Fuzzy rules

	if			**then (leakage)**
	MSD_Pressure	**MSD_Flow**	**MSD_Demand**	
Parameter	Normal	Normal	Normal	No
	Low	Medium	Normal	Yes
	Low	Low	Normal	Yes
	Normal	Normal	Low	No
	Normal	Low	Normal	No
	Low	Low	Low	No
	Medium	Low	Low	Yes
	Low	Medium	Normal	Yes
	Medium	Medium	medium	No
	Low	Low	Low	No

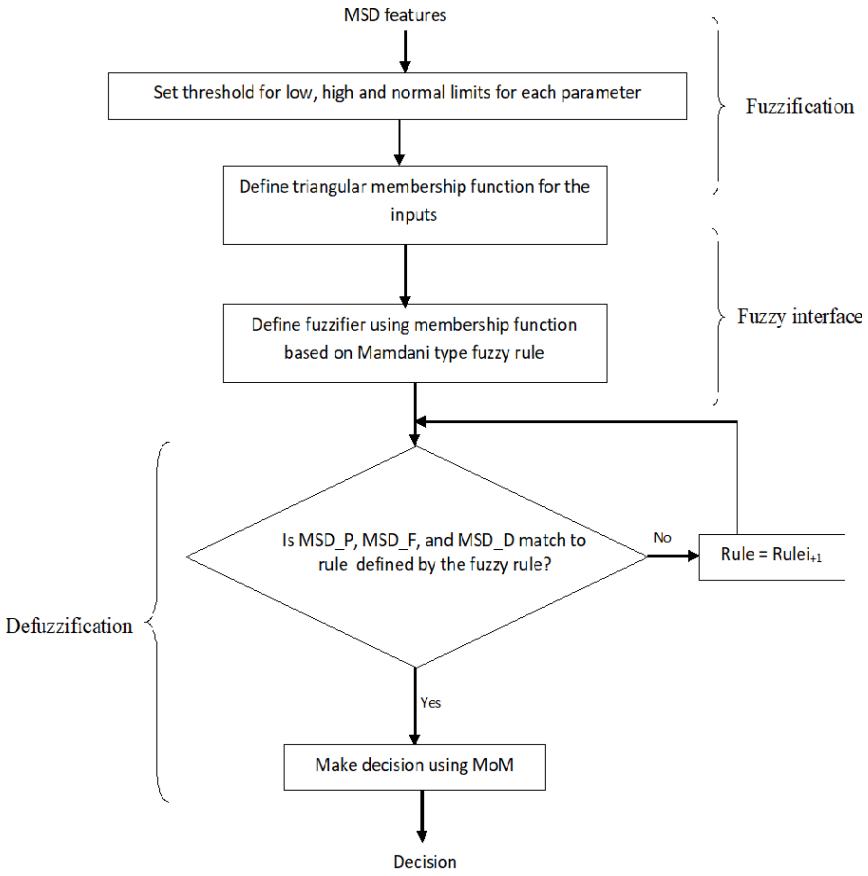
3.3 Flow Chart



Processing Flow Chart 1



Processing Flow Chart 2



3.3.1. Leakage Detection algorithm

Algorithm:1 Leakage Detection using fuzzy logic approach

Input: Layout,measured parameters.
Output: Leakage Decision
Input: Read each parameter for a period of 't'
P(t) = P [1, 2, … t]
Pressure, Flow, Demand, Leakage Value, Time, Label
Start
Step1: Initialize parameter P1, P2, P3, P4, P5, P6
Step2: Read data
Step3: Xlsread function reads the data from excel sheet
Step4: Select parameters P1, P2, P3, P4, P5, P6 & input given (5000:6000)
Step5: Apply HPc, LPc Decomposition filter coefficient
Step6: Perform convolution method
if Decomposition Scale perform
Yes
Then compute mean spectral density

$$MSD = \frac{\sum_{i=1}^{n} |B^2|}{n}$$

Else if
read Bi(t)
Step7: Select top two MSD values
Sel Bi = max (MSD Bi)
Step8: Set threshold for low, high and normal limits for each parameter
Step9: Select triangular function for the inputs fuzzification
Step10: Apply fuzzifier based on Mamdani Approach
Step11: Apply Defuzzification

if MSD_P, MSD_F, and MSD_D match to ruledefined by the fuzzy rule
yes
Then make decision using Mean of maximum
Else if
Rule = Rule i +1
Step 12: Stop

IV.Result

For the monitoring and detection of leakage in a water pipeline network, a threshold based correlative approach was used. This approach, reads the sensors data in discrete (where each sensed value is compared) and a correlation with the threshold decide the leakage status. In this approach, if the sensed value is above the threshold an indication is given.

However, we observe that, discrete value can be biased (changed) due to sensor fault, or external effects. Hence, the decision of leakage status will be erroneous.

Hence, we propose to use a continuous monitoring of the measured data for a time period and rather to comparing its value to a threshold, we go for finding its variation with time. When we observe the variations, if a change in sensed value is observed due to external effects it can be clearly observed in the variations which can then be used for decision making.

Secondly, we see that each of the nodes has a pressure, flow and demand input. Wherein existing approach takes the decision in monitoring of each parameter separately, each parameter could result in different decision. This again tends to a confusion state in monitoring.

To avoid this confusion issue, a fuzzy based system is stated which use multiple inputs together in making a decision.

4.1 Observation

In a network, the monitoring unit is placed at selected nodes.

We select node 9 and 11 in this simulation and observe the parameters variation by which a decision is made.

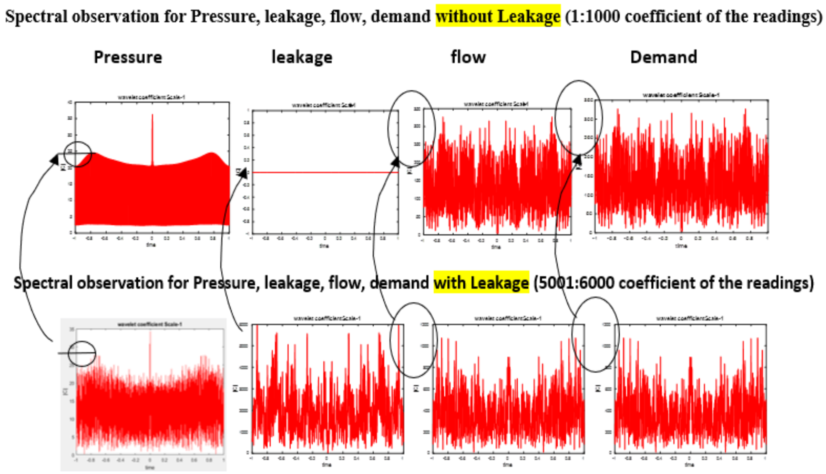


Figure3: Comparison between with leakage and without leakage

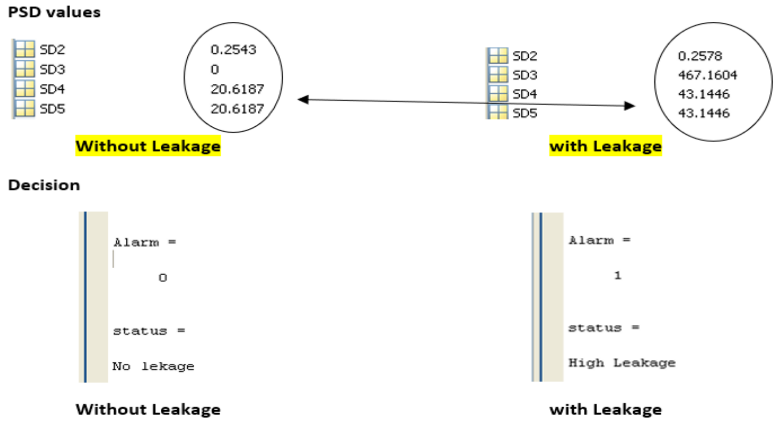


Figure4: Comparison with PSD values

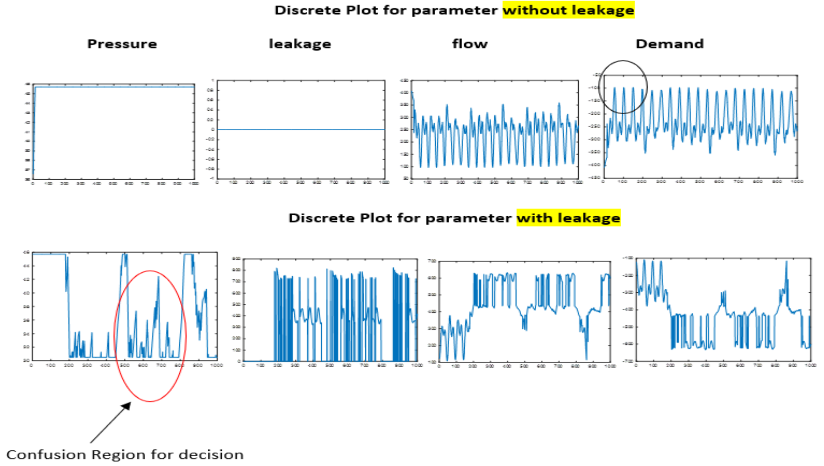


Figure5: Discrete plot for parameter with and without leakag

Table4:Real data

	A	B	C	D	E	F	G
1		Time	Pressure	LeakValu	flow Value	Demand Value	Label
2		0:00	36.576	0	406.8	-406.8	0
3		0:30	37.265	0	403.2	-403.2	0
4		1:00	37.985	0	399.6	-399.6	0
5		1:30	38.741	0	396	-396	0
6		2:00	39.505	0	392.4	-392.4	0
7		2:30	40.286	0	388.8	-388.8	0
8		3:00	41.079	0	385.2	-385.2	0
9		3:30	41.857	0	381.6	-381.6	0
10		4:00	42.606	0	378	-378	0
11		4:30	43.325	0	378	-378	0
12		5:00	43.997	0	374.4	-374.4	0
13		5:30	44.614	0	370.8	-370.8	0
14		6:00	45.167	0	370.8	-370.8	0
15		6:30	45.644	0	370.8	-370.8	0
16		7:00	45.72	0	237.6	-237.6	0
17		7:30	45.72	0	259.2	-259.2	0
18		8:00	45.72	0	277.2	-277.2	0
19		8:30	45.72	0	302.4	-302.4	0
20		9:00	45.72	0	306	-306	0
21		9:30	45.72	0	324	-324	0
22		10:00	45.72	0	331.2	-331.2	0
23		10:30	45.72	0	316.8	-316.8	0
24		11:00	45.72	0	320.4	-320.4	0
25		11:30	45.72	0	309.6	-309.6	0
26		12:00	45.72	0	295.2	-295.2	0
27		12:30	45.72	0	284.4	-284.4	0
28		13:00	45.72	0	270	-270	0
29		13:30	45.72	0	255.6	-255.6	0
30		14:00	45.72	0	241.2	-241.2	0
31		14:30	45.72	0	234	-234	0
32		15:00	45.72	0	223.2	-223.2	0
33		15:30	45.72	0	216	-216	0
34		16:00	45.72	0	226.8	-226.8	0
35		16:30	45.72	0	226.8	-226.8	0
36		17:00	45.72	0	226.8	-226.8	0
37		17:30	45.72	0	237.6	-237.6	0
38		18:00	45.72	0	252	-252	0

- Fuzzy rules to use if else rules that is called membership function. In my work we use triangular membership function. There is condition of true and false. We are given a range not give a discrete value. If we want to crisp decision we will go for else if condition. If our parameters in between low and high then go for else if condition and define a membership function.

    - F1=mean (p1_limit low) / (limit low-limit high). Average the P1 with respect range of limit minimum and high maximum. This is your 1 status.
    - If mean (p1-limit high) / (limit low- limit high). Relation of high two values is not exiting then we say no distortion. Above both conditions to say there are chance of minor leakage.
    - We go for deeply analysis: F1(i)=1 means pure leakage, F2(i)=0, means there are no leakage at all.
    - These three cases define in fuzzy rules with triangular rules. F1 to F6 we use for status flag.
    - All the parameters have different status that basis we generate a combination which combination on the basis of Mamdani rules in fuzzy system. This is a standard rule.
    - If F1(i)>= maxF1, F2(i)>=max F2, F3(i)>=max F3 … if all function to say greater we trigger zero else if trigger 1or else if trigger 0.5(partial leakage). There are 6 multiple observations discrete system we taken independent observation.
    - But there is fusion, we can see 1,0.5 and 0. if tr(j)=1,alarm1,then status is high leakage. Tr(j)=0.5 then partial leakage or Tr(j)=0 then no leakage. Decision system to tell us about all conditions of leakage.

- Now, we enhance the discrete monitoring system towards the continuous monitoring system.
- We have implemented the continuous monitoring system using fuzzy logic system and the transformation approach.
- Automatically all the function calls in Main.m function. After run the Main.m program, density of every observation come in command window and also show the decision.

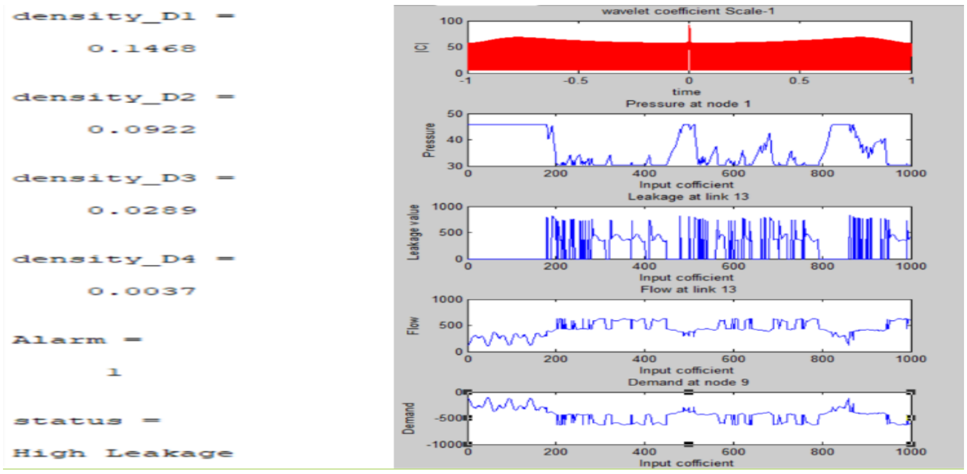


Figure6: Comparison between parameters

- Spectral variation in figure 1: Pressure variation from node 1 to node 2 in frequency domain. In blue color we have highlight a particular point that detect a high variation means suddenly come a peak point. We can see at one place we observe rapid variation which circle with blue color and then go for towards normalization.

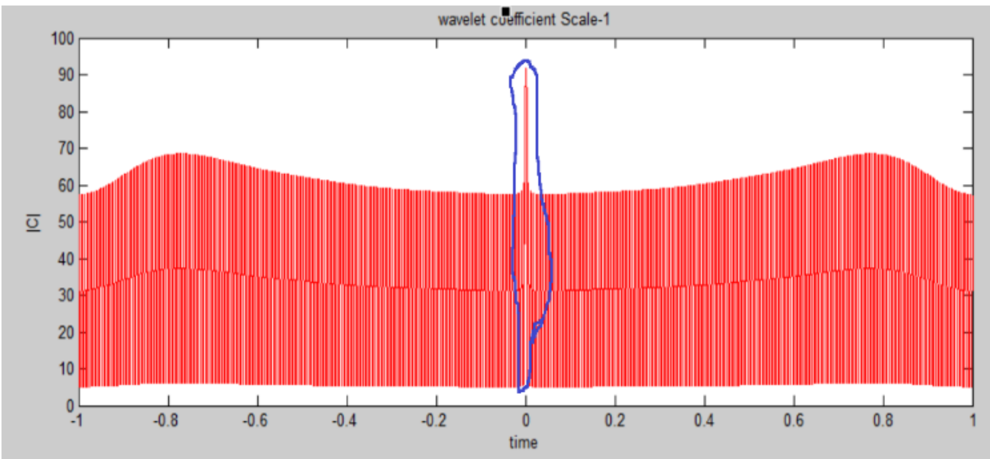


Figure7: Spectral density at peak point

- Spectral variation in figure 1: Pressure variation from node 1 to node 2 in frequency domain. In blue color we have highlight a particular point that detect a high variation means suddenly come a peak point. We can see at one place we observe rapid variation which circle with blue color and then go for towards normalization
- In previous work only include the discrete monitoring system which not take the accurate decision because they do discrete comparison means take a one coefficient and compare with threshold so

on. But with time we don't know this happen or not. If sudden distortion come or sensor disable, heavy pressure come etc. that time discrete monitoring system can't take accurate decision.

- Today's time continuous monitoring has been not used. So, we have continuous monitoring fort o take a correct decision. To take the decision to observed all parameters. In compare of this if we have only monitored the pressure then pressure to show leakage and flow to show no leakage because pressure and flow to have different threshold.

V.CONCLUSIONS

This paper described the simulation scenario that based on the real leakage data. In the given scenario we take different nodes with different parameters. To design a fuzzy system which analysis the leakage with spectral density. Fizzy system is intelligent system which can help to take a correct decision about leakage. This is a good method for to detect a correct decision about leakage in water supply system. We can apply this data at the real layout of Narwana (Haryana) water supply system.

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AUTHORS PROFILE

Ms. Neeraj is currently pursuing the Ph.D. degree in Computer Science & Engineering with the Poornima University, Jaipur, India. She completed B. tech in Computer Science and Engineering in 2011 and M. tech in Computer Science in 2013.She is having experience in teaching as a lecturer in Govt College. She has attended IEEE conferences, scoops conference, workshop and trainings on Ns2, Wireless sensor network etc. She has published research papers in conference and journals. She is also IEEE member. Her research interests include Wireless Sensor Network and MATLAB.

Dr. Meenakshi Nawal is currently working as Associate Professor with the Poornima University, Jaipur, India. She is Gold Medalist in M.Sc. (IT) from MDS University Ajmer. She has completed Ph. D (Computer Science) from Banasthali Vidhya pith, Jaipur. She is having 13 years' experience of Academics and Research.Her area of research is "Patient Authentication and Security measures in Remote Health Monitoring". She has attended many National and International Workshops, Conferences and Published papers in National conference.Her areas of research interest are Machine Learning, Deep Learning, Image Processing, Big Data Analytics and Software Defined Networks etc.

Professor (Dr.) Mahesh M. Bundele has completed his Bachelor's degree in Electronics and Power in 1986 from Nagpur University and immediately joined as Lecturer in Electronics at Babasaheb Naik College of Engineering, Pusad,Yavatmal district. He did his Master's in Electrical Power System and Doctoral in Computer Science & Engineering with a topic "Design and Implementation of Wearable Computing System for the Prevention of Road Accidents" from Amravati University in 1990 and 2013 respectively. He has worked as Lecturer, Assistant Professor, Professor and Head of CSE & IT during 25 Years at BNCOE and guided many research projects at UG and PG level on various applications in Electrical, Electronics & Computer Sciences including city and village Wi-Fi/Wi-Max design up to 195 villages. He has worked on various govt. and industry research projects. He was also appointed as Principal of Babsaheb Naik College of Engineering, Pusad from March 2011. He has worked in various capacities such as, member Board of Studies, Chief-Valuation officer etc. at university level. He has also worked for getting ISI to Krishak Motor pumps at Amravati. He has visited US, UK, China and Malaysia for research presentations. He has published more than 50 research papers in National and International conferences and journals. He is senior member of IEEE, Life member of ISTE and IEI and the member of ACM. Presently he is working as Member, STDCOM Technical & Professional Activities, and Member Execom, IEEE Delhi Section & Secretary, IEEE Rajasthan Subsection. He is having total 34 years of teaching including 7 years of research and internship. Presently he is working as Principal & Director, Poornima College Engineering, Jaipur, India. He has also worked Dean (R&D) at Poornima University and Heading Advanced Studies & Research Center dealing Master of Technology programs and Doctoral degree programs of the University. His areas of research interest are Wearable & Pervasive Computing, Software Defined Networks, Wireless Sensor Networks, and Smart Grid Issues etc.

Prof. P.K. Suri, Dean (R & D), Chairman & Professor (CSE/IT/MCA) of HCTM Technical Campus, Kaithal, since Nov. 01, 2012. He obtained his Ph.D. degree from Faculty of Engineering, Kurukshetra University, Kurukshetra and Master’s degree from IIT Roorkee(formerly). He started his research carrier from CSIR Research Scholars,AIIMS. He worked former as a dean Faculty of Engineering & Technology, Kurukshetra University, Kurukshetra, Dean Faculty of Science, KUK, Professor & Chairman of Department of Computer Sc. & Applications, KUK. He has approx. 40 yrs experience in different universities like KUK, Bharakhtala University Bhopal & Haryana Agricultural university, Hissar.He has supervised 18 Ph.D. students in Computer Science and 06 students are working under his supervision. Their students are working as session judge, director & chairpersons of different institute. He has around 150 publications in International/National Journals and Conferences. He is recipient of 'THE GEORGE OOMAN MEMORIAL PRIZE' for the year 1991-92 and a RESEARCH AWARD – “The Certificate of Merit – 2000” for the paper entitled ESMD – An Expert System for Medical Diagnosis from INSTITUTION OF ENGINEERS, INDIA. The Board of Directors, governing Board Of editors & publication board of American Biographical institute recognized him with an honorary appointment to Research board of Advisors in 1999.M.P. Council of Science and Technology identified him as one of the expert to act as Judge to evaluate the quality of papers in the fields of Mathematics/Computer Science/ Statistics and their presentations for M. P. Young Scientist award in Nov. 1999 and March 2003.His teaching and research activities include Simulation and Modeling, Software Risk Management, Software Reliability, Software testing & Software Engineering processes, Temporal Databases, Ad hoc Networks, Grid Computing, and Biomechanics.