PIPELINE CRACK DETECTION USING FLOWSENSOR FOR MILK INDUSTRY

[1]Dr.R.Suresh Babu,M.E.,MBA.,PhD.
[2]B.Priyanka,[3]J.Sabintaj,[4]S.Sivageetha
[1]Head of the department and Professor of ECE,
[2,3,4] UG Student, Department of ECE
Kamaraj College of Engineering and Technology,Virudhunagar.

1.INTRODUCTION

Nowadays all over the country the problem faced by many milk industry is the leakage in the pipeline. In milk industry, the products flow between the components of the plant in the pipe system. A dairy is also having a conduit system for other media such as water, stream, cleaning solutions, coolant and compressed air. All the system are basically build up by stainless steel with the grade of AISI304 and AISI307.

Normally stainless steel does not corrode but however with some chemicals, notably acids, the passive layer may be uniformly depending on concentration and temperature. Our project is well suited to detect the leak detection in the pipe using signal processing algorithms with flow rate calculated.

As "prevention is better than cure", this project deals with the early detection of crack in the pipes. The proposed model diagnoses the gap created due to the crack in the metallic or other material pipes used in the industries like milk, oil and water industry. For the surveillance of the pipe we use two flow sensor which measures the flow rate. The observation of the break in the pipe is done by processing the flow rate measured by both the sensor. This method also avoids the leakage in the pipe which enhance the economically of the industry by avoiding major issues.

2.OBJECTIVE

- The main objective of this project is to detect crack or leak in the pipeline by using signal processing algorithms.
- To analyze and verify the crack the signal parameters are measured using flow sensor.
- The result is verified in both hardware and software method.

1.2 PROJECT DESCRIPTION

The basic concept used in this method is speed varies if there exists a crack in the pipeline. In this method two flow sensors are used to measure the speed of the milk flowing through the pipeline. The readings of both the flow sensors are noted as x and y, Then the cross correlation for these two observed reading is calculated. Using the method of cross correlation, the spectral density is obtained.

The signal processing algorithm used are MUSIC algorithm, periodiogram, welch method, covariance and modified covariance. The peak of the frequency spectrum is noted for detecting the presence of crack in the pipeline.

2.LITERATURE SURVEY

2.1. IN-SITU CALIBRATION OF PERMANENT MAGNET FLOW METERS IN PFBR USING NOISE ANALYSIS TECHNIQUE

Ranga Ramakrishna n, P.AnupKumar,M.Thirumalai,G.Vijayakumar,V.A.Sureshkumar, K.V. SureshKumar, IndiraGandhi Centre for Atomic Research, Kalpakkam, India. SEPT2013.

This system uses Permanent Magnet Flow Meter (PMFM) to measure the liquid sodium flow rate. Prototype Fast Breeder Reactor (PFBR) which is a 500MWe pool type, sodium cooled, fast breeder reactor, is under construction at Kalpakkam, India. Sodium flow in PFBR is measured mainly at pump outlet and subassembly outlet in the primary circuit and also in different places of secondary sodium circuit. In Fast Breeder Reactors,permanent magnet flow meters (PMFM) are mainly used to measure the liquid sodium flow rate . This degradation results in reduction in output voltage and affect flow meter stability. The distortion of the magnetic field in the large diameter flow meters makes its characteristics nonlinear. Further, the performance of the flow meter is also affected by vibrations, shocks, temperature and change of resistance within the magnetic circuit. Hence, it is desirable to calibrate the PMFM at periodic time intervals for ensuring accuracy and stability. The calibration carried out using cross correlation technique. This method , the voltage fluctuations from two sets of electrode pairs in a PMFM are cross correlated and the transit time of fluctuation between two electrode pairs, caused by flow turbulence, is found from the peak value of the cross correlation function. As the spacing between electrode pairs is known, flow rate can be easily calculated. The deviation of the flow rate estimated using cross-correlation technique is found to be within 75.5% which is comparable with that of calibration of the flow meter in actual sodium test loop.

2.2. WATER PIPELINE MONITORING AND LEAK DETECTION USING FLOW LIQUID METER SENSOR

R F Rahmat, I S Satria, B Siregar1, R Budiarto

IAES International Conference on Electrical Engineering, Computer Science and Informatics

This system uses a Flow liquid meter sensor is one of the sensors that is used for this monitoring process. This sensor uses Hall Effect sensor inside it to measure the water flow rate and is placed on a pipe that has a diameter equal to the diameter of the sensor. The sensor will retrieve water flow data by analysing rotation count of the wheelThe wheel rotation count is further processed in order to get the data of water flow passing through the sensor every second using equation, where n = number of wheel rotation, Q= liquid flow rate (m3/sec), and c = calibration factor. Every water flow rate data received per second will be compared by Arduino. If there is a significant reduction in normal water flow rate, then the data of it will be stored temporarily until the flow is stable, stability is measured by comparing the normal and potential leakage data. Once the data is stable, the normal and the potential leakage data will be processed to get the velocity of the normal water and the flowafter leakage.

2.3. LEAK DETECTION IN GAS PIPELINE BY ACOUSTIC AND SIGNAL PROCESSING

N F Adnan , M F Ghazali , M M Amin and A M A Ham at 3rd International Conference of Mechanical Engineering Research(ICMER 2015)

In this paper, the study of gas leak detection is done by using acoustic, sound propagation, signal analysis and some simulation synthetic signal. Basically, the leak can described as gas or liquid flow through the wall with the imperfection such as hole, crack or ruptures. The pressure difference in pipeline always flows from higher pressure to lower pressure. The imbalance pressure detected and analysed to detect the leak. The wave propagation or speed of sound, a will be dependent on the material and pipe diameter. When a sound wave comes into contact with a surface, some part of the energy is reflected from it, some are transmitted through it and some is absorbed. If absorption and transmission are low, and thus most of the sound energy incident on the surface is reflected, it is supposed to be acoustically hard and can be regarded as mirror reflect the illumination. The basic rule behind this acoustic method is when leak or ruptures occur, the friction between the rampart in the pipeline happen because of the pressure balance was broken. The acoustic signal will propagate to upstream and downstream. The stress wave that transmitted through the pipeline can be recorded by acoustic sensor or accelerometer. Acoustic sensor normally installed outside the pipeline network. The leak generates noise and pick up by these acoustic sensors and the most important thing is to minimize the background noise. The location and size can be determined by using acoustic methods. This method can be used on new as well as on existing pipe network.

2.4. AUTOMATIC CRACK DETECTION AND CLASSIFICATION METHOD FOR SUBWAY TUNNEL SAFETY MONITORING

Wenyu Zhang, Zhenjiang Zhang *, Dapeng Qi and Yun Liu, 16 October 2014

In this method crack is detected by image processing using segmentation of the crack. This paper presents a crack detection and classification approach for subway tunnels on the basis of applying CMOS line scan cameras .In gray-scale images, cracks present themselves as dark regions with local minimum gray-level components. Morphological image processing operations have an advantage in segmenting relevant structures without complex iterative calculations. For this reason, they can be used to detect local dark regions in the original gray scale image, in which most irrelevant objects with high gray levels or small regions can be easilyeliminated by thresholding operations.

3.SYSTEM REQUIREMENTS

3.1.1. POLYVINYL CHLORIDE (PVC)

It's the white plastic pipe commonly used for plumbing and drainage. PVC stands for polyvinyl chloride, and it's become a common replacement for metal piping. PVC's strength, durability, easy installation, and low cost have made it one of the most widely used plastics in the world.

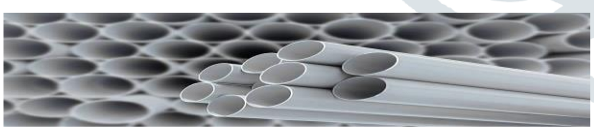

Figure 3.1 PVC pipe

3.1.2. FLOW SENSOR (YF-S201)

Water flow sensor consists of a plastic valve body, a water rotor, and a hall-effect sensor. When water flows through the rotor, rotor rolls. Its speed changes with different rate of flow. The hall-effect sensor outputs the corresponding pulse Signal. This sensor sits in line with your water line and contains a pinwheel sensor to measure how much liquid has moved through it. There's an integrated magnetic hall effect sensor that outputs an electrical pulse with every revolution.

The sensor comes with three wires: red (5-24VDC power), black (ground) and yellow (Hall effect pulse output). The pulse signal is a simple square wave so it is quite easy to log and convert into liters per minute using the following formula,Pulse frequency (Hz) / 7.5 = flow rate in L/min.

4.FUNCTIONALBLOCKDIAGRAM

4.1.PROPOSED SYSTEM

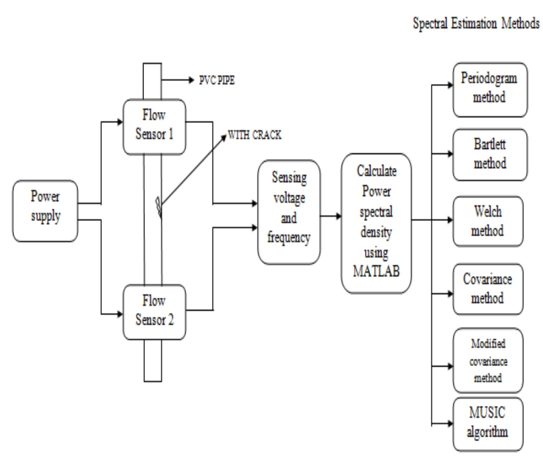

Figure 4.1 Pipeline without crack

The proposed method consists of 2- flow sensors (yf-s201) which requires 5V power supply. The length of the pipeline choosen is 90cm. Two flow sensors are connected to ½'' PVC pipe as shown in figure at a distance of

35.5cm.When the product flows through the sensor, it creates an electrical pulse. Then DSO is used as display unit from which amplitude and time period of the pulse is measured. For the values obtained, the power spectral density is estimated using signal processing algorithms. The obtained peak frequency is estimated and noted down. Later it is compared with the frequency obtained from pipe with crack.

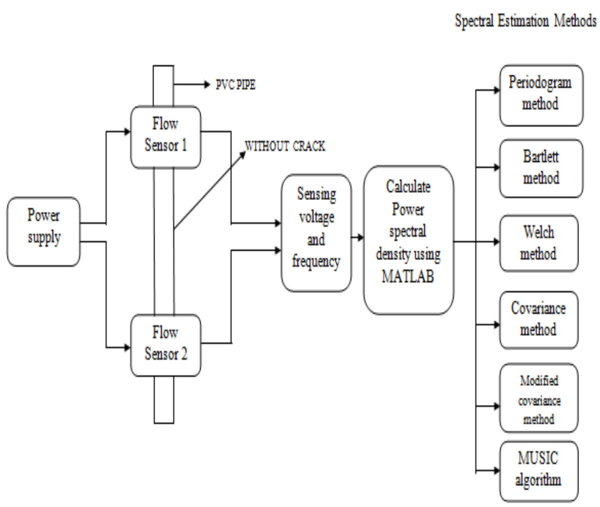

Figure 4.2 Pipeline with crack

4.2 FLOW DIAGRAM

Using the display unit (DSO), the signal parameters of flow sensor-1 such as amplitude, time period and frequency are noted. Similarly the parameters of flow sensor-2 are also noted. If there is any deviation in relation to frequency and flow rate then it is assumed that there exists a crack in the pipeline. If there is no deviation then it is confirmed that no crack present in the pipeline.

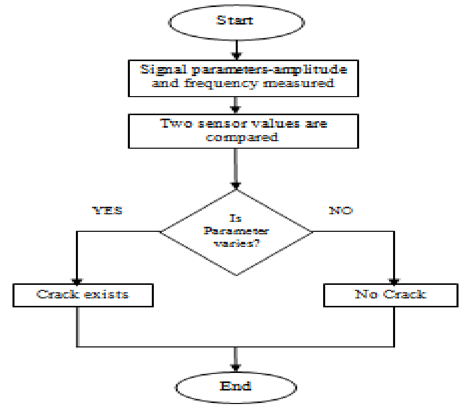

Figure 4.3.Flow Diagram for Hardware implementation

The measured amplitude and time period are given as input to the Matlab software. The power spectral is estimated by using various non-parametric methods such as Periodogram, Bartlett method, Welch method, Covariance and Modified covariance method and parametric method such as MUSIC algorithm. Using these methods peak frequency of the spectrum is noted. The frequency obtained in one method is then compared with the all other methods used.

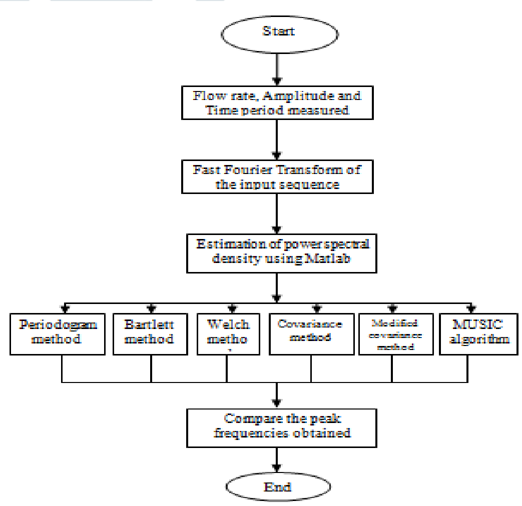

Figure 4.4 Flow Diagram for Software simulation

5.SYSTEM IMPLEMENTATION

5.1.HARDWARE IMPLEMENTATION

Figure 5.1 Proposed model

5.2.2. ANALYSIS OF SIGNAL PROCESSING ALGORITHMS

5.2.2.1. NON PARAMETERIC METHOD

PERIODOGRAM-The modulus-squared of the discrete Fourier transform

CONTENT	EQUATIONS
Power spectrum	$P_{per}(e^{j\omega}) = \frac{1}{N}\left\lvert\sum_{n=0}^{N-1} x(n)e^{-j\omega n}\right\rvert^2$
Mean	$E\{P_{per}(e^{j\omega})\} = \frac{1}{2\pi}P_{per}(e^{j\omega}) * W_B(e^{j\omega})$
Resolution	$\Delta\omega = 0.89\frac{2\pi}{N}$
Variance	$Var\{P_{per}(e^{j\omega})\} \approx P_x^2(e^{j\omega})$

MODIFIED PERIODOGRAM- The modified periodogram windows the time-domain signal prior to computing the DFT in order to smooth the edges of the signal.

CONTENT	EQUATIONS
Power spectrum	$P_M(e^{j\omega}) = \frac{1}{NU}\left\lvert\sum_{n=-\infty}^{\infty} \omega(n)x(n)e^{-j\omega n}\right\rvert^2$
Where,	$U = \frac{1}{N}\sum_{n=0}^{N-1}\lvert\omega(n)\rvert^2$
Mean	$E\{P_M(e^{j\omega})\} = \frac{1}{2\pi NU}P_x(e^{j\omega}) * \lvert W(e^{j\omega})\rvert^2$
Variance	$Var\{P_M(e^{j\omega})\} \approx P_x^2(e^{j\omega})$

BARTLETT METHOD-the average of the periodograms taken of multiple segments of the signal to reduce variance of the spectral density estimate

CONTENT	EQUATIONS
Power spectrum	$P_B(e^{j\omega}) = \frac{1}{N}\sum_{i=0}^{K-1}\left\lvert\sum_{n=0}^{L-1} x(n+iL)e^{-j\omega n}\right\rvert^2$
Mean	$E\{P_B(e^{j\omega})\} = \frac{1}{2\pi}P_x(e^{j\omega}) * W_B(e^{j\omega})$
Resolution	$\Delta\omega = 0.89K\frac{2\pi}{N}$
Variance	$Var\{P_B(e^{j\omega})\} \approx \frac{1}{K}P_x^2(e^{j\omega})$

WELCH METHOD- a windowed version of Bartlett's method that uses overlapping segments

CONTENT	EQUATIONS
Power spectrum	$P_W(e^{j\omega}) = \frac{1}{KLU}\sum_{i=0}^{K-1}\left\lvert\sum_{n=0}^{L-1} \omega(n)x(n+iD)e^{-j\omega n}\right\rvert^2$
Where,	$U = \frac{1}{L}\sum_{n=0}^{L-1}\lvert\omega(n)\rvert^2$
Mean	$E\{P_W(e^{j\omega})\} = \frac{1}{2\pi LU}P_x(e^{j\omega}) * \lvert W(e^{j\omega})\rvert^2$
Variance	$Var\{P_W(e^{j\omega})\} \approx \frac{9}{16}\frac{L}{N}P_x^2(e^{j\omega})$

5.2.2.2. PARAMETERIC METHOD

MUSIC(Multiple Signal Classifiaction)- popular superresolution method.

$$P_{MU}(e^{jw}) = \frac{1}{\sum_{i=P+1}^{M}\lvert e^{H}\, v\rvert^2}$$

v-noise vector,e^H-steering vector

6.RESULTS AND DISCUSSIONS

6.1.HARDWARE IMPLEMENTATION

6.1.1 DSO OUTPUT-WITHOUT CRACK

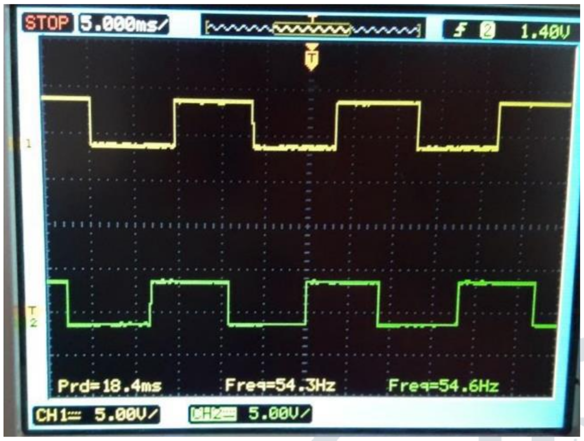

Figure 6.1. Pulse wave output-without crack

The figure 6.1 shows the pulse wave output of flow sensor 1 and 2. The yellow colored signal represents the output of flow sensor 1 and green represents output of flow sensor 2.The amplitude of flow sensor 1 and 2 is in the range of 4.56 to 4.87 V. The frequency obtained in both the sensors remains same as 54.3Hz and 54.1 Hz in the case of pipeline without any crack. There will be 0.03 variations in the frequency of both flow sensors.

6.1.2 DSO OUTPUT-WITH CRACK

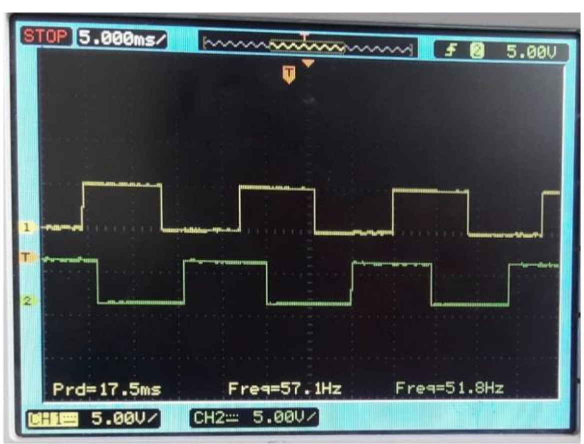

Figure 6.2. Pulse wave output-with crack

The figure 6.2 shows the pulse wave output of flow sensor 1 and 2. The yellow colored signal represents the output of flow sensor 1 and green represents output of flow sensor 2.The amplitude of flow sensor 1 and 2 is in the range of 4.56 to 4.87 V. The frequency obtained in both the sensors is not same as sensor 1 shows 57.1 Hz and sensor 2 shows 51.8Hz in case of pipeline with crack. The variation of frequency is about 5.3Hz.

6.2.SOFTWARE IMPLEMENTATION

6.2.1.WATER DATA-WITHOUT CRACK

The flow sensor data of water are listed as follows,

FLOW SENSOR-1 READING				FLOW SENSOR-2 READING			
TIME (sec)	VOLTAGE(v)	TIME (sec)	VOLTAGE(v)	TIME (sec)	VOLTAGE(v)	TIME (sec)	VOLTAGE (v)
0	0.02	0.50	-0.022	0	0.02	0.50	-0.022
0.02	-0.04	0.52	-0.07	0.02	-0.06	0.52	-0.073
0.04	-0.045	0.54	-0.02	0.04	-0.050	0.54	-0.02
0.06	-0.030	0.56	-0.03	0.06	-0.036	0.56	-0.034
0.08	-0.0320	0.58	-0.022	0.08	-0.0325	0.58	-0.024
0.10	-0.0365	0.60	-0.01	0.10	-0.036	0.60	-0.01
0.12	0.023	0.62	-0.06	0.12	0.02	0.62	-0.064
0.14	-0.045	0.64	-0.02	0.14	-0.040	0.64	-0.02
0.16	0.02	0.66	-0.02	0.16	0.02	0.66	-0.024
0.18	-0.03	0.68	-0.033	0.18	-0.03	0.68	-0.033
0.2	-0.05	0.70	-0.05	0.2	-0.04	0.70	-0.054
0.22	-0.02	0.72	-0.03	0.22	-0.02	0.72	-0.034
0.24	-0.07	0.74	-0.05	0.24	-0.06	0.74	-0.056
0.26	-0.02	0.76	-0.02	0.26	-0.03	0.76	-0.02
0.28	-0.023	0.78	0	0.28	-0.023	0.78	0
0.30	-0.05	0.80	-0.03	0.30	-0.05	0.80	-0.032
0.32	-0.044	0.82	-0.03	0.32	-0.04	0.82	-0.032
0.34	-0.055	0.84	-0.02	0.34	-0.055	0.84	-0.02
0.36	-0.04	0.86	-0.06	0.36	-0.04	0.86	-0.06
0.38	-0.01	0.88	0	0.38	-0.01	0.88	0
0.40	-0.06	0.90	-0.05	0.40	-0.059	0.90	-0.052
0.42	-0.01	0.92	-0.06	0.42	-0.012	0.92	-0.062
0.44	-0.03	0.94	-0.06	0.44	-0.03	0.94	-0.06
0.46	-0.02	0.96	0	0.46	-0.02	0.96	0
0.48	-0.04	0.98	-0.02	0.48	-0.04	0.98	-0.02

Table 6.2.1 Water flow rate data-without crack

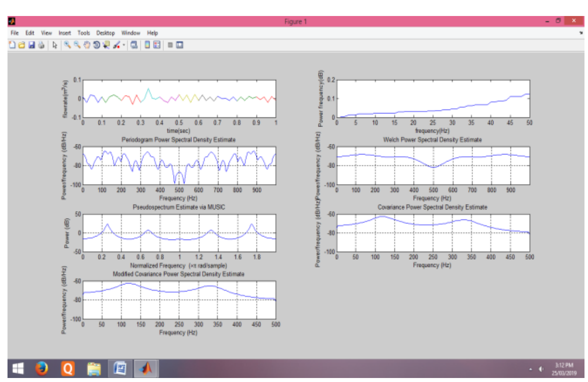

Figure 6.3 Power spectral estimation of water-Flow sensor 1

INFERENCE

The peak frequency obtained using various methods of power spectral density estimation are compared and the resulting frequency obtained using various methods are same that is 50Hz.

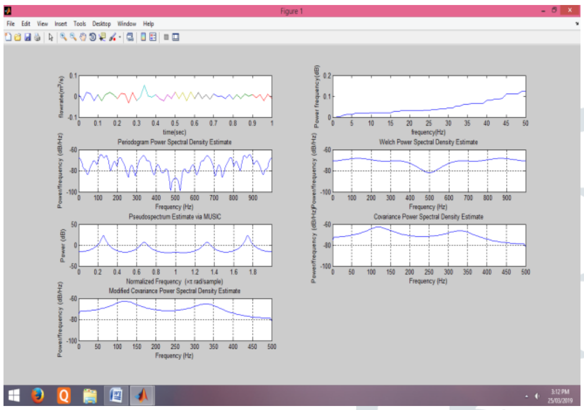

Figure 6.4 Power spectral estimation of water-Flow sensor 2

INFERENCE

The peak frequency obtained using various methods of power spectral density estimation are compared and the resulting frequency obtained using various methods are same that is 49Hz.

6.2.2.WATER DATA-WITH CRACK

FLOW SENSOR-1 READING				FLOW SENSOR-2 READING			
TIME (sec)	VOLTAGE (v)	TIME (sec)	VOLTAGE (v)	TIME (sec)	VOLTAGE (v)	TIME (sec)	VOLTAGE (v)
0	0.02	0.50	-0.022	0	0.01	0.50	0.022
0.02	-0.04	0.52	-0.07	0.02	-0.02	0.52	-0.01
0.04	-0.043	0.54	-0.02	0.04	0.02	0.54	0.02
0.06	-0.030	0.56	-0.03	0.06	0.015	0.56	-0.022
0.08	-0.0320	0.58	-0.022	0.08	-0.02	0.58	0.022
0.10	-0.0365	0.60	-0.01	0.10	0.01	0.60	-0.01
0.12	0.023	0.62	-0.06	0.12	-0.02	0.62	0.02
0.14	-0.043	0.64	-0.02	0.14	0.01	0.64	-0.01
0.16	0.02	0.66	-0.02	0.16	0.02	0.66	0.01
0.18	-0.03	0.68	-0.033	0.18	0.01	0.68	-0.0133
0.2	-0.05	0.70	-0.05	0.2	-0.01	0.70	0.012
0.22	-0.02	0.72	-0.03	0.22	0.015	0.72	-0.001
0.24	-0.07	0.74	-0.05	0.24	0.012	0.74	0.002
0.26	-0.02	0.76	-0.02	0.26	-0.03	0.76	-0.01
0.28	-0.023	0.78	0	0.28	0.02	0.78	0..01
0.30	-0.03	0.80	-0.03	0.30	-0.02	0.80	-0.014
0.32	-0.044	0.82	-0.03	0.32	-0.001	0.82	0.01
0.34	-0.055	0.84	-0.02	0.34	0.055	0.84	-0.01
0.36	-0.04	0.86	-0.06	0.36	0.002	0.86	0.012
0.38	-0.01	0.88	0	0.38	-0.003	0.88	0.001
0.40	-0.06	0.90	-0.05	0.40	0.01	0.90	0.01
0.42	-0.01	0.92	-0.06	0.42	-0.01	0.92	-0.005
0.44	-0.03	0.94	-0.06	0.44	-0.02	0.94	0.01
0.46	-0.02	0.96	0	0.46	0.01	0.96	-0.02
0.48	-0.04	0.98	-0.02	0.48	-0.01	0.98	0.012

Table 6.2.2Water flow rate data-with crack

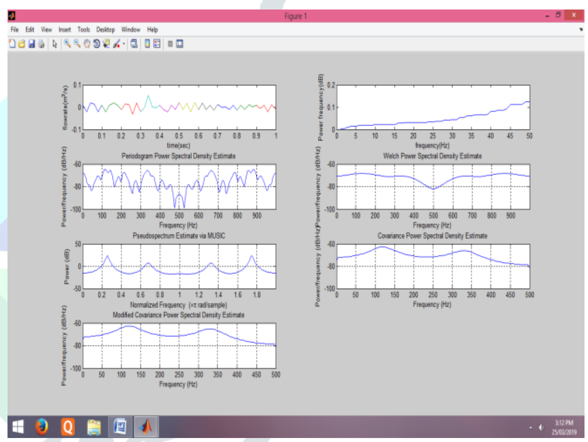

Figure 6.5 Power spectral estimation of water-Flow sensor 1

INFERENCE

The peak frequency obtained using various methods of power spectral density estimation are compared and the resulting frequency obtained using various methods are same that is 51Hz.

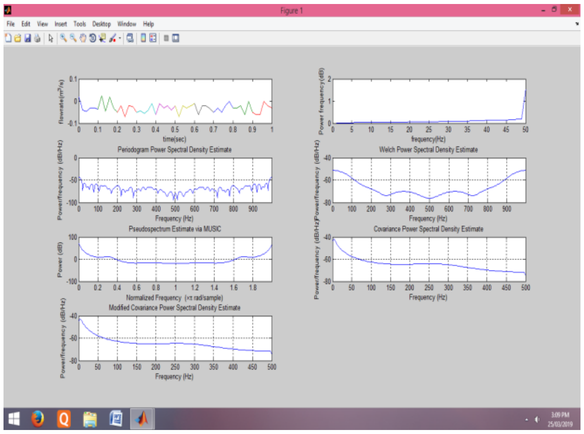

Figure 6.6 Power spectral estimation of water-Flow sensor 1

INFERENCE

The peak frequency obtained using various methods of power spectral density estimation are compared and the resulting frequency obtained using various methods are same that is 47Hz.

7.CONCLUSION AND FUTURE WORK

7.1 CONCLUSION

Power spectral density technique was established for estimation of the flow rate measurement and to detect the presence of crack in pipeline. It is used to estimate the flow rate and peak frequency water. It is concluded that the peak Water data without crack is 54Hz in both sensors and it varies from 51Hz to 47Hz in case of crack.

7.2 FUTURE WORK

The proposed system could be implemented with modification in the output module by linking it to internet of things(IoT) using GSM module or WIFI module through which the officials can be intimated about the crack through message services for future purpose. It can also be applicable for domestic purposes and in the oil pipelines under sea

8.REFERENCES

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