Condition Monitoring in Drilling Operation based on Vibration Signals

John Stephen R, Thangeswari T, Palani S, D.Dinakaran

Abstract ***: Tool condition monitoring is the efficient process for all machining managing operation and the maintenance of machinery operation. Tool condition monitoring implies effective production cost, the rate of tool life, tool quality, dimensional accuracy in terms of tolerance and surface finish in machine shop. Here the machining operation is fully depending on the whims & fancies of the operator. So when a new person operating the machine it makes more troubles in terms to find out the tool wearing point and it make operation difficulty by the operator. To overcome this difficulty a systematic methodology required for machining operation. This paper deals with monitoring the condition on the drilling operation with the help of Accelerometer sensor a physical vibration model 8636C50 having a broad band sensitivity of Sensitivity (±5%) 100.0mV/g and resonant frequency up to 22.0 kHz and performing the drilling operation on EN 24 steel at various operation parameters and analyzing the time domain signal response and frequency domain response graph and implemented analyze the feasibility of proposed methodology for practical applications. Further, the Lab View was used to predict amplitude of work piece vibration which determines the tool condition after various experimental tests. In the time domain, the characteristic parameter during drill wear represent RMS value increase in flank wear and also shows the linear relationship between these two. In the frequency domain, the characteristic parameters during drill failure represent the magnitude of vibration amplitude and the increase in flank wear. Here multilayer Artificial Neural Network (ANN) model, Fuzzy Neural Network and Taguchi Method have been trained with the experimental data using back propagation algorithm. Condition monitoring of drilling is fully depending on the vibration signals. Based on the vibration signal the tool wear point is found out. Experiments results indicated the effect of unconditional drilling operation and detected the tool failure and proper operating condition for drilling machining.***

Keywords: Condition monitoring, Drilling Process, Tool wear, Vibration Analysis.

I. INTRODUCTION

In manufacturing division drilling is most important machine tool operation. Drilling also perform the machining processes like reaming, boring and tapping. In machining operation 45% metal removal operations depends on drilling process. Every manufacturing Industry there are spent more money for drilling and drill tools. Normally two problems are arrived in drilling operation, drill tool wear and breakage. Due to the drilling operation fully depend on experience and skill of operator, it producing dynamics tool wear in drilling tools. In a particular stage the tool wear it affect the work piece and various level of drilling states and tool setup. The drilling tool and machining cost of drilling operation in very high. Therefore to detect the tool wear stage and failure mode is very important one in drilling operation. TCM monitoring system using sensors in monitoring process and detect the failure stage and worn tool wear in cutting operation in proper time in machining. So sensor based tool condition is necessary for machining operation and research. Tool condition monitoring normally based on indirect method and direct method by using sensor in TCM techniques. This paper based on-line monitoring techniques are used during the machining process. By using direct measurements method is efficient for to identify the tool wear and condition of tool in machine operation due to continuous contact of tool and work piece in operation. On-line condition monitoring using different sensors and integrated signal recording software for machining operation. Therefore, On-line monitoring method is suitable for drilling operation in running condition in drilling.

This work is based on the tool condition monitoring using vibration signals. Vibration signals are acquired using accelerometer. Data acquisition card is used to convert these analog signals to digital signals. These signals are fed to the LABWIEW software and the data are analyzed. Then later, the fast Fourier transfer (FFT) subprogram transfers the acceleration data to frequency data for analysis. Evaluate process neural network based fuzzy logic model used in monitoring of drilling tool operation to find the flank wear point in drilling tool. The machining parameters are related to tool wear. In this research we attempt to decide cutting condition of machining parameters by using the neural network model to predict suitable machining operating condition for drilling process.

Rogério Thomazella [1] using FFT Fast Fourier transform for single analysis in machining operation and predict the changes in irreversible damage, hardness and surface roughness in grinding operation. Vigneashwara et al. [2] in belt tool grinding process the condition is monitoring by AE acoustic emission sensor based on Genetic Algorithm for detect the surface condition and abrasive grain condition using analysis model.

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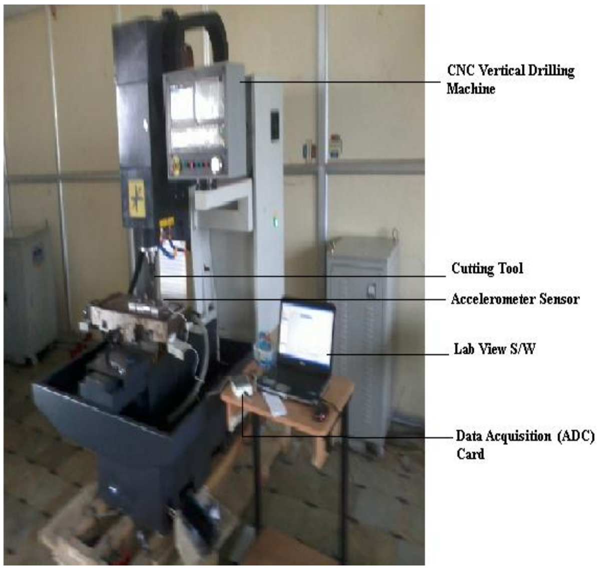
Xiaoqiang et al. [3] Sound-based condition monitoring predict the accuracy of belt layer robotic grinding operation by using microphone the signal analysis using FFT and result show the belt wear condition from 10 to 15kHz .The hidden layer structure is observed by using microscope and display the ability in of grinding operation.
Damiano et al. [4] & Ahmed et al. [5] Coal power Particle size distribution is monitoring in a coal fired power plant, AE acoustic emission signals are effective method of measuring the power size. Artificial Neural Network method expresses the 90% accurate result by 13 measuring point on 13 burners in the coal fired power plant. Vibration based condition monitoring signal analysis discussed [4] & [5] to identify the faults in rolling elements. Neural network algorithm result shows the compressed measurement accuracy of fault detection in rotating machines. Piotr Gierlak et al. [6] Manipulator tool condition is measured using vibration signals and the performance analysis by artificial neural network signal analysis domain. The analysis database indicates the functioning of the system and the research environmental obtained the good technical state and damaged tool. Antonio Romero et al [10] concentrated in health condition of Wind machine condition monitoring and cost impact of wind turbine using vibration signals. Manish et al.[11] proposed condition monitoring of various rotating machines and its helps to performance the machine to operate the optimal level. Jack P et al. [15] proposed wind turbines condition monitoring techniques used to determine the efficient terms of energy production and focusing the fault detection methods. Siliang Lu et al. [14] Wireless sensor networks condition monitoring is a potential application on fault diagnosis in motor bearings. Output of experiment result the 80% of date length and transmission time decrease is indicating the fault in motor bearing. Everaldo et al. [7] complex grinding operation mainly concentrates the mechanical parameters of Surface roughness & finishing levels. The acoustic emission signals are analysis by FFT and wavelet domain algorithm detects the surface quality and errors in through feed centreless grinding operation. Dressing operation directly integrated with tool wear progress and tool life of grinding wheel. Doriana [9] describes a method using Artificial Neural Networks based on vibration signal analysis in the dressing process. The result shows the grinding wheel wear and optimum parameters for dressing operations. Error estimation method mainly concentrates with condition monitoring method. It used to find the cutting error in the machine tool and evaluate the relative position between the tool centre and cutting point. Fei Zhao [9] method is a effective mathematic model for estimate the cutting error in grinding machine tool. The experimental sensor signals are analyzed and verify the cutting tool error in the machining operation. Primoz et al. [12] refrigeration appliances the performance of compressors directly relate with the several nonlinear classifiers. The condition monitoring of Semi-supervised vibration-based signals analysis based on neural networks model. Monica Egusquiza [13] presented the condition monitoring methodology for Pelton turbines the vibration based signals predict the damage found were due to fatigue, cavitations and silt erosion. FEM model used to simulate the dynamic behavior of the Pelton turbine. Yedige [16] 3D printing condition monitoring detects the clogging errors in nozzle. Nozzle placed under three different stag of filament fabrication. The signals are monitored using accelerometer senor. The signal analysis based on geometry tolerance, surface roughness, and mechanical properties. A reliable methodology presented by Giulio [17] the accuracy is measured by condition monitoring of centreless grinding based on acceleration and AE signals at different operating parameters evaluated by MATLAB.

In our research work deals with monitoring the condition on the drilling operation with the help of Accelerometer sensor a physical vibration model 8636C50 having a broad band sensitivity of Sensitivity (±5%) 100.0mV/g and resonant frequency up to 22.0 kHz and performing the drilling operation on EN 24 steel at various operation parameters and analyzing the time domain signal response and frequency domain response graph and implemented analyze the feasibility of proposed methodology for practical applications.

II. EXPERIMENTAL SETUP

Figure 1: Experimental setup

The experiments conducted on Vertical CNC drilling machine of machine centre. Work piece of EN24 steel diameter 120 x 10mm thickness of work piece used in machining operation. The speciation of Vertical CNC machining 21*17*21 inches. The driving speed 1000 rpm to



3000rpm. Five stage of speed division and 20 tool changers. The parameter values of speed feed indicate the 16" color monitor. The motor power of CNC drilling 30 hp and memory of 1MB of system with two USB port. It have intelligent coolant system connected with integrated with NC. Sensor (±5.1%) 100.0mV/g sensitivity Piezoelectric Accelerometer sensor 8636C50 used in the vibration analysis test the sensor having high sensitivity of accuracy and to act up to 100.0mV/g of vibration waves. Initially the sensor place in near the drilling bit the signal if vibration to monitoring and recording by using Matlab. The sensor moved in various place in the experiment motor and mounting plate and tool head of CNC drilling machine and the vibration signal to record. The dimensions of the plate are 120mm diameter, and 9mm thickness. Drilling operation conducted by using twist Drill bit C40 material of 6.1mm diameter used for drilling operation.

In the experiments the speed to limited by 450 rpm to 2500 rpm and the feed rate of 90 to 400 mm/min. The accelerometer is fixed on the work piece in the feed direction to measure the vibration in that direction.

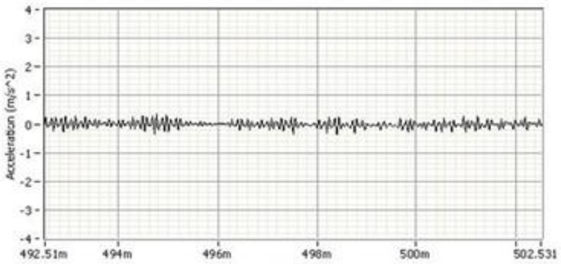


Figure 2: Normal tool 1600rpm, 254mm/min

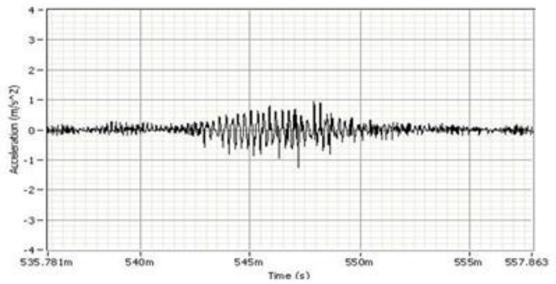


Figure 3: Flank wears 0.1mm 1600 rpm, 254 mm/min

The accelerometer is interfaced to the computer using data acquisition system. The data acquisition system NIcDAQ-9172 transfers the analog signal to digital signal in the computer. The lab view software stores the vibration signals using the time domain and fast Fourier transformation. The Vibration signal are carried out in two set of methods based on No of Holes and Drilling Speed and Feed.

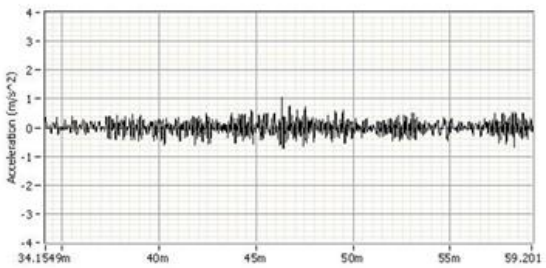


Figure 4: Flank wear 0.2mm 1600rpm, 254mm/min

From time domain signal it is observed that signal pattern of the normal tool of speed 1600 rpm and feed 254 mm/min is similar to entry of the drill and exit of drill. But there are slight changes occurring in the pattern while the drill bit with flank wear of 0.1mm. Figure 4 shows the flank wears 0.2mm 1600rpm, 254mm/min

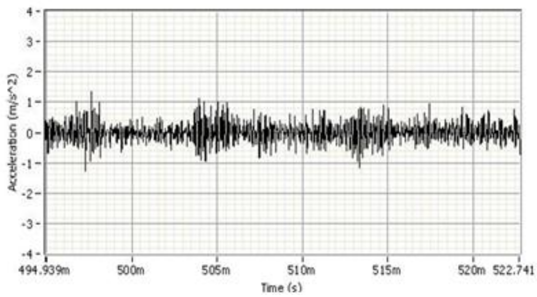


Figure 5: Flank wear of 0.35mm 1600rpm, 254mm/min

Figure 5 express the flank wear of 0.35mm 1600rpm, 254mm/min and flank wear of 0.35mm 1600rpm, 254mm/min. Obviously there is a change in the amplitude level for the drill with flank wear of 0.2mm and 0.35 mm but more or less same amplitude level which it is clearly shows that till wear upto0.35mm is steadily increasing. But when the flank wear of 0.47mm that is beyond the level of tool failure signal pattern is totally changed i.e., there is drastic changes in the amplitude level.

III. RESULTS AND DISCUSSION

A. Artificial flank wear:

The data is viewed in vibration assistant software. The Time domain and Fast Fourier transform are signature analysis to find the effect of tool wear in the vibration signals.

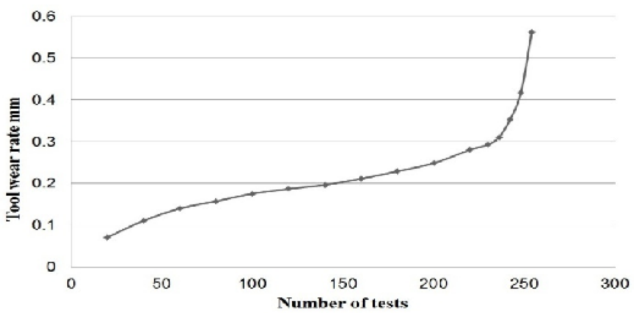


Fig 6. Tool wear rate vs. No. of tests

B. Artificial Induced Flank Wear On Drills

a)Normal tool b) Tool wear 0.1101mm c)Tool wear0.2101mm

FIGURE 7: A) NORMAL TOOL B) TOOL WEAR 0.1101MM C) TOOL WEAR 0.2101MM

C. Artificially Tool Wear Analysis based no number of Holes.

Typical Neural Network Has Three Layers, Namely, The Operation Parameters (First) Layer, The Flank Wear (Second) Layer And (Third) Tool Wear Layer. Signals Are Received At The First Layer, Pass Through The Second Layer And Reach The Third Layer. Operation Parameters Layers Are Input Layers and Flank and Tool Wear Layers Are Output Layers. These Layers Can Have A Dissimilar Number Of Neurons Networks And Establishment Functions, These Establishment Functions Predict The Tool Wear. The sampling function input layer, the number of holes and lip wear values are taken in the operation parameter layer. The network system is processed to produce the corresponding tool wear values. The number of data points is the total samples during one revolution of a drilling with a 0.000065mm wear found in sampling interval. Initially Flank wear of four artificially drill tool have been induced for speed 800rpm and feed 71mm/min. The results of the experiment are tabulated and graph plotted between Numbers of holes vs. Tool wear which shows the linear relationship.

Table 1: Experimental Data for Drilling holes in Amplitude (m/s2)

			Flank wear in mm				
Exp no	Cutting conditions		Normal tool / 0.0	0.1	0.2	0.35	0.47
	Speed rpm	Feed rate mm/ min	Vibration Amplitude (m/s2)				
1	500	101.6	4.45	5.25	6.5	8	9.8
2	600	254	5.57	6.33	8.45	8.92	10.5
3	800	254	7.83	8.56	10.0	13.5	28.5
4	1200	254	8.34	9.84	10.5	13.9	29.4
5	1600	254	9.74	10.2	11.7	14.5	29.7
6	1800	127	10.2	10.4	12.3	14.8	30.5
7	1800	254	10.9	10.7	12.8	15.3	30.9
8	1800	381	11.1	11.2	13.4	15.7	31.3
9	1800	127	11.4	11.4	13.8	16.2	31.7
10	1800	254	11.9	11.6	14.1	16.8	32.8
11	1800	381	12.2	12.3	15.8	17.5	33.4
12	2000	254	12.4	12.5	16.1	17.8	33.9
13	2400	127	12.9	12.8	16.5	18.2	34.8
14	2400	254	13.3	13.4	16.9	18.7	35.5
15	2400	381	13.7	13.9	17.3	19.3	36.4
16	2400	127	13.9	14.1	17.4	19.3	36.8
17	2400	254	14.4	14.3	17.6	19.4	37.1
18	2400	381	14.6	14.5	17.7	19.5	38.1

In this experiment Taguchi DOE analytical method used in the analysis path. Vibration signal analysis based on array orthogonal is estimated the level of process parameter for various stages. The experiment signal result analysis used to determine the optimum level of machining parameters and relative effect of individual machining operation. If the signals result shows the levels for various stages and the level of signals increases the flank wear rate. The suitable machining parameters identify based on the signal levels. The cutting feed identify by using the signals analysis 0.101mm, 0.201mm, 0.03566, and 0.4777mm. The level of amplitude for various timing of vibration singles using orthogonal array parameter speed and feed is calculated. Orthogonal array analysis eight degree of freedom based L18 Taguchi model vibration amplitude and RMS level to find the best marching parameters. L18 Orthogonal array used in vibration signal analysis in each experiment also the corresponding machining parameters carried out the effect of machining input and output parameter to be calculated. Each experiment result show the level of vibration beak and flank wear of tool. The increasing level of vibration result indicates the level of wear rate in drilling operation. Flank wear measured using tool maker microscope. The ware measured in five various stages the of vibration signal analysis also the range of crank to measured in microscope. The result indicates the wear rate is directly proposal to the rate of Vibration signals it express in Fig 7. Every stage the vibration signals and rate of wear increased based on machining time and machining parameters. The experiment conducted spindle speed of 500 to 2400 rpm and eight level of different high speed operation in five stages. The drilling holes are 9mm thickness and 120mm diameter of EN 24 work piece.

Table 2: Experimental Data for Drilling holes in Vibration RMS - Amplitude (m/s^2)

			Flank wear in mm				
Exp no	Cutting conditions		Normal tool / 0.0	0.1	0.2	0.35	0.47
	Speed rpm	Feed rate mm/ min	RMS- amplitude (m/s2)				
1	500	101.6	0.023	0.044	0.051	0.12	0.25
2	600	254	0.0356	0.067	0.124	0.17	0.32
3	800	254	0.0492	0.074	0.197	0.20	0.39
4	1200	254	0.0632	0.092	0.235	0.24	0.42
5	1600	254	0.0845	0.134	0.321	0.29	0.52
6	1800	127	0.0934	0.167	0.384	0.37	0.59
7	1800	254	0.145	0.198	0.452	0.46	0.63
8	1800	381	0.184	0.205	0.491	0.50	0.69
9	1800	127	0.154	0.245	0.41	0.52	0.78
10	1800	254	0.172	0.294	0.504	0.59	0.80
11	1800	381	0.192	0.363	0.592	0.62	0.88
12	2000	254	0.243	0.399	0.648	0.70	0.92
13	2400	127	0.282	0.467	0.723	0.74	0.97
14	2400	254	0.324	0.512	0.832	0.78	1.14
15	2400	381	0.395	0.592	0.862	0.84	1.18
16	2400	127	0.314	0.493	0.734	0.87	1.23
17	2400	254	0.345	0.572	0.854	0.90	1.16
18	2400	381	0.401	0.62	0.873	0.89	1.24

IV . CONCLUSION

This methodology detecting the tool wear and failure of drilling tool in drilling operation in automated machining operation in flexible manufacturing systems. In Condition monitoring drilling operation mount the accelerometer used to detect tool breakage provides a less mechanical vibration collection technique that can record strong vibration signals produced by the cutting process. From experimental results it is observed that by fixing threshold value has a high success rate in monitoring tool breakage under varying cutting conditions.

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Even though the proposed tool breakage detection system has been experimentally proven to have great usefulness at different cutting parameters, final result and further improvement steps such as, the proposed method could accurately identify flank wear rate and life cycle of drilling machining tools.

This method is suitable for the particular range of CNC Vertical Milling machine parameters such as spindle speed-500-2500r.p.m.; feed rate-101.6-381mm/min; depth of cut-through hole and no coolant. The cutting tool is suitable only for C40 6.1 (mm) Parallel shank twist drill high-speed tool steel. The proposed Work piece material set-up is only suitable for EN 24 steel of Diameter 120 x 10mm Thickness. In further work use different types of tool and material these application needed.

REFERENCES

1. Rogério Thomazella et al., "Digital signal processing for self-vibration monitoring in grinding: A new approach based on the time-frequency analysis of vibration signals". Elsevier measurement manufacturing processes, Vol.145 (2019) pp.71-83.
2. Vigneashwara Pandiyana et al., "In-process tool condition monitoring in compliant abrasive belt grinding process using support vector machine and genetic algorithm". Journal of manufacturing processes, Vol.31 (2018) pp.199-2013.
3. Xiaoqiang et al.,"Novel sound-based belt condition monitoring method for robotic grinding using optimally pruned extreme learning machine" Journal of Materials Processing Technology, Vol. 260 (2018) pp. 9-19.
4. Damiano Rossettia et al "Power plant condition monitoring by means of coal powder granulometry classification" Mechanical Systems and Signal Processing, Vol. 123 (2018) 39-47.
5. H.O.A. Ahmed ,Wong and Nandi "Intelligent condition monitoring method for bearing faults from highly compressed measurements using sparse over-complete features" Mechanical Systems and Signal Processing, Vol.99 (2018) pp.459-477.
6. Piotr Gierlak et al., "On-line manipulator tool condition monitoring based on vibration analysis" Mechanical Systems and Signal Processing, Vol.89 (2017) pp.14-26.
7. Everaldo Araujo Dias et al., "Monitoring of through-feed centreless grinding processes with acoustic emission signals" Measurement, Vol. 94 (2016) pp.71-79.
8. Doriana et al., "Neural networks tool condition monitoring in single-point dressing operations" Elsevier Vol. 41 (2016) 431 – 436.
9. Fei Zhao et al., "Online machining error estimation method of numerical control gear grinding machine tool based on data analysis of internal sensors" Mechanical Systems and Signal Processing, Vol.81 (2016) pp.515-526.
10. Antonio Romero et al., "Condition Monitoring of a wind turbine drive train based on its power dependant vibrations" Renewable energy, PII (2018) S0960-1481(17)30713-9.
11. Manish et al., "Vibration Analysis & Condition Monitoring for Rotating Machines" Material today proceedings, Vol.4 (2017) pp.2659–2664.
12. Primoz, Potocnik and Edvard "Semi-supervised vibration-based classification and condition monitoring of compressors" Mechanical Systems and Signal Processing, Vol.93 (2017) pp.51-65.
13. Monica et al., "Advanced condition monitoring of Pelton turbines" Measurement, Vol.119 (2018) pp.46-55.
14. Siliang Lu et al., "Condition monitoring and fault diagnosis of motor bearings using under sampled vibration signals from a wireless sensor network" Journal of Sound and Vibration, Vol. 414 (2018) pp.81-96.
15. Jack P. Salameh et al., "Gearbox condition monitoring in wind turbines" Mechanical Systems and Signal Processing, Vol.111 (2018) pp.251-264.
16. Yedige, Geok and Wen, "Condition monitoring in 3D printing" Robotics and Computer Integrated Manufacturing, Vol. 54 (2018) pp. 45–55.
17. Giulio et al., "Improvement of defect detectability in machine tools using sensor-based condition monitoring applications" Elsevier, Vol. (2018) pp.325 – 331.

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Publications

- John Stephen R, "Optimization of machining parameters in electro chemical micro machining processusing Taguchi's orthogonal array" International Journal of Pure and Applied Mathematics, ISSN 1314-3395 Vol. 115 No.6, (2018) 221-226.
- John Stephen R, "Machine Vision Monitoring system for Milling using ANFIS" International Journal of Pure and Applied Mathematics, ISSN 1314-3395 Vol. 119 No.85, (2018) 1083-1090.
- John Stephen R, "Power Generation System using Wastage Energy in Automobile Vehicles Machine" International Journal of Pure and Applied Mathematics, ISSN 1314-3395 Vol. 119 No.85, (2018) 1059-1071.
- John Stephen R, "Study of Mechanical Properties of Treated Coir Sheath By Epoxy Resin" International Journal of Pure and Applied Mathematics, ISSN 1314-3395 Vol. 119 No.85, (2018) 1091-1096.
- John Stephen R, "Defect Analysis of Linke Hofmann Busch Bogie Frames" International Journal of Pure and Applied Mathematics, ISSN 1314-3395 Vol. 119 No.85, (2018) 1115-1123.
- John Stephen R, "On Line Monitoring Of Grinding Wheel Loading In Grinding Using Vibration Analysis" International Journal of Applied Engineering Research, ISSN 0973-4562 Vol. 10 No.83 (2015)
- John Stephen R, "Design and development of JIG for Making Anchor Head in three Axis Vertical Milling Machine" International Journal of Applied Engineering Research, ISSN 0973-4562 Vol. 10 No.83 (2015)
- John Stephen R "Optimization of Machining Parameters for Face Milling Operation using ANOVA" IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) e-ISSN: 2278-1684, p-ISSN: 2320-334X PP 81-87
- John Stephen R, "Condition Monitoring and Numerical Simulation of Subsonic Jets using Thermograph Analysis" International Journal of control Theory and Applications ISSN NO: 0974-5572, Vol.9, 2016)
- JohnStephenR,"Designanddevelopmentofindustrialreceivergaugeincoordinatemeasuring machine for reducing inspection time" International Journal of control Theory and Applications - Submission ID: 682392013.

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Publications

1. Ann Tresa George, R. Ganesan and T. Thangeeswari, Redox Deposition of Manganese OxideNanoparticles on Graphite Electrode by Immersion Technique for Electrochemical Super Capacitors, *Indian Journal of Science and Technology*, 9, 2016.
2. Thangeeswari*, Ann Tresa George and A. Arun Kumar, Optical Properties and FTIR Studies of Cobalt Doped ZnO Nanoparticles by Simple Solution Method, *Indian Journal of Science and Technology*, 9, 2016.
3. T. Thangeeswari, J. Velmurugan, M. Priya, N Padmanathan, Optical and Magnetic Properties of Yb – ions doped cobalt based Zno Nanoparticles for DMS Application, *Bulletin of Material Science*, 38, pp: 1389-1398, 2015.
4. T. Thangeeswari, J. Velmurugan, M. Priya, Enhancement of optical and magnetic properties in ZnO :Co implanted Gd3+ nanoparticles, *Journal of Materials Science : Materials in Electronics*, 26, pp.2436-2444, 2015.

5. Thangeeswari, J. Velmurugan, M. Priya, Influence of Co and Dy Doping on the Optical and Magnetic Properties of ZnO Nanoparticles for DMS Application, *Journal of Superconductivity and Novel Magnetism*, 28, pp. 2505-2515, 2015.

6. T.Thangeeswari, Abishek Karanta, J. Velmurugan, M. Priya , Effect of doping on the microstructure of ZnO nanoparticles, International Journal of Applied Engineering Research, 10, pp.12-15, 2015.

7. Thangeeswari T, C. Abishek and R.Ajith Balaji, Structural and optical properties of Co-Bi doped ZnO nano particles for opto-electronic devices, *International Journal of Applied Engineering Research*, 10, 2015.

8. Thangeeswari, T, Velmurugan, J & Priya, M , 'Ferromagnetic property of ZnO: Co^{2+}:Bi^{3+} Nanocrystals for DMS applications', International Journal of Chem Tech Research, vol.6, pp. 2150-2152, 2014 .

9. T. Thangeeswari , J. Vetrimurugan, M. Priya, Strong room temperature in chemically precipitated ZnoCo2+Bi3+ nano crystals for DMS applications, Journal of Materials Science : Materials in Electronics, 24, pp.4817, 2013

10. T Thangeeswari, G Parthipan2, and S Gowtham, Impact of Rare Earth (Dy and Yb) Ions doping on Magnetic and Optical Properties of ZnO Nanoparticles, AIP Conference Proceedings, 2019, 2105, 20003-1-10

11. G. Parthipan and T. Thangeeswari, Relaxation and Viscosity Analysis on the Mixture Anisole and Decyl Alcohol in Benzene at 303, 313 and 323 K

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