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ACOUSTIC NOISE OPTIMUM ANALYSIS ON HOME APPLIANCES

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Abstract: In the current work noise analysis is done on the home appliances that are used commonly and also major noise causing appliances. The work presents the procedures and the results of noise source at the following home appliances: Ceiling fan, washing machine and Air-conditioner compressor used in daily needs. Noise reduction is perhaps one of the most important parameters Every noise reduction process starts with identification of noise sources & ranking the noise sources from machinery. Different models and variants of the above appliances are used at different working conditions. Analysis of noise has been done using sound intensity from recording. The sound from the microphone will be analyzed by using INVH by BOSCH. The results from the noise were showed in mapping with different color patterns which indicates the different level of noises from different sound intensities. Three different graphs FFT, Overall, FFT vs Time are obtained from noise data. The vibrational data is obtained. The software makes use of the accelerometer present in the device to give acceleration values in different directions with respect to time. Response surface methodology is used to predict noise characteristics. The noise analysis data is further developed using optimization technique: Surface response method. MINITAB software is used for optimization. Response surface methodology is used to predict noise characteristics.

Keywords: Acoustics, Noise reduction, MINITAB, characteristics.

1. Introduction

Ceiling fans are mainly employed to circulate or mix air within a space and provide local air movement for enhancing the thermal comfort of people. In particular, they consume a relatively low amount of energy compared to the air conditioning units, and therefore are used on a large scale worldwide.

The hidden ceiling fan has a lot of advantages with an enclosing housing, but its housing must be evaluated thoughtfully. Because the majority part of hidden ceiling fan is embedded in ceiling floor, the enclosing housing will be needed to surround the axial-flow fan this design can prevent the explosion of rotational blades to occupant’s space and save the required space for installation.

Air conditioning (also A/C, air conditioner) is the process of removing heat and controlling the humidity of air in an enclosed space to achieve a more comfortable interior environment by use of powered 'air conditioners' or a variety of other methods including passive cooling and ventilative cooling. Air conditioning is a member of a family of systems and techniques that provide heating, ventilation and air conditioning.

Air conditioners, which typically use vapor-compression refrigeration, range in size from small units used within vehicles or single rooms to massive units that can cool large building. Air source heat pumps, which can be used for heating as well as cooling are becoming increasingly common in cooler climates.

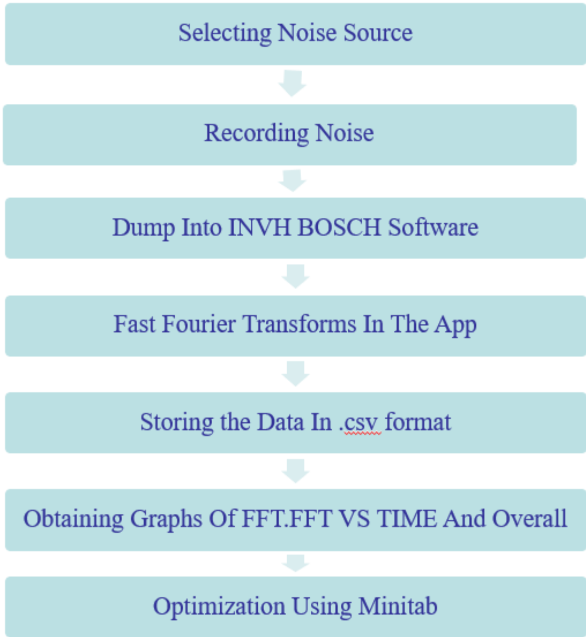
A washing machine is a huge time saver over hand washing. Do not have to sit and monitor the washing process. Can load your clothes in the machine, start the cycle and walk away. Can carry out another task and then return to your machine to hang clothes to dry or put them in the dryer. A washing machine (laundry machine, clothes washer, or washer) is a home appliance used to wash laundry. The term is mostly applied to machines that use water as opposed to dry cleaning (which uses alternative cleaning fluids and is performed by specialist businesses) or ultrasonic cleaners

2. **Literature Review**

S.NO	JOURNAL	LITERATURE REVIEW	LITERATURE GAP
1	Numerical Investigation of Ceiling Fan Noise by Using Response Surface Method Journal: International Journal of Innovative Science, Engineering & Technology Publication: Elsevier	In this paper ceiling fan's tendency of noise due to small change in parameters is obtained. Small change in design parameter causes various changes in noise from fan. It shows sensitivity of room size, fan rod length, and knob position on noise. The small variation of room size causes large changes in noise when room size changes.	Response survey method can be used to optimize the output that is the noise with different parameters.
2	Reducing noise from fans Journal: Noise & Vibration Worldwide Sage publications	Although noise is unavoidable when fans are used, this can be reduced largely by following simple rules. On the industrial scale, it is more effective to employ noise-cancelling methods. Using more efficient fans or bladeless fans may be more welcome in specific cases.	Methods to reduce fan noise can be used. Based on this the different sources and varying parameters for the cause of noise can be found.
3	Experimental Design Of A Low Noise Centrifugal Fan Purdue University e-publication	In this paper fan laws are used to compare the sound power generated by centrifugal fans having differing designs. In this way it has been possible to compare the noise produced by several fans. Based on this comparison scheme, a low noise fan design was identified. A technique has been developed that can be used to predict the 1/3-octave band sound power levels of centrifugal fans. The predictions are based on measurements of aerodynamic and acoustical performance made using a low noise reference fan identified in the first part.	Based on the designs given an understanding of aerodynamic characteristics of fan wings can be made. Instead on calculated data real time data from recorded sound can be used.
4	Performance Improvement of a Hidden Ceiling Fan Publications : Trans Tech, Switzerland	In this study, computational fluid dynamic (CFD) numerical simulation and experimental investigation were used to predict and valid the flow pattern with different geometric housing and operating conditions. The unique inhale-return phenomenon probably happens when inappropriate enclosing housing was designed such as high ring-plate and outlet-inlet ratio. in conclusion, this systematic design investigation on hidden ceiling-fan.	Investigating the flow pattern and fan evaluation, five parameters are involved in this study which includes various blockage length, ring-plate high, inlet-outlet ratio, various fan rpm and fan guard.
5	Performance results for a high efficiency tropical ceiling fan and comparisons with conventional fans Demand side management via small appliance	An axial flux brushless DC machine (BDCM) with high energy-efficiency is used to drive newly designed, high efficiency blades, incorporated into a complete new overall design. Comparative results of measurements of electrical input power, mechanical power on the shaft, approximated power in the air flow, and calculated efficiencies are presented.	Newly developed high efficiency ceiling fans have been tested using the same setup as for the conventional fans. At a power in the air flow of 7.3 W, which is the highest achieved by commercially available conventional ceiling fan when consuming 63 W

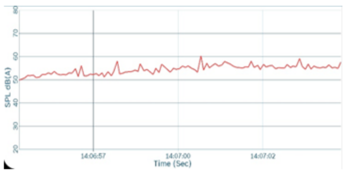
	efficiency Publications: Elsevier		
6	Noise control and sound quality evaluation of outdoor unit of split air-conditioner	In this paper, a composite noise control scheme (CNCS) involving dynamic vibration absorbing technology, the sound absorption technique, controlling noise in the outlet, and particle damping technique is determined to control noise and vibration of outdoor unit. The developed CNCS can not only effectively control the sound radiation from the unit, but also significantly improve the sound quality of the unit.	CNCS has been applied successfully in controlling the noise level from one type of domestic split air-conditioner.
7	Structure-borne Noise Reduction in Washing Machines: Noise Reduction by Modal Analysis	Noise will be produced form washing machine motor generating frequency and the resonant frequency of a certain motor part. For investigation and refinement work. This will be done by using modal analysis, modal analysis was done using both FEA and experimentation. By using this analysis the time will be more saver.	Modal analysis was done using both FEA and experimentation. Experimental modal analysis provides the real behaviour of vibration modes and exact frequencies. By using the software the data obtained is real time data. Both vibrational and noise analysis can be done.
8	Study on the Design Improvement of an Indoor Ceiling Fan	Computational modelling and simulation of the ceiling fan rotating inside the room is performed. The computational mode is validated by the experimental data, A parametric study of ceiling fans is carried out with the objective to improve flow field variables and fan efficiency. The performance indicators such as velocity profile, mass flow rate, torque, rated air delivery and service value are calculated.	Different rake angles are used to evaluate the flow field variables. The geometries with varying rake angles from 0 to 10 degrees, indicates that the air velocity decreases at some distance away from the fan blades. Rated air delivery is the volume of the air on a given surface per unit time.
9	Frequency Analysis Of Air Conditioning Noise In Landscaped Offices Journal of Sound and Vibration Publicaion: Elsevier	In this paper the site measurements of spectral levels of air conditioning system noise in ten landscaped offices were made. These measurements were related to the response of the occupants to air conditioning noise, in order to show the design rules. It was given that if the background office noise was NR 45, then the design value of the air conditioning should be NR 40, in order to limit the percentage of people aware of noise from the air conditioning.	Measurement of air conditioning system noise in ten landscaped offices were made. This data is used in selecting the appropriate compressor for vibrational and noise analysis.

3. Experimental Procedure:

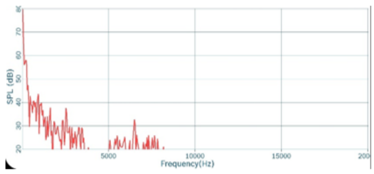


4. Results and Discussion

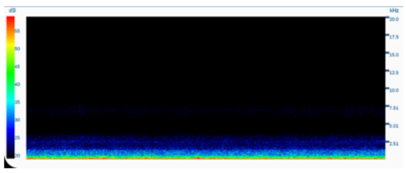
Fan 1(New Model Crompton)



Overall graph



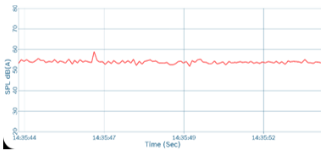
FFT graph



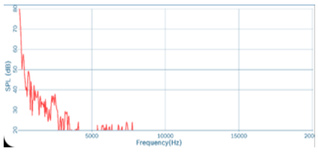
FFT vs Time graph

- The fan is set at different knob positions 5,3,1 respectively.
- At each knob position the sound is recorded.
- It is found that highest noise is obtained at Knob position 5(greater than 60 decibels)
- Highest value of noise is obtained in the lowest frequency range

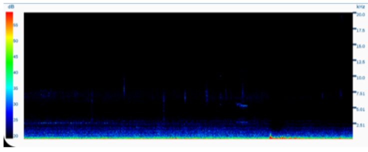
Fan 2(Old Model)



Overall graph



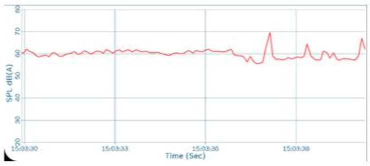
FFT graph



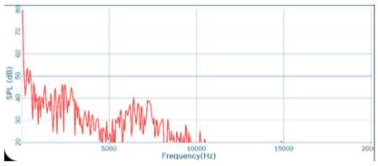
FFT vs Time graph

- The fan is set at different knob positions 5,3,1 respectively.
- At each knob position the sound is recorded.
- It is found that highest noise is obtained at Knob position 5(greater than 60 decibels)
- Highest value of noise is obtained in the lowest frequency range

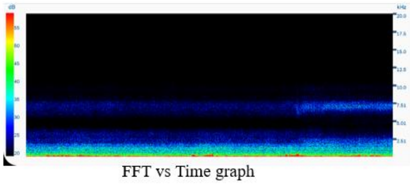
Fan 3(Usha)



Overall graph



FFT graph

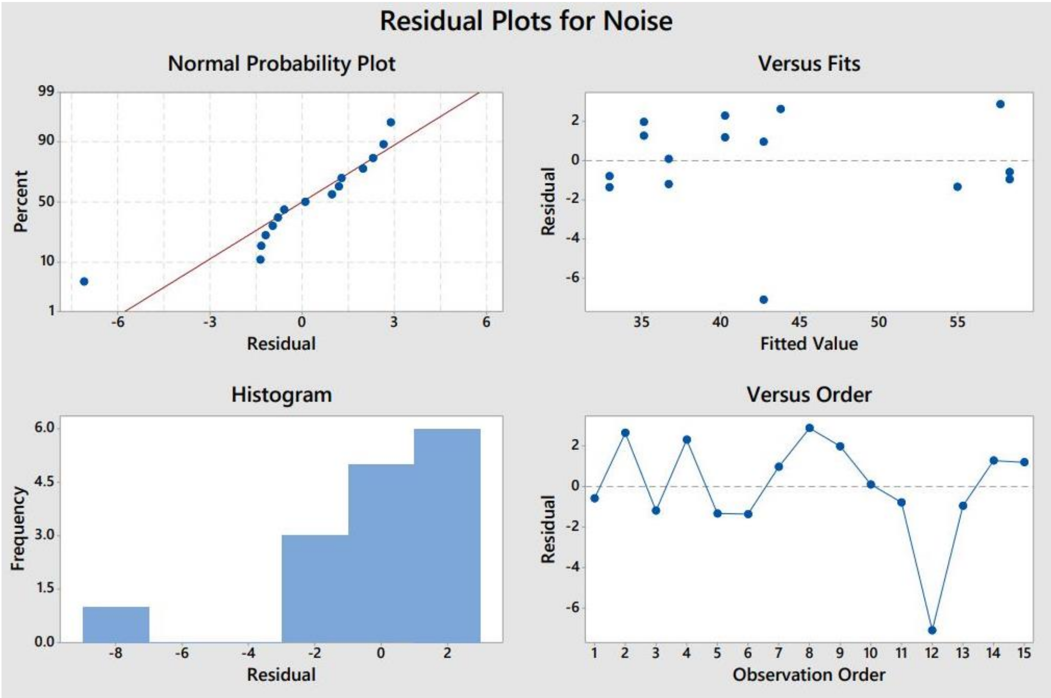


FFT vs Time graph

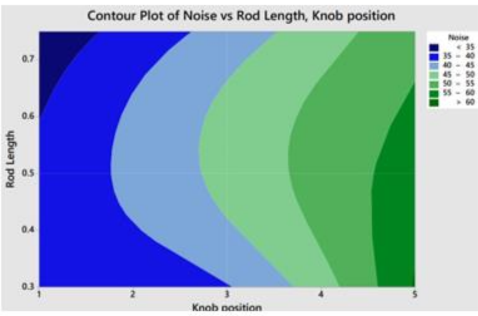
- The fan is set at different knob positions 5,3,1 respectively.
- At each knob position the sound is recorded.
- It is found that highest noise is obtained at Knob position 5(greater than 50 decibels)
- Highest value of noise is obtained in the lowest frequency range

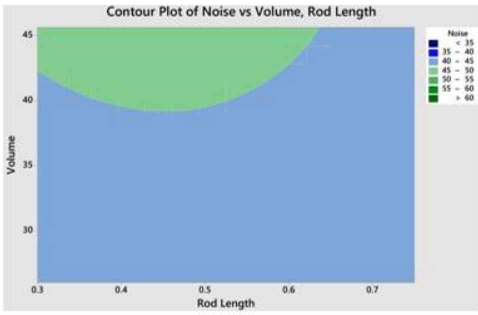
Optimisation Of Noise Output for Fan

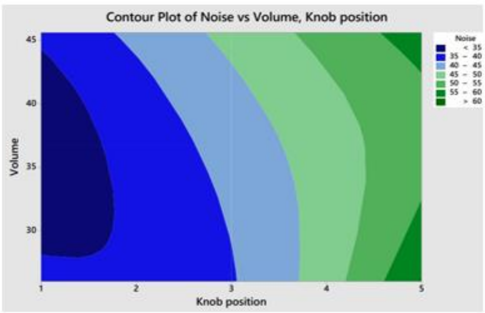
Surface response method:



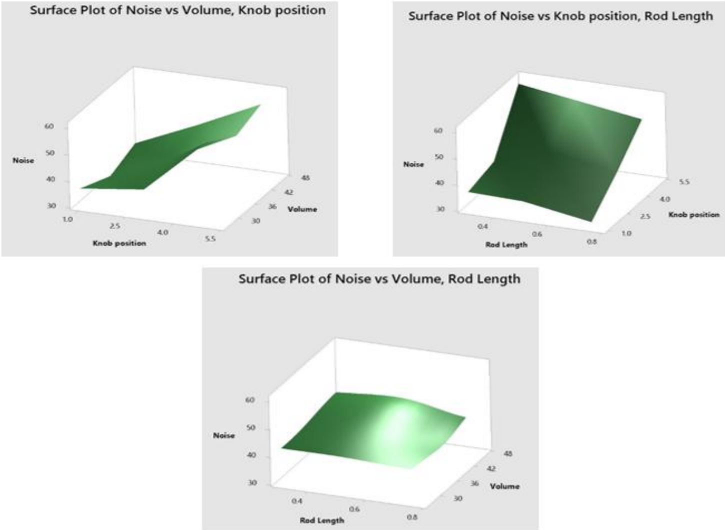
Contour plots:





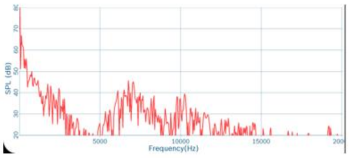


Surface Plots:

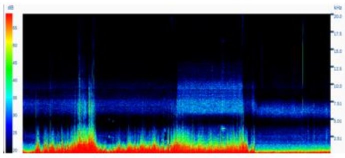


Air Conditioner Compressor 1(Panasonic)

Overall graph



FFT graph

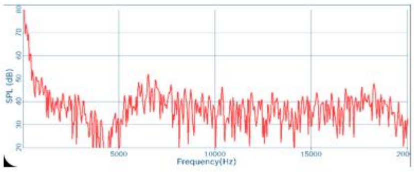

FFT vs Time graph

Vibration graph

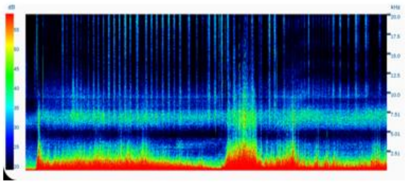
- The AC is set at different temperatures 18,21,26 degrees Celsius respectively.
- At each temperature the sound is recorded from the compressor.
- Highest noise is recorded to be at 18 degrees Celsius (greater than 60 decibels)
- Vibration is mostly observed along y axis which is indicated in green color.

Air Conditioner Compressor 2(Hitachi)

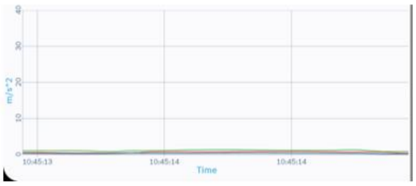
Overall graph



FFT graph



FFT vs Time graph

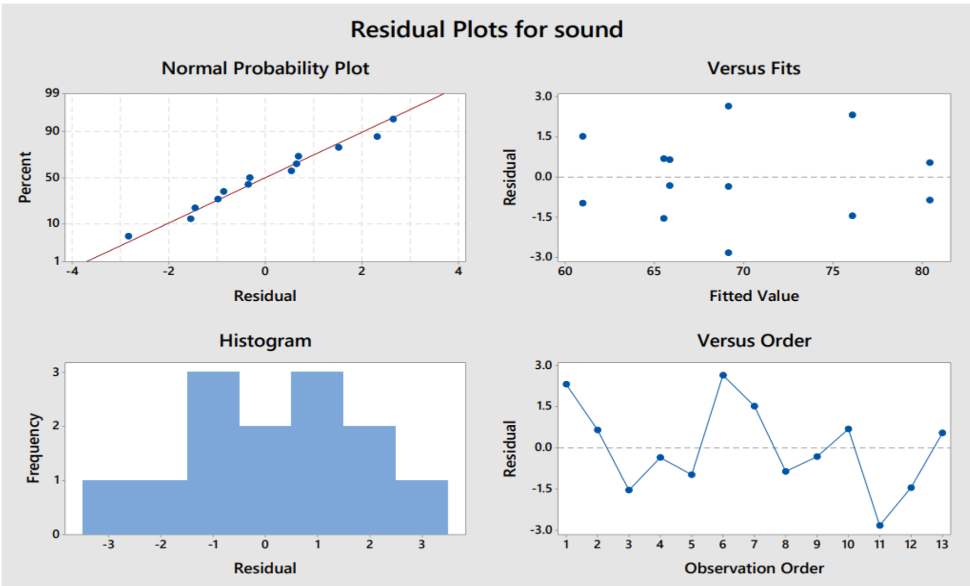


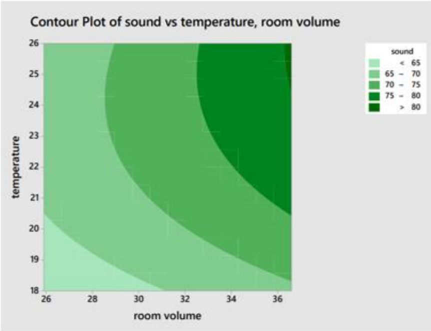
Vibration graph

- The AC is set at different temperatures 18,21,26 degrees Celsius respectively.
- At each temperature the sound is recorded from the compressor.
- Highest noise is recorded to be at 18 degrees Celsius (greater than 66 decibels).
- Vibration is mostly observed along y axis which is indicated in green color.

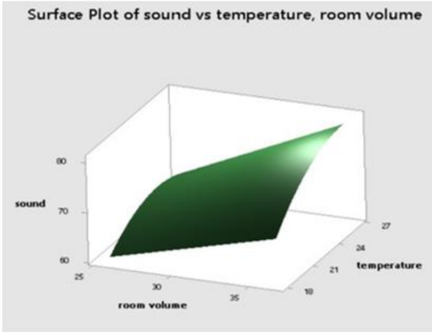
Optimisation of noise output for AC

Surface response method:



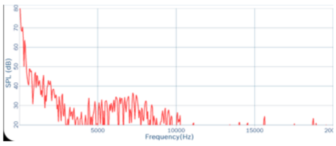


Contour Plot

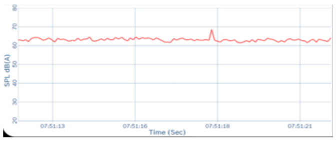


Surface Plot

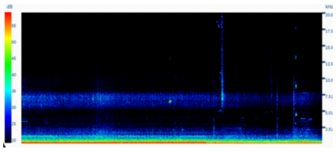
Washing Machine 1(IFB)



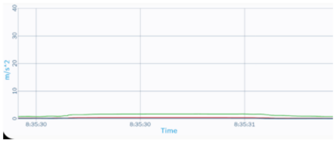
Overall graph



FFT graph



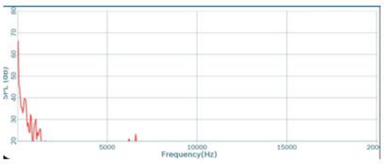
FFT vs Time graph



Vibration graph

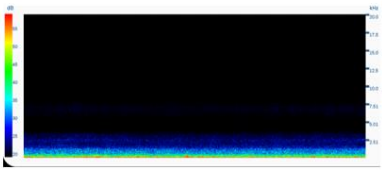
- Washing machine drum is loaded in 2 ways i.e., Full loaded, No load
- The noise is recorded during spinning function of the washing machine
- Highest noise is recorded during fully loaded condition (greater than 60 decibels)

Washing Machine 2(IFB)

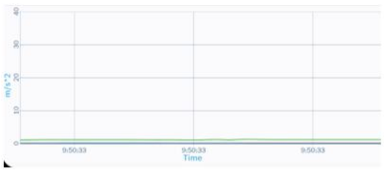


Overall graph

FFT graph



FFT vs Time graph

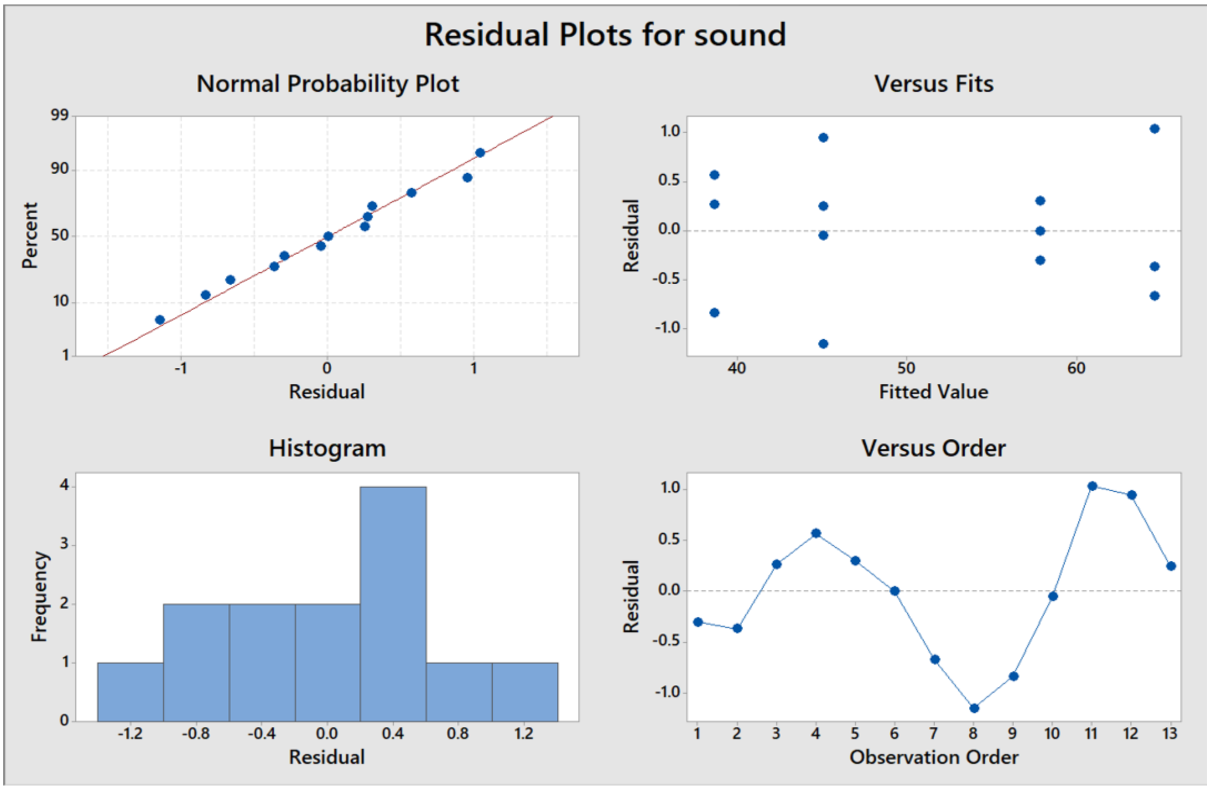


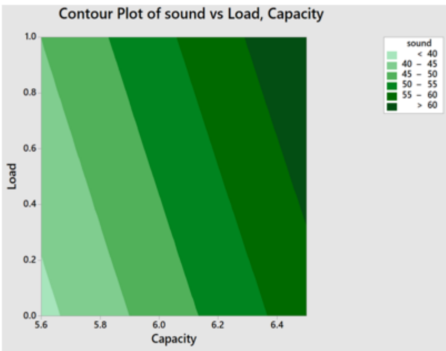
Vibration graph

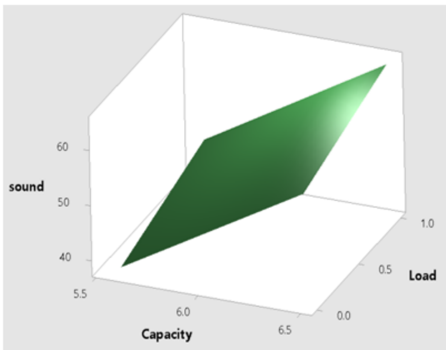
- Washing machine drum is loaded in 2 ways i.e., Full loaded, No load
- The noise is recorded during spinning function of the washing machine
- Highest noise is recorded during fully loaded condition (greater than 40 decibels)

Optimisation of noise output for Washing Machine

Surface response method:







Contour Plot **Surface Plot**

5. Conclusions

Conclusions Drawn from Observations on Fan:

- From the analyzed data from the fans, it is found that fans relatively make more noise at higher speeds. In the study 3 different fans of different companies are taken.
- It is found that the Crompton fan makes least sound of all the fans. The old fan makes the highest noise.
- The main factors affecting this noise are Aerodynamic design of the fan wings in newer fans. Other factor affecting that is components that are crudely used in old fan.
- Further optimization is done considering the variable factors volume of room, rod length and knob position. The output is considered as sound in decibels. Form the surface plots, values of the variables for less noise can be found.

Conclusions Drawn from Observations on Air Conditioner Compressor:

- The noise data from AC compressors are analyzed and the results are showed in noise mapping.

- The highest noise sound levels occur at the front side of air conditioner which is at the fan that is about 80.5 decibels where our procedure is done.
- From comparison of graphs concluded that sound power level will increase as higher fan speed and the lowest temperature of the air conditioner.
- The further optimization is done using surface response method where, a surface plot is obtained where it is possible to determine optimum variable parameters that is room size and temperature for lower noise of compressors.

Conclusions Drawn from Observations on Air Conditioner Compressor:

- From the washing machine data, it is found that the major amount of noise is produced during spinning (i.e. the drum rotates to dry clothes) function.
- The highest amount of sound recorded is about 65 decibels for a top load washing machine and 30 decibels for a front load washing machine.
- It is also found that top load washing machines make almost double the noise that is made compared to front load.
- The vibrational data gave that for a top load washing machine more vibration is more in vertical direction whereas for a front load washing machine, where vibration is almost negligible it is along horizontal direction.

References

1. Krzysztof Mazur, Stanislaw Wrona, Marek Pawelczyk,” Active noise control for a washing machine”, Applied Acoustics 146 (2019) 89–95 ,6 November 2018
2. M.S.M.Sani, M.H.A. Rasid, M.R.M.Rejab, M.M.Noor, K.Kadirgama & M.M.Rahman,” Experimental Study On Noise Source Identification Of Split Unit Air Conditioner System”, International Conference on Advance Mechanical Engineering (ICAME09),22-25 Jun 2019.
3. Nitin Gulhane, Sandip Patil, Kanwaljeet Singh,” Acoustic Analysis of Condenser Fan of Split Air Conditioner Using Numerical and Experimental Method”, International Journal of Air-Conditioning and Refrigeration, Vol. 23, No. 2 (2015) 1550012, 28 April 2015.
4. Muhammad ,Hanif Bin ,Abd Rasid,”noise Source Identification Of Split Unit Air Conditioner System, International Journal Of Innovative Science, Engineering & Technology 2008.
5. B.Hay ,M.F.Kemp , “Frequency analysis of air conditioning noise in landscaped offices” , Journal of Sound and Vibration ,Volume 23, Issue 3, Pages 375-381, 8 August 2014
6. Llado-Paris, Juan; Sanchez-Tabuenca, Beatriz, Acoustic analysis of the drainage cycle in a washing machine Dyna, vol. 82,Universidad National de Colombia Medellin, Colombia. May 2015
7. Gino Iannace , Giuseppe Ciaburro and Amelia Trematerra "Heating, Ventilation, and Air Conditioning (HVAC) Noise Detection in Open-Plan Offices Using Recursive Partitioning" 3 December 2018
8. Ricky Kim, Rob Lawrence "Structure borne Noise Reduction in Washing Machines: Noise Reduction by Modal Analysis" Vol. 18, No. 4 NEW ZEALAND ACOUSTICS ,2014
9. B. Hay And M. F. KEMP "Frequency Analysis Of Air Conditioning Noise In Landscape Offices" Journal Of Sound And Vibration ,August 2015.
10. WU Chengjun, LIU Jiang,” Influence of Surrounding Structures upon the Aerodynamic and Acoustic Performance of the Outdoor Unit of a Split Air-Conditioner , Chinese Journal Of Mechanical Engineering, may 2014
11. Un-Chang Jeong a , Jin-Su Kim a , Jae-Eun Jeong,” Development of a sound quality index for the wash cycle process of front-loading washing machines considering the impacts of individual noise sources, 2 June 2014.
12. Marek Moraveca , Gabriela Izarikovab , Pavol Liptaia,” Development of psychoacoustic model based on the correlation of the subjective and objective sound quality assessment of automatic washing machines,2018.
13. Can Nerse, Hyung Woo Kim, "Vibro-Acoustic Noise Analysis of a Washing Machine" Semyung Wang Intelligent System Design Laboratory, School of Mechanical Engineering Gwangju Institute of Science and Technology (GIST) April 2017
14. Samantha Di Loreto , Fabio Serpilli ,Valter Lori , Stefano Squartini "Sound quality evaluation of kitchen hoods" Department of Industrial Engineering and Mathematical Sciences, University polytechnic dell Marche, Brecce Bianche 12, 60131 Ancon, Italy Accepted 4 May 2020.
15. Manish Vishwakarmaa, Rajesh Purohit, V.Harshlata, P.Rajput, Department of Mechanical Engineering M.A.N.I.T, Bhopal, India. Centre for Remote Sensing & GIS,M.A.N.I.T, Bhopal, India. "Vibration Analysis & Condition Monitoring for Rotating Machines" International Conference of Materials Processing and Characterization (ICMPC 2016).

16. Sanjay R.Shinde, MangeshR.Phate, Rupesh V.Bhortake3 , “Numerical Investigation of Ceiling Fan Noise by Using Response Surface Method” , - International Journal of Innovative Science, Engineering & Technology, Vol. 1 Issue 3, May 2014.

17. M.S.M Sani, M.H.A.Rasid, “Reducing noise from fans”, Noise & Vibration Worldwide, Vol. 49(1) 11–13, 2018.

18. Muhammad AaqibAfaq; Adnan Maqsood; Khalid Parvez; Ammar Mushtaq ,” Study on the design improvement of an indoor ceiling fan”, Study concluded that six degree rake angle show enhanced performance. Proceedings of 2014 11th International Bhurban Conference on Applied Sciences & Technology (IBCAST) Islamabad, Pakistan, 14th - 18th January, 2014

19. Ricky Kim, Rob Lawrence Fisher & Paykel,” Structure-borne Noise Reduction in Washing Machines: Noise Reduction by Modal Analysis”, Vol. 18, No. 4 New Zealand Acoustics ,2014.

20. B.Hay ,M.F.Kemp, “Frequency analysis of air conditioning noise in landscaped offices” , Journal of Sound and Vibration ,Volume 23, Issue 3, Pages 375-381, 8 August 1972

21. Sheam-Chyun Lin a, Ming-Yuan Hsiehb and Cheng-JuChangc, Performance Improvement of a Hidden Ceiling Fan, Applied Mechanics and Materials Vols 479-480 (2014) pp 279-283 (2014) Trans Tech Publications, Switzerland.

22. Kersten Schmidt*, Dean J. Patterson, Performance results for a high efficiency tropical ceiling fan and comparisons with conventional fans Demand side management via small appliance efficiency, Renewable Energy 22 (2001) 169-176

23. Chengjun Wu1, Xiaofei Lei2, Noise control and sound quality evaluation of outdoor unit of split air-conditioner, accepted 16 June 2016.

24. Sheam-Chyun Lin and Ming-Yuan Hsieh,“An Integrated Numerical and Experimental analysis for Enhancing the Performance of the Hidden Ceiling Fan,” Hindawi Publishing Corporation, Volume 2014, , Article ID 214967,2014.

25. Wenhua Chen, ShichaoLiua, YunfeiGaoc,d , Hui Zhangc,” Experimental and numerical investigations of indoor air movement distribution with an office ceiling fan”,Elsevier,2018

26. Malcolm J. Crocker , Jorge P. Arenasb, Rajeev E. Dyamannavar ,” Identification of noise sources on a residential split-system air-conditioner using sound intensity measurements”, Applied Acoustics 65 ,2004

27. S. Bolton and P. Konieczny, “Experimental Design of a Low Noise Centrifugal Fan,” appearing in Fan Noise, An International Institute of Noise Control Engineers Symposium, pp. 253-260, Senlis, France, September 1992.

28. Pushpesh Singh, Gajendra VasantraoPatil ,” Design And Cfd Analysis Of Ceiling Fan For Regular Room Size” , International Journal of Mechanical Engineering and Technology (IJMET) Volume 11, Issue 4, April 2020, pp. 25-33.

29. Yu-Tuan Chou, Shao-Yi Hsia, “Numerical Analysis of Indoor Sound Quality Evaluation Using Finite Element Method”, Hindawi Publishing Corporation Mathematical Problems in Engineering Volume 2013.

30. Cheng Zhiwei1,2 and Lu Yigang ,” Diagnosis and analysis of abnormal noise in the pure electric vehicle’s air condition compressor at idle”, Journal of Low Frequency Noise, Vibration and Active Control 2018, Vol. 37(4) 711–724.