

Design of Ultrasonic Conical Horn using Aluminium Alloy and Steel



Priyadarshini Ch., M. Kalyan Naik

Abstract: Horn plays an important role in ultrasonic machining process. The design of horn is critical to its efficiency and quality of machining process. Ultrasonic horns are tuned Components designed to vibrate in a longitudinal mode at ultrasonic Frequencies. Reliable performance of such horns is normally decided by the uniformity of vibration amplitude at the working surface and the stress developed during loading condition. The design parameters of horn are calculated from the theoretical derivation of horn. By these parameters, the horn is designed and analyzed using CREO PRO and ANSYS software. In this paper the main object of the project is to Improve the performance of the Horn from the analysis test results, The horn is compared with other available horn results by comparing its natural frequency, amplitude vibration and temperature of the horn.

Keywords: Ultrasonic horn, Ansys, Creo pro, Aluminum alloy, steel.

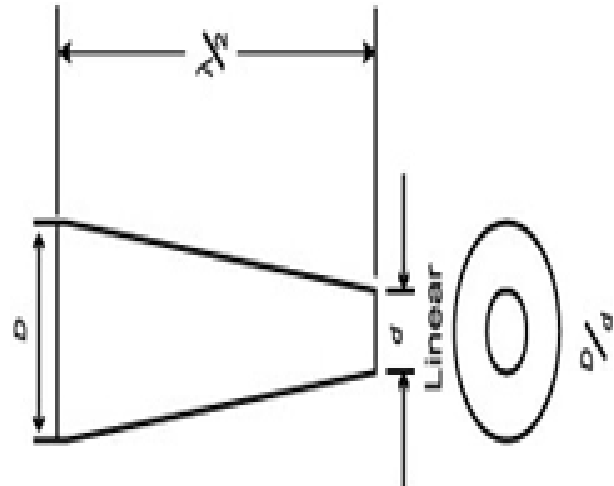


Fig.2. Conical Horn [8]

I. INTRODUCTION

Now a days in Industries like Manufacturing, Aerospace, Medical, Defence army, in all these field every component has to be very precise cut and accurate shape. In Ultrasonic machining process each component of material removing process has precise cut and accurate shape, Horn is the tool which connects physical connection between the transducer and tool in ultrasonic machining process as shown in fig 1 & 2. It provides the high amplitude between (15-25 kHz). The horn is used to amplifies the amplitude frequency passes through the tool which generates less stress on horn can improve the machining process in material removal rate. In this experiment we improve the amplitude frequency of conical horn with different materials Aluminium alloy and steel. From the literature review we have observed that very few paper has published on aluminium alloy horn, here we develop the amplitude frequency, stress, displacement, strain and heats flux of horn and compare both aluminium alloy horn and steel horn.

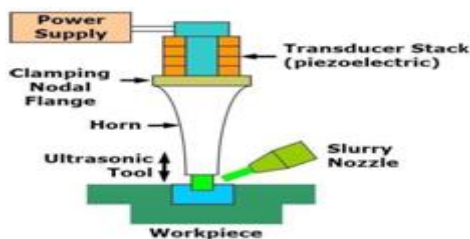


Fig.1. Principle of Ultrasonic Machining [7]

II. EXPERIMENTATION SETUP

In this experiment we find out the amplitude frequency, length of the horn from derived equation. The most important aspect of the horn design is a horn resonant frequency and the determination of the correct horn resonant length. The performance of the horn is indicated by an amplification factor.

- Amplification factor (L_n) is the area of horn at the input end to the area of horn at the output end

$$L_n = \ln [N]$$

Where,

N = Boundary condition [a_0/a_n]

a_0 = Area at the input end of the horn a_n = Area at the output end of the horn

- The resonant length (L) of the horn is determined by substituting the known boundary conditions

$$L = \frac{C}{2\pi f} \sqrt{1 + \left[\frac{\ln(N)}{2\pi}\right]^2}$$

Where,

2π

C = sound velocity of the material horn

f = amplitude of the horn

- In order to check the frequency of the horn where $2\omega c > \alpha$

$$\frac{2\omega}{c}$$

$$\alpha = \frac{\ln(N)}{L}$$

- Critical frequency of the horn is

Revised Manuscript Received on December 30, 2019.

* Correspondence Author

Mrs. Priyadarsini Chilukuri*, Assistant Professor, VNR VAN Jyothi Institute of Technology and Science, Hyderabad, (Telangana) India.

Mr. M. Kalyan Naik, P.G. scholar, Advanced Manufacturing system, VNRVJIEET, Hyderabad, (Telangana) India.

© The Authors. Published by Blue Eyes Intelligence Engineering and Sciences Publication (BEIESP). This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>)

$$f_c = \frac{\alpha * c}{4\pi}$$

Where, critical frequency should be double than the amplitude frequency.

- Assumed input parameters of the conical horn at an amplitude frequency 20KHZ and 24 KHZ for steel and aluminum horn respectively shown in table 1

Table.1. Input parameters assumed for conical horn

parameters	symbol	Dimension of the steel tool (mm)	Dimension of the aluminum alloy tool (mm)
Area of the horn at input end	a ₀	80*40	80*40
Area of the horn at the output end	a _n	40*80	40*80

From the derived equations, the length and critical frequency of the conical horn at an amplitude frequency of 20KHZ, 25KHZ for steel and aluminum horn respectively are calculated as shown in table 2

Table2. Calculated Results of steel and aluminum horn for conical horn

S.No	Calculated Results	
	Steel	Aluminum
Material		
Sound frequency (c)	4320 m/s	6320 m/s
Amplification factor (L _n)	2.9957	2.9957
The resonant length (L) of the horn	133m	159 mm
frequency of the horn ^{2ω/c}	22.524 KHZ	47.871 KHZ
frequency of the horn α	52.359 KHZ	18.784 KHZ
Critical frequency of the horn	6.6 KHZ	9.6KHZ

III. RESULTS AND DISCUSSION

A. DESIGN OF HORN:

From the calculated result the resonance length of the aluminum alloy horn and steel horn are 159 mm and 139 mm respectively, Area of the horn at input end is 80*40 mm and at output end is 40*80 mm for both aluminum alloy and steel horn as shown in fig 3.

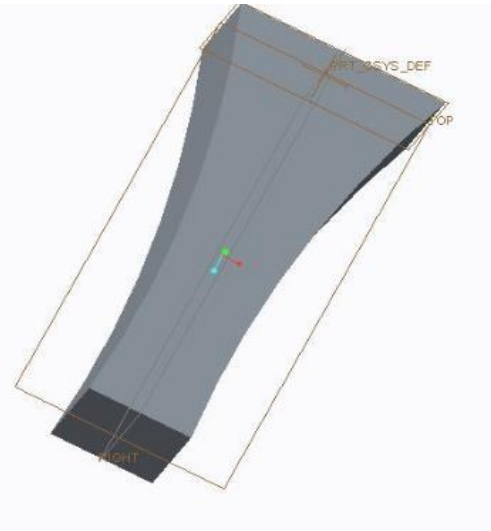


Fig.3. 3D model of steel and aluminum alloy

B. ANALYSIS OF HORN:

Firstly, the conical horn is designed according to the calculated equation parameters and then finally the designed horn is analyzed by ANSYS SOFTWARE.in ANSYS SOFTWARE the given parameters of aluminum alloy and steel. The designed part of the conical horn is analyzed by parameters of 7000N in download direction and materials properties are applied as shown in table3

Table.3.composition of Al-7075

COMPOSTION OF AL-7075	CONTENTS (%)
Aluminum	90
Zinc	5.6
Mg	2.5
Copper	1.6

Materials properties and loads are applied to the designed part of the conical part in ANSYS SOFTWARE. In both aluminum and steel horn the materials properties are taken chemical composition of respective from the material as shown in the table4. 7000N load is applied in (z) the download direction by fixed supported nodal, to find out the stress, thermal, stain, frequency of the conical horn

Table.4. Composition of Mild Steel

COMPOSITION OF MILD STEEL	CONTENTS (%)
Combined Carbon	0.360
Sulphur	0.042
Phosphorous	0.056
Manganese	0.0620
Iron	98.861

C. FREQUENCY RESPONSE OF ALUMINIUM

From fig4 frequency response analysis the amplitude is maintained low vibrations at 9600Hz.when compare to other vibration frequency, low temperature is generated and surface roughness is reduced with high effective energy.

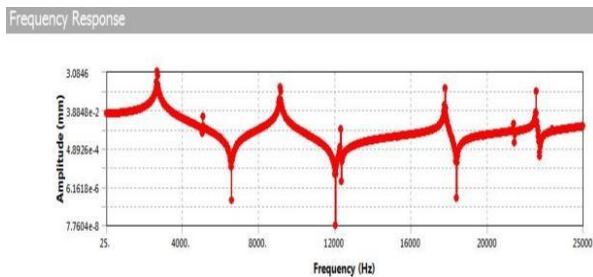


Fig.4. Frequency Response Displacement of Aluminum

From fig 5 & 6 gradually amplitude at 9600Hz and 13.696 Mpa of stress & strain is maintained low .the elasticity of the aluminum horn is reduced so that machining process is performed well.

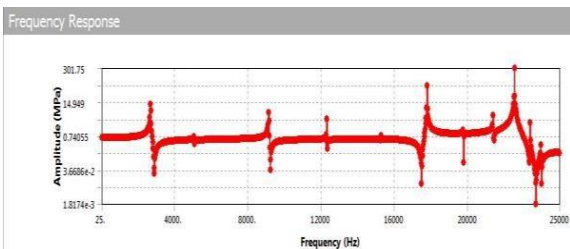


Fig.5. Frequency Response Stress of Aluminum

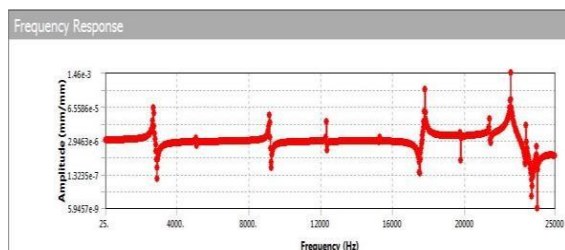


Fig.6. Frequency Response Strain of Aluminum

D. FREQUENCY RESPONSE OF STEEL

From fig 7 frequency response analysis the amplitude is maintained low vibrations at 6900 Hz.when compare to other vibration frequency, low temperature is generated and surface roughness is reduced with high effective energy.

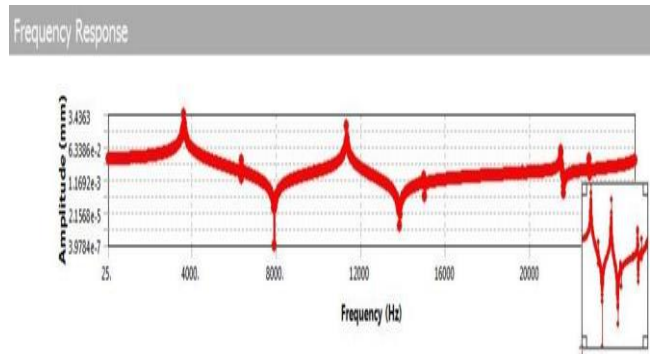


Fig. 7. Frequency Response Displacement of Steel

From fig. 8 & 9 gradually amplitude at 6900Hz and 7.66 Mpa of stress & strain is maintained low .the elasticity of the aluminum horn is reduced so that machining process is performed well.



Fig.8. Frequency Response Strain of Steel

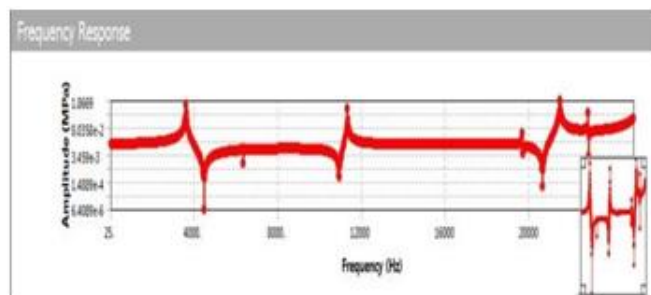


Fig.9. Frequency Response Stress of Steel

IV. CONCLUSION

From the ansys analysis,

- In frequency response displacement, aluminum horn has high vibration frequency When Compared to the steel horn, so Aluminum horn has low material removal rate.
- By operating under the same condition with different dimensions, we can conclude that the aluminum horn is vibrating at less frequency with less amplitude comparing with the steel horn.
- Aluminum horn can withstand high temperature in ultrasonic machining process and low stress concentration at high amplification displacement.

ACKNOWLEDGEMENT

The authors are thankful to Dr. G.S Gupta, Professor and HOD Mechanical engineering, VNR VJIET, Dr. E.V Ramana P.G Coordinator, MED, VNR VJIET.

REFERERNCES

1. Shu, Kuen Ming, Wen Hsiang Hsieh, and Hoa Shen Yen. "Design and Analysis of Acoustic Horns for Ultrasonic Machining." In Applied Mechanics and Materials, vol. 284, pp. 662-666. Trans Tech Publications, 2013.
2. Vivekananda, K., G. N. Arka, and S. K. Sahoo. "Design and analysis of ultrasonic vibratory tool (UVT) using FEM, and experimental study on ultrasonic vibration-assisted turning (UAT)." Procedia Engineering 97 (2014): 1178-1186.
3. Yadava, Vinod, and AniruddhaDeoghare. "Design of horn for rotary ultrasonic machining using the finite element method." The International Journal of Advanced Manufacturing Technology 39, no. 1-2 (2008): 9-20.
4. NAD, Milan. "Ultrasonic horn design for ultrasonic machining technologies." (2010).
5. Rani, M. Roopa, and R. Rudramoorthy. "Computational modeling and experimental studies of the dynamic performance of ultrasonic horn profiles used in plastic welding." Ultrasonic 53, no. 3 (2013): 763-772.
6. Chang, Zensheu, Stewart Sherrit, XiaoqiBao, and Yoseph Bar- Cohen. "Design and analysis of ultrasonic horn for USDC (Ultrasonic/Sonic Driller/Corer)." In Smart Structures and Materials 2004: Industrial and Commercial Applications of Smart Structures Technologies, vol. 5388, pp. 320-327. International Society for Optics and Photonics, 2004.
7. https://www.google.com/imgres?imgurl=http%3A%2F%2F1.bp.blogspot.com%2F-F1ZuREmbuKA%2FvfPKGZaUubI%2FAAAAAAABVQ%2FOQW9aAnU14c%2Fs1600%2FUSM2.jpg&imgrefurl=http%3A%2F%2Fmechanicalinventions.blogspot.com%2F2015%2F09%2Fultrasonic-machining-usm-working.html&docid=y0e6zLpLBKrOaM&tbnid=IziV62IIIv9LxM%3A&vet=10ahUKEwi2IJHsSsTmAhW_zTgGHbMqDB0QMwiDASgSMBI..i&w=745&h=599&bih=625&biw=1366&q=ultrasonic%20machining&ved=0ahUKEwi2IJHsSsTmAhW_zTgGHbMqDB0QMwiDASgSMBI&iact=mr&uact=8
https://www.google.com/url?sa=i&source=images&cd=&ved=2ahUKEwi3xejDs8TmAhXbxjgGHSSnBJkQjRx6BAGBEAQ&url=http%3A%2F%2Fwww.sonicsystems.co.uk%2Fpage%2Fpower-ultrasonics-a-guide%2F39%2F&psig=AOvVaw2BvrRf6xupq6_avES9gx4i&ust=1576937291300339

AUTHORS PROFILE



Mrs. Priyadarsini Chilukuri, received her M. TECH, (CAD/ CAM) from Jawaharlal Nehru Technological University Hyderabad, B.E, (MECHANICAL ENGINEERING) from (Andhra University).working As Assistant Professor in VNR VAN JYOTHI INSTITUTE OF TECHONLOGY AND SCIENCE AND Having 9

Years Teaching experience



Mr. M Kalyan Naik is a PG scholar in Advanced Manufacturing system (AMS) from VNRVJIET, Hyderabad. His area of research work is in comparison of ultrasonic aluminum horn and steel horn by designing and analysis