IARJSET

ISSN (Online) 2393-8021
ISSN (Print) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Vol. 8, Issue 6, June 2021

DOI: 10.17148/IARJSET.2021.8656

Results: Investigation for Effect of Parameters on Corrugated Wire Mesh Laminates Strength

A. S. Shinde[1], B. R. Chavan[2], S. M. Patankar[3]

Assistant Professor, Mechanical Engineering Department, A. P. Shah Institute of Technology, Thane, India[1]

Assistant Professor, Mechanical Engineering Department, A. P. Shah Institute of Technology, Thane, India[2]

Assistant Professor, Mechanical Engineering Department, A. P. Shah Institute of Technology, Thane, India[3]

Abstract: It has been observed that the mechanical response mainly depends upon the parameters such as geometry of corrugation, corrugation angle, number of corrugated layers, configuration of laminates of the corrugated wire mesh laminates and the material properties. In testing, the samples of aluminium wire mesh laminates for different geometrical parameters are prepared and tested for compressive strength by using universal testing machine. Results obtained by experimentation are validated by using ANOVA.
Scope: Thesis will identify the parameters of CWML and give the best material to the industry which has application for light weight and high strength.

Keywords: CWML, Compressive Strength, Corrugation Angle, ANOVA.

I. INTRODUCTION

From the referred literatures it is cleared that very few researchers have been done on parametric study of CWML panel hence our main focus is on finding various parametric combination which can give better life at lowest possible weight. Hence on the basis of above fundamental criteria problem has been defined as "Parametric Study of Corrugated Wire Mesh Laminates for Aluminium Alloy" in which, strength of various parametric combination of CWML using Taguchi approach at lowest possible weight for cost effectiveness and better performance was find out.
It has long been seen that for forming light weight structures with high anisotropic performance, stability under buckling load and energy absorption capability for different industrial applications. "Corrugation" is described as a series of parallel ridges and furrows. Structures having corrugation on its surface are called as corrugated structures.
Corrugated Wire Mesh Laminate (CWML) has various industrial applications and numerous innovative developments to corrugated structures, involving more elaborate and ingenious corrugation geometries and combination of corrugations with advanced materials [1]. By combining several layers of metallic wire meshes on top of each other, CWML is manufactured.

II. METHODOLOGY

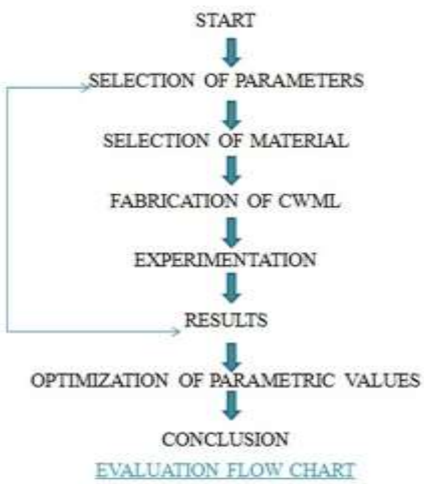

Fig. 1 Flow Chart

IARJSET

ISSN (Online) 2393-8021
ISSN (Print) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Vol. 8, Issue 6, June 2021

DOI: 10.17148/IARJSET.2021.8656

A. SELECTION OF PARAMETERS

In Taguchi's methodology, all factors affecting the process quality can be divided into two types: control factors and noise factors [7]. The signal factors are material of the wire mesh, the wire diameter, the opening width, number of layers, number of corrugations and corrugation parameters such as the corrugation height and the base angle which can be altered to provide a wide range of transverse stiffness and strength to the CWML [1]. Previous studies employed samples in which the corrugations were created using the same base angle. The selected signal factors are corrugation angle, laminates structure and number of corrugated layers while noise factors are surrounding temperature, moisture content in air, acidic environment, humidity etc which often cannot be eliminated and causes variation in the output. The repeatable and uniform corrugations are obtained if sheets are prepared using 45° triangular profile [8]. Hence levels of corrugation angles (φ) can be taken as 40°, 45°, 50° and below these range load carrying capacity of CWML structure decreases and above the range there are chances of breaking wire mesh at the centre of corrugation as well as weight also increases. Typically, alternating layers of the CWML may be arranged orthogonally so that the high stiffness provided by the corrugation is available in both directions [1]. Hence levels of laminates structure can be taken as sandwich, orthonormal and orthogonal. For a given wire diameter, minimizing the number of layers or the number of corrugation waves is likely to make structure less capable of carrying load. Therefore, from the point of view of increasing mechanical strength and stiffness, it may be desirable to have multiple layers of wire mesh with multiple corrugations in each layer and on the other side increasing no of layers increases the weight of the structure. Since our aim is to obtain a high strength light weight structure number of corrugated layers may be 2, 3 and 4.

B. SELECTION OF MATERIAL

An important and main phase of this work is that the selection of material. As in market many materials species available such as copper, titanium, stainless steel, aluminium, cast iron and much more. On market research basis, all materials specifications like cost, weight, corrosive properties, etc. This work is based on high strength to low weight ratio, so selected material is aluminium.

C. CONTROL FACTOR

In Taguchi's methodology, all factors affecting the process quality can be divided into two types:

- Control factors
- Noise factors

The selected signal factors in this study are geometrical structure, laminates structure and number of corrugated layers while noise factors are surrounding temperature, moisture content in air, acidic environment, humidity, etc. which often cannot be eliminated and causes variation in the output.

III. COMPRESSIVE STRENGTH

Compressive strength is the capacity of a material or structure to withstand loads tending to reduce size, as opposed to tensile strength, which withstands loads tending to elongate. In other words, compressive strength resists compression (being pushed together), whereas tensile strength resists tension (being pulled apart). In the study of strength of materials, tensile strength, compressive strength, and shear strength can be analyzed independently.

Table:1 Selection of Control Factors and it's Levels

Level / Control Factor	I	II	III
Type of Corrugation	Square	Triangular	Trapezoidal
Configuration of Laminate	Orthogonal	Orthonormal	Sandwich
No. of Layers	2	3	4

IV. SELECTION OF ORTHOGONAL ARRAY (OA)

In Taguchi method, experimental analysis is based on orthogonal array. Orthogonal array is used to minimize the number of experiments, by which quality characteristics are examined. The appropriate OA is selected on the basis of total degrees of freedom required. By using number of factors, number of levels of each factor and number of interactions DOF is determined. In this research work, the interaction effect between the process parameters is not considered. The degree of freedom for three levels is 2 (DOF = number of levels - 1). The required total DOF for three factors and three levels is 6 (3 x (3 - 1) = 6).In Taguchi method, the total DOF of selected OA must be greater than or equal to the total DOF required for the experiment. Hence L9 OA having eight DOF is selected in this paper. [14]

ISSN (Online) 2393-8021
ISSN (Print) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Vol. 8, Issue 6, June 2021

DOI: 10.17148/IARJSET.2021.8656

Table: 2. Numbering of Selected Factors

Type of Corrugation	Configuration of Laminate	No. of Layers
1. Triangular 2. Square 3. Trapezoidal	1. Orthonormal 2. Orthogonal 3. Sandwich	1. 2 2. 3 3. 4

By using Taguchi L9 array and level as 3 in Minitab software following combination of parameter is got for experimentation and manufacturing of laminates. (Table: 3)

Table: 3. Taguchi's L9 Array

Sr. No.	Type of Corrugation	Configuration of Laminate	No. of Layers
1	1	1	1
2	1	2	2
3	1	3	3
4	2	1	2
5	2	2	3
6	2	3	1
7	3	1	3
8	3	2	1
9	3	3	2

V. ANALYSIS OF VARIANCE (ANOVA)

ANOVA is a method most widely used for determining significant parameters on response and measuring their effects. In the cooling tower performance, the major factor of the non- reproducibility is the controls the test facility and the cooling tower operating condition. In ANOVA, the ratio between the variance of the process parameter and the error variance is called as F-test. It determines whether the parameter has significant effect on the quality characteristics. This process is carried out by comparing the F-test value of the parameter with the standard value (F0.05) at the 5% significance level. If F-test value is greater than F0.05, the process parameter is considered significant. It can be seen that all factors are significant. [14]

VI. SAMPLE CALCULATION

Specimen 1: Triangular shape having orthonormal orientation with number of layers are 2.

Strength to Weight Ratio:

$$\text{STRENTH TO WEIGHTRATIO} = \frac{\text{COMPRESSION LOAD}}{\text{WEIGTH}}$$

$$= 0.9/0.02427$$

$$= 37.7992 \text{ KN/Kg}$$

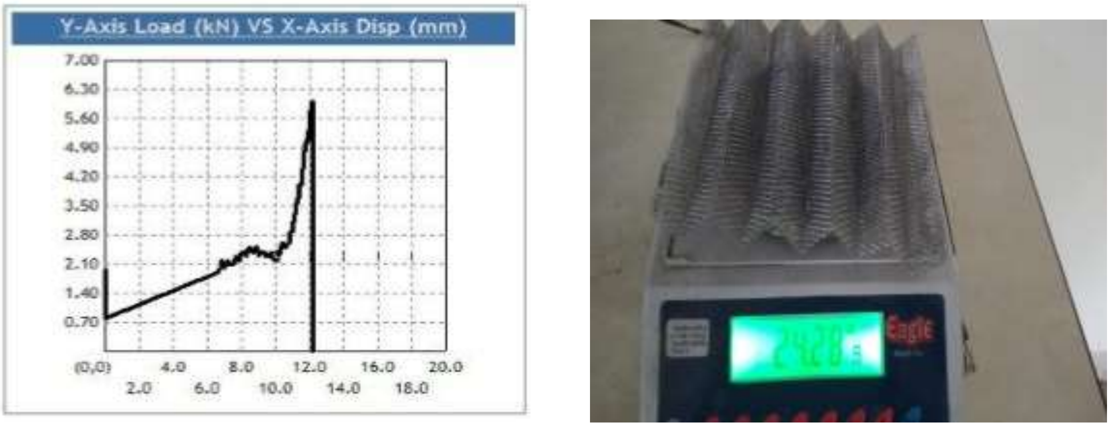

Fig. 2. Load - Displacement Graph and Weight of Specimen 1

International Advanced Research Journal in Science, Engineering and Technology

Vol. 8, Issue 6, June 2021

DOI: 10.17148/IARJSET.2021.8656

The Strength to weight ratio of each corrugated wire mesh laminates structure and by comparing them all and by larger is better criteria the following result we get from Minitab Software.

Table: 4. Results Validation by Using Minitab Software

Sr.No.	Factor	Sum of Square	Mean of Square	F-Value	P-Value	Rank
1	Shape	65.48	32.74	0.14	0.879	1
2	Configuration of Laminate	459.05	229.52	0.96	0.510	2
3	No. of Layers	760.89	380.45	1.59	0.385	3

VII. COEFFICIENT OF CORRELATION

Coefficient of correlation value is nearer to **1** show the good agreement between each value of S/W ratio and parameters. There is value $R^2 = 0.7292 = 0.73$ is nearer to one and showing better results.

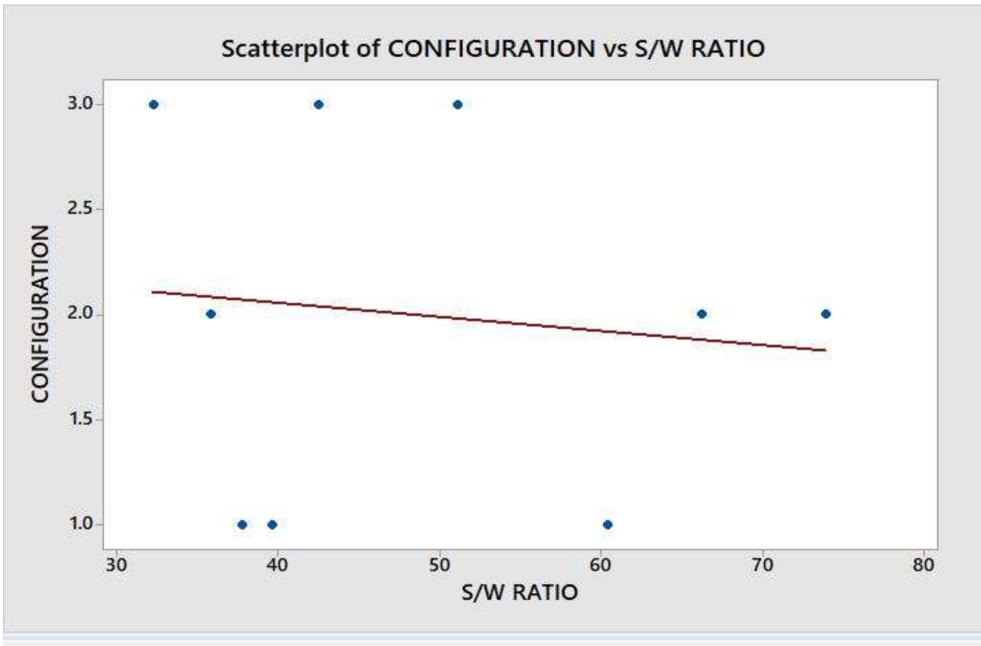

Fig. 3. Scatter Plot of Configuration Vs S/W Ratio

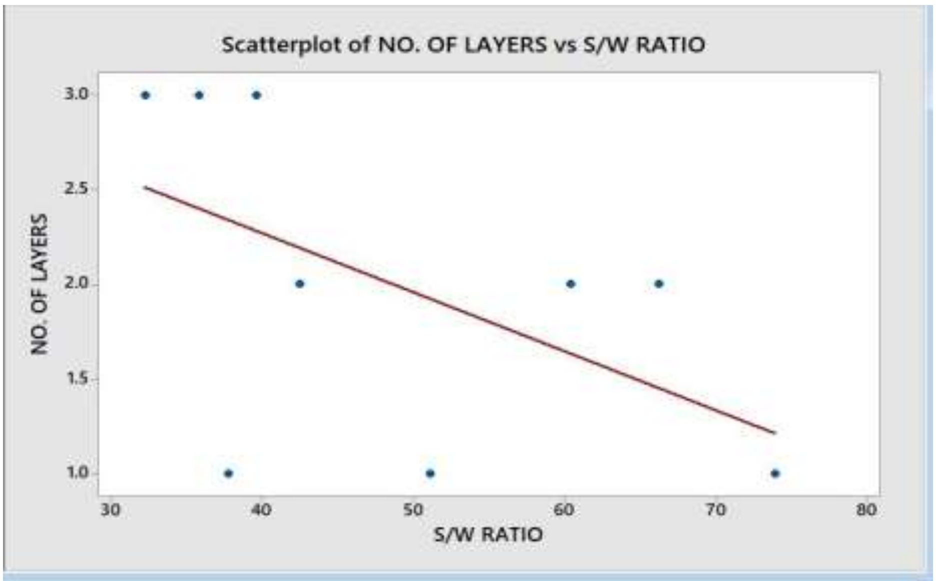

Fig. 4. Scatter Plot of No. of Layers Vs S/W Ratio

IARJSET
ISSN (Online) 2393-8021
ISSN (Print) 2394-1588
International Advanced Research Journal in Science, Engineering and Technology
Vol. 8, Issue 6, June 2021
DOI: 10.17148/IARJSET.2021.8656

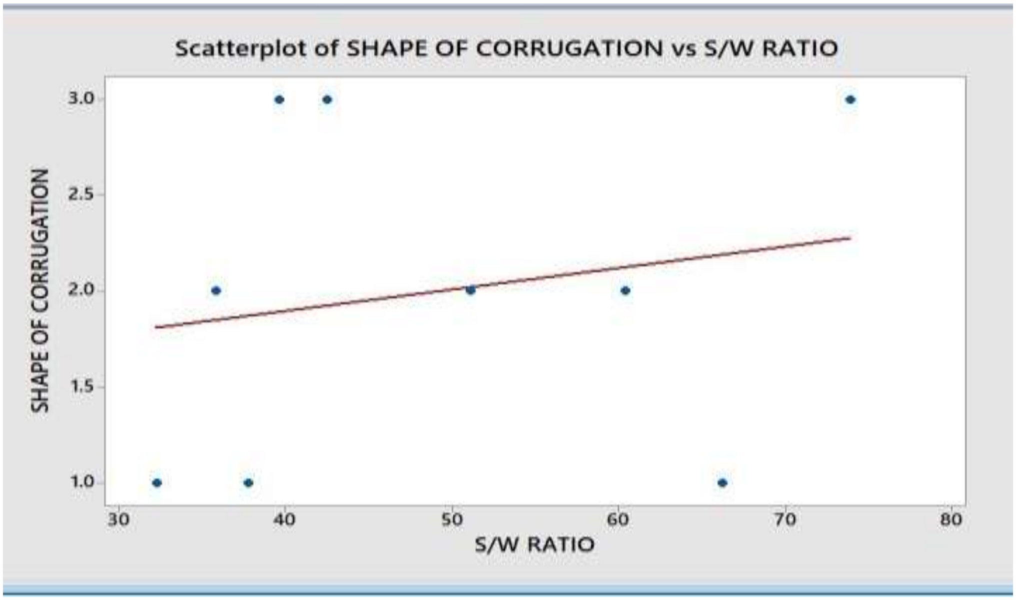

Fig. 5. Scatter Plot of Shape of Corrugation Vs S/W Ratio

Fig.5 shows main effect of CWML parameters on the mean values of strength to weight ratio. The mean values of strength to weight ratio are obtained from Table 4. Since larger strength to weight ratio is desirable. The quality characteristic applicable in this case is "Larger the better". For "Larger the better" quality characteristics of strength to weight ratio, the main effect plot for signal to noise ratio is shown in Fig.6. With reference to Fig. 3, 4 and 5, the increase in the level of number of layers leads in general to a lower the strength to weight ratio and it also shows the effect of individual parameter on strength to weight ration of CWML. Also, the p-value is maximum in case of shape of corrugation and configuration of Laminates. Thus, shape of structure and orientation plays significant role in deciding strength to weight ratio of test specimen. Increase in the levels of number of layers causes increase in strength, but simultaneously it increases weight of structure leads to lower the strength to weight ratio of the structure. Based on Analysis of S/N ratio and main effect plot, the optimum performance for maximum strength to weight ratio can be obtained by setting control factors at 1, 2 & 3.

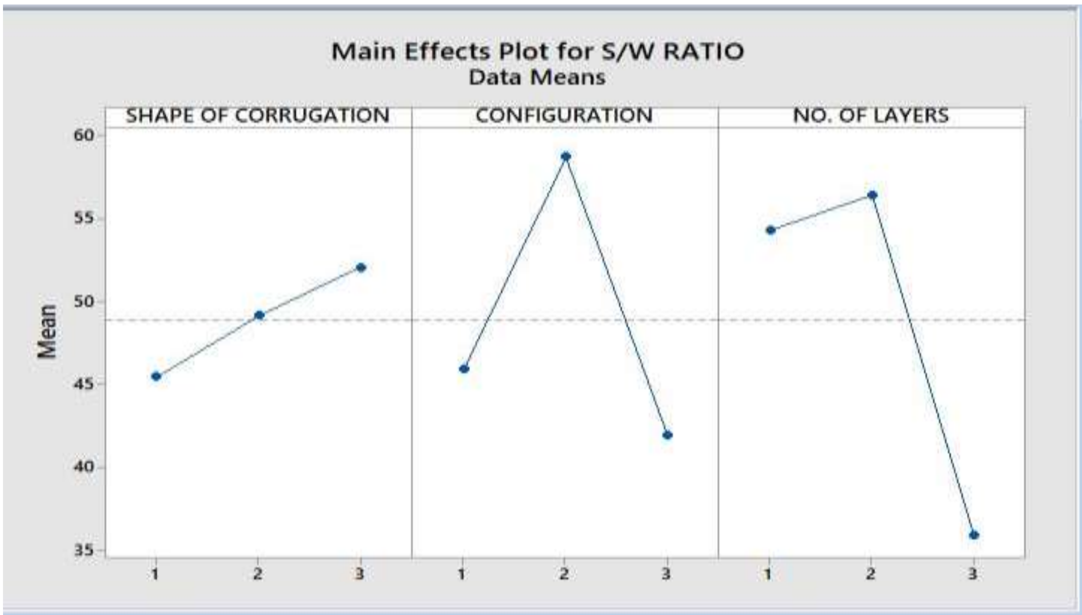

Fig. 6. Main Effect Plot for Strength to Weight Ratio

Table: 5. Optimized Parameters of CWML for Maximum Strength

Shape	Configuration of Laminate	No. of Layers
TRAPEZOIDAL	ORTHOGONAL	2

DOI: 10.17148/IARJSET.2021.8656

VIII. CONCLUSION

In the present work, the effect of different parameters on the strength of CWML has been investigated. It was found that all the three parameters have strong influence on the strength of CWML. After performing experimental tests on CWML samples and analysing the results using Taguchi's technique. The designed experiments based on Taguchi methods were performed using L9 orthogonal arrays to analyse the compression strength of CWML as response variable. The influences of corrugation angle, configuration of laminate and the number of corrugated layers on this response were established. All the three factors effectively contributed in maximizing the compressive strength of CWML structure. The most significant factor in CWML is shape of wire mesh structure which affects its strength greatly as compared to other factors. If the number of layers increases which increases strength of the structure but it also increases weight of the structure. Therefore, the number of layers inversely affects the strength to weight ratio of the structure. By making different combinations, the number of layers can be changed. The optimum conditions of CWML parameters for strength to weight ratio is 3, 2 & 1. The maximum compressive strength to weight ratio was obtained for trapezoidal shape of structure, orthogonal configuration of laminate and number of layers are 2.

ACKNOWLEDGMENT

The authors are grateful to **Mr. Onkar Sonare, Mr. Vinay Bhatkar, Mr. Ankush Biradar** and **Dr. Ram Reddy** for their guidance throughout the work. The authors express their gratitude to **Dr. Sameer Nanivadekar, Mr. Shivshankar Kore, Mr. Amarnath Landge, Mr. Vineet Kutty, Ms. Yogita Mali.** Authors would like to also thank Principal, all teaching and non-teaching staff of A. P. Shah Institute of Technology, Thane for their support and providing labs for the work.

REFERENCES

[1]. Dayyani, et al., (2015) "The mechanics of composite corrugated structures: A review with applications in morphing aircraft" Elseveir, composite structures 133 pp. 158-180.
[2]. Jeongho Choi, et al., (2013) "Research of elasticity for a corrugated wire mesh", Elseveir, Materials and Design 52 pp.78-91.
[3]. P.Isaksson et al., (2007) "Shear correction factors for corrugated core structures", Elseveir, composite structures 80 pp. 123-130.
[4]. Jeongho Choi, et al., (2011), "Methods for manufacture of corrugated wire mesh laminates", International Journal of Aerospace and Mechanical Engineering 5:3.
[5]. S. P. Kondapalli et al., (2015), "Application of taguchi based design of experiments to fusion arc weld processes: A Review", International Journal of Business Research and Development, Vol. 4 No. 3, pp. 1-8.
[6]. R. Ramkrishnan, et al., (2014), "Experimental study and performance analysis of ceramic packing cooling tower using taguchi method", International Journal of Thermal & Environmental Engineering, Volume 8, pp. 45-53.
[7]. David J. Sypeck et al., Cellular metal truss core sandwich structure.
[8]. David j. Sypeck, Wrought aluminum truss core sandwich structures.
[9]. M.R.M. Rejab, et al., (2013), "The mechanical behavior of corrugated core sandwich panels, composites", Part B 47.
[10]. R. A. Kishore, et al., (2009) "Taguchi analysis of the residual tensile strength after drilling in glass fiber reinforced epoxy composites", Journal of materials and design 30, pp. 2186-2190.
[11]. Martin Philip Venter, (2011), "Development and validation of a numerical model for an inflatable paper dunnage Bag using finite element methods", Department of Mechanical & Mechatronic Engineering University of Stellenbosch Private Bag X1, 7602, Matieland, South Africa.
[12]. Xiaobo Gong et al., (2017), "Variable stiffness corrugated composite structure with shape memory polymer for morphing skin applications", Smart Materials and Structures.
[13]. Francesco Previtali et al., (2014), "Performance of a three-dimensional morphing wing and comparison with a conventional wing", AIAA Journal.
[14]. Phillip J. Ross, "Taguchi technique for quality engineering" McGraw-Hill publication.
[15]. Murray Spiegel, "Probability and Statistics" McGraw-Hill publication.