International Journal of Latest Engineering and Management Research (IJLEMR)
ISSN: 2455-4847
www.ijlemr.com || Volume 03 - Issue 04 || April 2018 || PP. 65-70

Optimization of Flange Connector for Transmission Line Tower

Pranav P. Shah[1] and V. R. Panchal[2]
[1]*Post Graduate Student (Structural Engineering), Department of Civil Engineering, Chandubhai S. Patel Institute of Technology, Charotar University of Science and Technology, Changa, Gujarat, India*
[2]*Professor and Head, Department of Civil Engineering, Chandubhai S. Patel Institute of Technology, Charotar University of Science and Technology, Changa, Gujarat, India*

Abstract: Transmission line towers are designed to fulfill the requirement of structural and electrical point of view. A flange coupling is a device used to transmit power by connecting two shafts together at their ends. Optimization of connector used in transmission line tower can not only give effective design of connector but can also reduce the overall cost of transmission line tower. The present study is done to make an attempt to optimize the weight of flange connector used in transmission line tower. Optimization of this flange connector is done by using particle swarm optimization in MATLAB. The results obtained are then analyzed in ANSYS and it is found that stress in connector with optimum weight is within permissible limit.

Keywords: ANSYS, Flange Connector, MATLAB, Optimization, Transmission Line Tower

I. INTRODUCTION

Transmission line tower are designed to fulfill the current higher demand of the electrical energy by making more economical and light weight structures. Transmission line tower costs about 28 to 42% of the cost of transmission line. So by optimizing the weight of connector it can reduce the overall weight of transmission line tower and economy. This optimization is done by optimization technique known as Particle Swarm Optimization. PSO is an optimization technique, inspired by bird flocking or fish schooling Flange connector is a mechanical component used to connect two shafts together at their ends for the purpose of transmitting load. Flange connector is usually made up of steel. Flanges are connected on the shaft and joined with the help of key at the end. Flanges are connected with the help of bolts. Singh and Bhusan [1] studied the reduction of weight of flange coupling which is usually utilized for joining two shafts of equal diameter which is aligned. Patil and Mattikali [2] studied the design and analysis of flange coupling. They did static structural analysis and found the optimum design of flange coupling. Amrita and Jajimoggala [3] mainly focused on problem of generating equation and hence tried optimization by coupling MATLAB and ANSYS. They found that the result obtained from MATLAB t are more reliable than that obtained from Design Optimization in ANSYS. Shah et al. [4] compared flange and Oldham connector for suspension transmission line tower and concluded that flange connector is more effective and safe.

The main objective of the present study is to optimize the design of flange coupling and check the stress of the connector with optimum weight is within permissible stress or not.

II. ANALYSIS OF TRANSMISSION LINE TOWER

Load calculation of transmission line tower is done by using IS 802-2015 for tubular circular section. Figure 1 shows the transverse, longitudinal and vertical loads assigned in transmission tower as per reliability, safety and security conditions. These loads are calculated for both normal wire and broken wire conditions in tower. Figure 1 shows member wherein axial force is maximum.

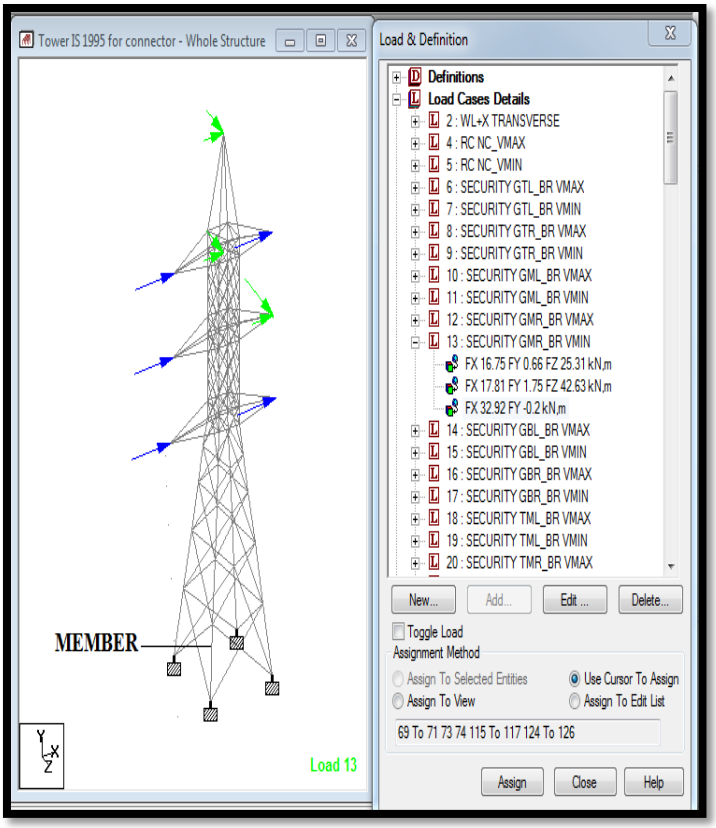

Fig. 1 Analysis of the tower as per IS 802-2015

III. OPTIMIZATION OF FLANGE CONNECTOR BY PARTICLE SWARM OPTIMIZATION

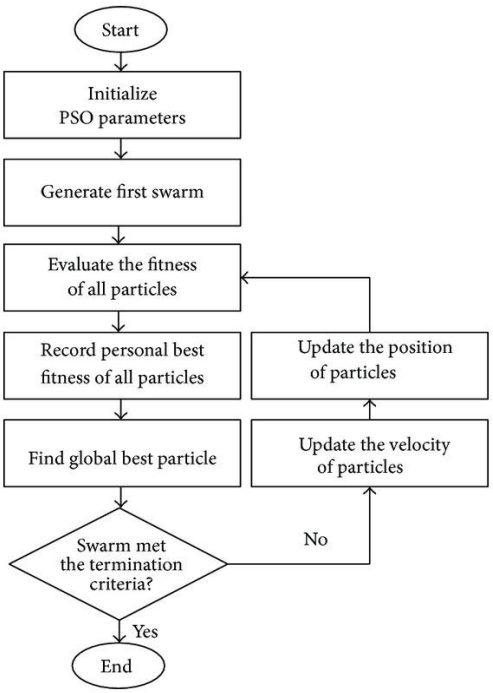

Fig. 2 Standard Flow chart of PSO [5]

Figure 2 [5] shows the standard flowchart of PSO. The program works in this way. First of all, individuals which are defined as random guesses are initialized. Individuals are considered as the particles, so the method is known as particle swarm. Value of the objective function for these individuals represents their positions. These positions are improved by iterative process. The location where they had their best success is remembered. The individual's best solution is called the particle best or the local best. This information of each particle is transferred to their neighbors. They can also observe where their neighbors have had success. The most effective solution among all the neighbors is called global best.

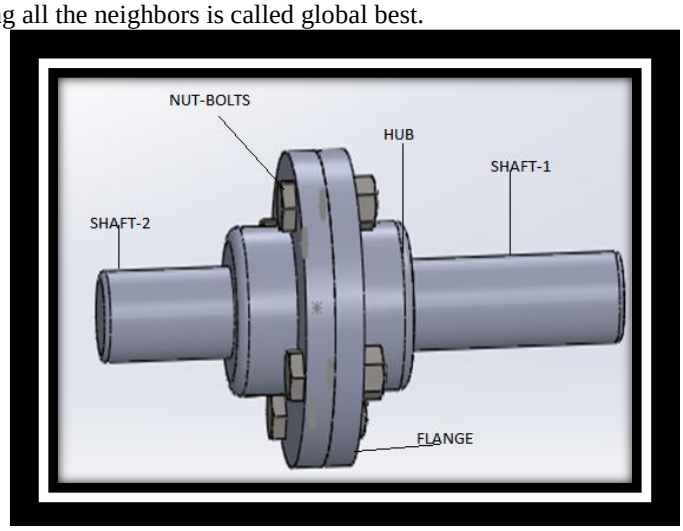

Fig. 3 Various Parts of Flange Connector

Figure 3 shows the various parts of flange connector. The objective function used to optimize the weight of flange connector is as follow:

Tensile Stress = $\frac{P}{nA_1}$ (1)

Crushing Stress = $\frac{P}{nA_2}$ (2)

where
P = Axial force on Flange Connector
N = Number of Bolts
A_1= Area of Bolt
A_2 = Area of Plate
Total Weight = Weight of Hub (W_1) + Weight of Flange (W_2) + Weight of Bolts (W_3)

$$=((\frac{\pi}{4}(D_1)^2-(D_0)^2)\times L_1\times\rho)+((\frac{\pi}{4}(D_2)^2-(D_1)^2)\times T_1\times\rho)+N((\frac{3\sqrt{3}}{2}(D_3)^2)\times L_2\times\rho) \quad (3)$$

where
D_0 = Diameter of shaft
D_1 = Diameter of Hub
D_2 = Diameter of Flange
D_3 = Diameter of Bolt
L_1 = Length of Hub
T_1 = Thickness of Flange
ρ = Density of Steel

Equations 1- 3 show the objective function of tensile stress, crushing stress and total weight of flange connector, respectively.

IV. RESULTS OBTAINED FROM MATLAB

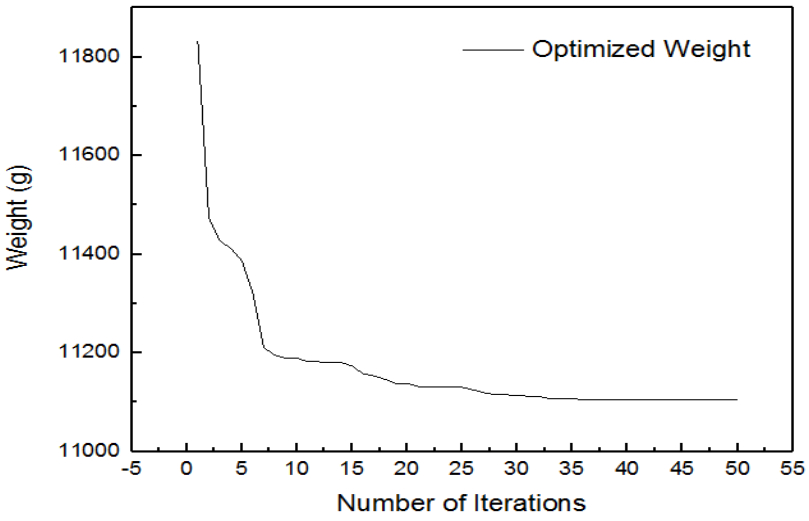

Fig. 4 Results from MATLAB

Figure 4 shows the graph of number of iterations performed Vs weight obtained in each iteration. Results obtained from MATLAB after optimizations are

D_1 = 45 mm
D_2 = 90 mm
D_3 = 14 mm
L_1 = 30 mm
T_1 = 9 mm
N = 5
Total Weight = 11.01 kg

V. MODELING AND ANALYSIS OF CONNECTOR

In present study, the theory adopted to calculate permissible stress is maximum shear stress theory which is shown in Equation 4.

$$\frac{1}{2}(\sigma_1 - \sigma_3) \geq \frac{1}{2}\sigma_y \quad (4)$$

where
σ_1= Maximum principal stress
σ_3= Minimum principal stress
σ_y= Maximum shear stress

Axial forces applied on connector for member is shown in Figures 5.

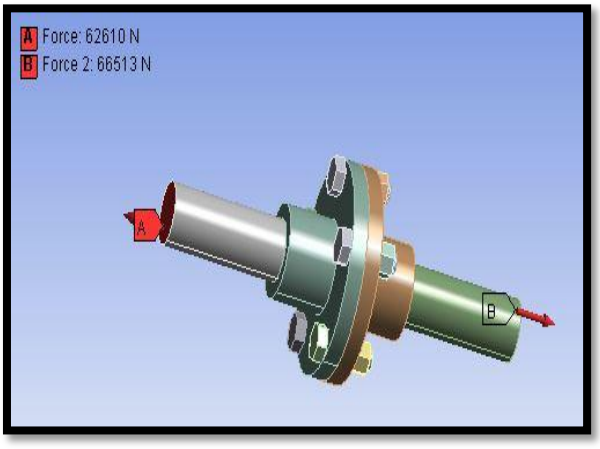

Fig. 5 Forces on Flange Connector

From the analysis carried out using ANSYS, the maximum principal stresses, minimum principal stresses and maximum shear stresses are shown in the Figures 6-8, respectively.

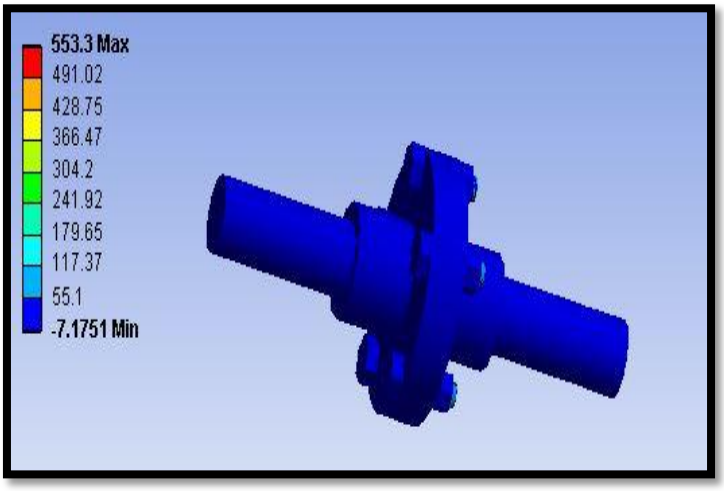

Fig. 6 Maximum Principal Stresses (N/mm^2) of flange connector

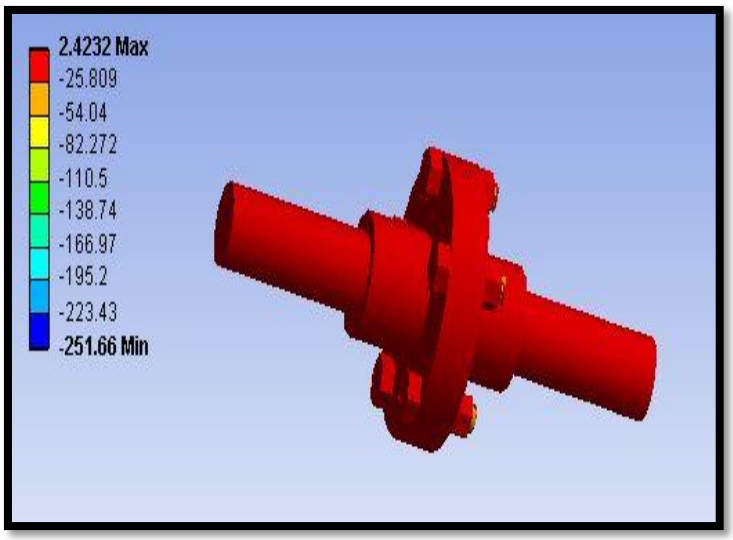

Fig. 7 Minimum Principal Stresses (N/mm^2) of flange connector

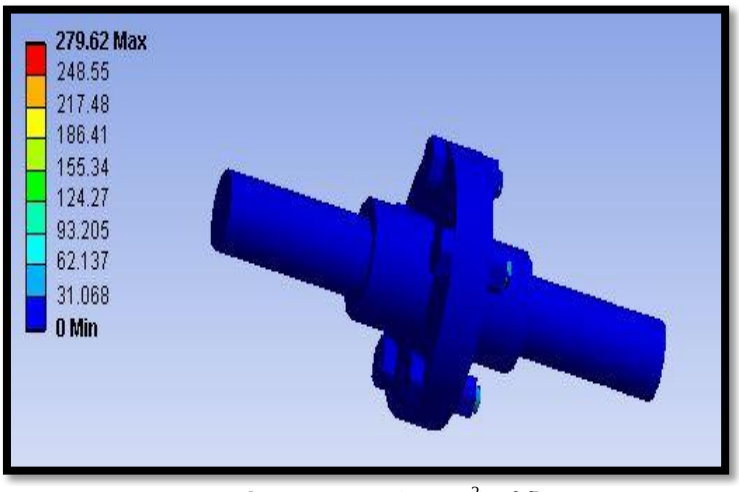

Fig. 8 Maximum Shear Stresses (N/mm^2) of flange connector

From the above results, it is observed that stress of connector is within permissible stress.

TABLE 1
COMPARISON OF WEIGHT

Connector	**Weight (kg)**
Flange Connector	16.39
Optimum Flange Connector	11.06
Percentage (%) of weight reduced in Optimum Flange Connector	32.51

TABLE 2
COMPARISON OF STRESSES

Connector	**Maximum Principal Stress (N/mm^2)**	**Minimum Principal Stress (N/mm^2)**	**Maximum Shear Stress (N/mm^2)**
Flange Connector	460.38	188.33	224.69
Optimum flange connector	553.3	251.66	279.62
Percentage (%) of stresses increased in optimum flange Connector	16.80	25.16	19.64

Tables 1 and 2 shows the comparison of weight and stress obtained between conventional flange connector and optimum flange connector. Values of weight and stresses of flange connector in Tables 1 and 2 are taken from Shah et al. [4].

VI. CONCLUSIONS

A constrained optimization of flange connector has been represented using particle swarm optimization. Hence, desired design of connector is obtained. From above study, the following conclusions are derived:

1) In optimum flange connector, reduction in weight of 32.51% is observed in comparison to normal flange connector.
2) For optimum flange connectors design, the maximum principal stress, minimum principal stress and maximum shear stress increase by 16.80, 25.16 and 19.64%, respectively.
3) Overall optimum design is more effective.

REFERENCES

[1] S. Singh and B. Bhusan,. "Finite Element Analysis and Weight Reduction of Flange coupling using CAE tools", 3(4), 2017, 197-202.
[2] C. Patil and A. Matilkali. "Design and analysis of Flange", Indian Journal of Engineering Research and application, 7(3), 2015, 89-93.
[3] M. Amrita and S. Jajimoggala "Design Optimization by using particle swarm optimization in MATLAB and apdl in ANSYS" International Journal of Science and Technology, 4(5), 2012, 1876-1855.
[4] P. Shah, V. Panchal and V. Shah. "Comparison of flange and Oldham connector for suspension transmission line tower", International Journal of Emerging Technology and Advanced Engineering, 7(12), 2017, 179-183.
[5] R. Kalatehjari and A. Rashid. "The Contribution of particle swarm optimization in three dimensional slope stability" The Scientific World, 2014, 2014, 1-12.