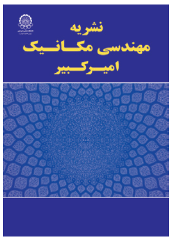

Amirkabir Journal of Mechanical Engineering

Amirkabir J. Mech. Eng., 50(4) (2018) 1-2
DOI:

Optimization of the Spot Weld Locations for Increasing the Joint Strength of the Welded Plates

D. Manafi, D. Akbari*

Mechanical Engineering Department, Tarbiat Modares University, Tehran, Iran

ABSTRACT: Resistance spot welding is one of the most common methods of joining especially in sheet metal assemblies. The number of spot welds and their pattern strongly affects the joint strength, time and costs. Therefore, a hybrid method of finite element and particle swarm optimization was introduced for determining the pattern of spot welds in this paper. At first, one spot weld joint was created on a sheet specimen, and mechanical properties of this joint were determined. The spot welding process of three cases was simulated and verified by three different experimental data. Particle swarm optimization and finite element method were linked to determine an optimum pattern of the spot weld joint. This method was utilized for two, three and four spot welds. According to this research, the fracture force of two, three, and four spot welds were 1.9, 2.13 and 2.76 times of one spot with the optimal pattern. The results indicate that the best pattern has four spots distributed on a circle with a radius of 18mm and the angle between the loading axis and symmetric axis was 66 degree.

Review History:

Received:
Revised:
Accepted:
Available Online:

Keywords:

Resistance spot welding
Spot welding pattern
Finite element method
Particle swarm optimization

1- Introduction

Resistance spot welding is one of the common methods for joining sheet metals. In this process, welding is produced from electrical current between electrodes in a short time. Also, pressure was needed to accomplish the spot welding process. The quality of spot welding depends on process parameters like the current, time, electrodes, and so on. It should be mentioned that the pattern of spot welds affect the joint strength, cost and time [1, 2].

Modeling of the spot welding process and studying of its parameters were performed in many types of research. However, determining the proper location of the spot welds with optimization methods wasn't investigated in researches. Therefore, in this paper, a hybrid method of the finite element and particle swarm optimization was introduced for determining the location of the spot welds in the sample plate joints.

2- Methodology

The main contribution is to determine the strength of a single spot weld using experimental data and to apply measured data to the comprehensive model. After it, a hybrid method of Finite Element (FE) and Particle Swarm Optimization (PSO) was used for determining the location of spot welds. The maximum error of FE was calculated as 1.45% by comparing with 3 different experimental data expressed in (Table 1 and Fig. 1). The verified FE model is linked to the PSO for determining the optimal location of welds. It should be mentioned that FE or experimental results are the fracture force of n-spot welding to the fracture force of one spot welding in Table 1.

*Corresponding author E-mail: **daakbari@modares.ac.ir**

Table 1. FE and experimental data

Number of spots	FE results (Strength ratio)	Experimental (Strength ratio)	Error %
1	1	1	0
2	1.63	1.61	1.45
3	2.1	2.07	1.45
4	2.07	2.05	0.81

The effect of the spot weld location on the fracture force is shown in Fig. 2. According to this figure, the ratios of fracture force were different when the location of the spot welds was changed from the vertical state to the horizontal state.

Spot welds were distributed on a circle with a radius of r according to Fig. 3. The Cartesian coordinate of spot welding was calculated with Eq. (1). So, variations of the optimization process were radius (r) and angle (α) based on Eq.(1). Fracture force of n-spot welding to the fracture force of one spot weld was the object function that this ratio must be maximized.

$$P_{i,x'y'} = r < \cos(\alpha + \frac{(i-1)2\pi}{n}), \sin(\alpha + \frac{(i-1)2\pi}{n}) > \quad (1)$$

(a) (b)

Fig. 1. Experimental tests, (a) two spot welds (b) three spot welds

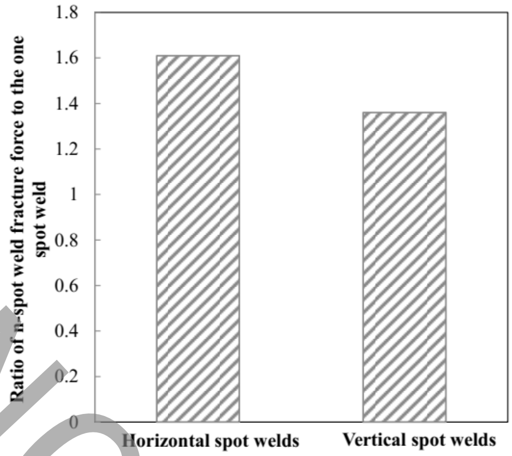

Fig. 2. Effect of the location spot weld on the fracture force

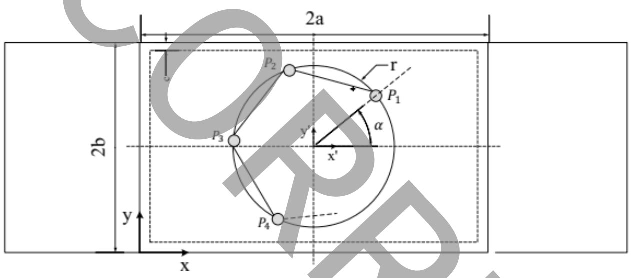

Fig. 3. Distribution of spot welds

In the hybrid of FE and PSO, radius and angle variables were determined based on particle swarm optimization rules for each particle. Then, the coordinate of spots will be calculated according to Eq. (1). FE model of spot weld was recalled and the position of spots was updated. After updating spots position, fracture force was obtained from the FE model. Then the object function of each particle was calculated based on this fracture force. This process was continued until convergence condition was satisfied. Radius and angle variables can be changed between [d, a-c] and [0, π/2] respectively.

3- Results and Discussion

The proposed method was utilized for determining the optimal pattern of n-spot welds, and particles size was 10 in this method. In Fig. 4, the convergence plot is shown for two spots weld. The vibrations show that a little change in pattern has effect on object function because particles are near to each other.

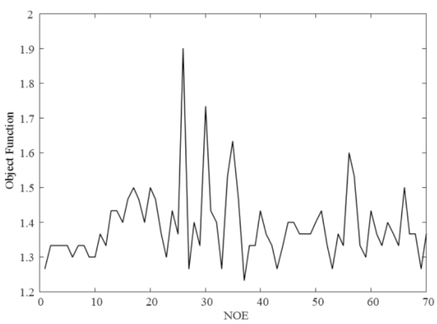

Fig. 4. Convergence plots 2 spots welding

Object function was shown based on the radius and the angle in Fig. 5 for two spot welds. This figure was plotted according to all patterns that were evaluated in the optimization process. According to this figure, object function does not have a linear relation with radius and angle (pattern). This relation probably becomes complex for larger parts. Therefore, this matter shows that the proposed method has great potential for determining the patterns of n-spot welds.

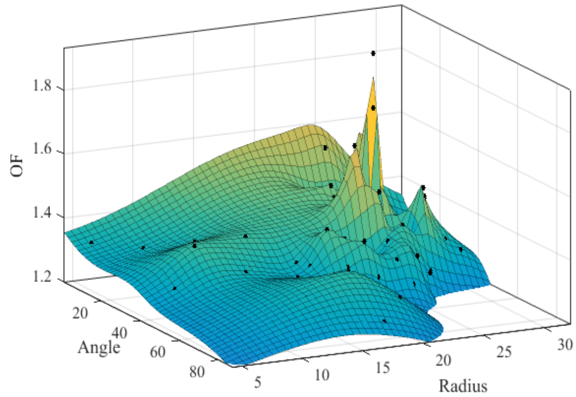

Fig. 5. Object function vs radius and angle

Optimal patterns for spot welding were shown in Fig. 6. Object function was 1.90, 2.13 and 2.76 for two, three, and four spot welds, respectively.

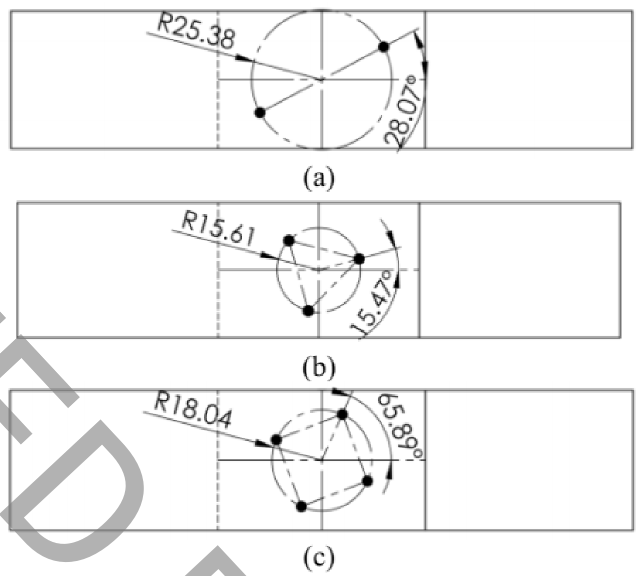

Fig. 6. Optimal location (a) 2 spots welding (b) 3 spots welding (c) 4 spots welding

4- Conclusion

A hybrid method of finite element and particle swarm optimization was introduced to optimize the location of two, three, and four spot welds. Results show that the fracture force of n-spot welds became 1.9, 2.133, and 2.76 times of one spot with an optimal pattern. Also it is shown that the spot locations do not have a linear relation to the object function. Results indicate a beneficial method for determining the location of spot welds.

References

[1] Salvini, P., Vivio, F. and Vullo, V., 2000. "A spot weld finite element for structural modeling". International Journal of Fatigue, 22(8), pp. 645-656.

[2] Aslanlar, S., Ogur, A., Ozsarac, U., & Ilhan, E., 2008. "Welding time effect on mechanical properties of automotive sheets in electrical resistance spot welding". Materials & Design, 29(7), pp. 1427-1431.