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Improving Deposition Quality of Stellite Powder on Valve Seats by Optimized TIG Welding Parameters

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Abstract: The quality of the Stellite powder coated on these valve seats depends on the discharge profile and is crucial to the service length and quality of these seats, especially when called upon to work at their maximum capabilities. This research seeks to work out how to minimize blow holes in the TIG welding process when depositing Stellite powder while maintaining other desirable qualities of the weld. In this respect, the work uses the OVAT technique and Taguchi design approach to analyze the effect of the major welding parameters, such as weld speed, feed rate and welding current, on the formation of blow holes. The research shows that it is possible to gain a remarkable increase in weld quality when the parameters mentioned are strictly controlled. In this systematic experimentation, the optimal welding condition found out was the welding speed of 6.5 rpm, feed rate of 120 mm/min, and welding current of 150A. With this combination, these parameters were determined to reduce the chances of blow-holes forming and increase the welds' quality and durability. With respect to the study objectives, the present investigation offers a clear direction to enhance TIG welding of valve seats with special reference to minimize the defects. Analysis done in the study shows that the welding parameters have the greatest impact in reducing the blow holes; the feed rate is 56.61%, weld speed is 22.28% and welding current is 20.17%. The results enhance weld quality, offering rules for eradicating imperfections in the TIG welding of valve seats, which is crucial for high-performance sectors.

Introduction

Engine valve seats are components used in internal combustion engines. Thus, they should exhibit excellent wear resistance and hardness as the product is usually under high stress and high temperatures during functioning (Mascarenhas et al., 2015). An example of this kind of alloy is Stellite cobalt-chromium-tungsten, which is most frequently used to deposit on valve seats due to its resistance to extreme hardness, corrosion, and high temperature. However, an issue arises when depositing Stellite powder on valve seats using welding processes, which easily increases defects such as blow holes (Selvi et al., 2008)

Blow holes are cavities that form due to the formation of gases when the weld pool solidifies, obstructing the quality of the weld and the service of the component. Adjusting the welding variables is unavoidable to minimize the chances of developing blow holes and thus obtain a quality Stellite layer on the valve seats (Bansod et al., 2023). This research aims to establish the effect of selected TIG welding parameters such as weld speed, welding feed rate, and welding current on the development of blow holes when applying Stellite powder on valve seats (Bharath et al., 2008). The conclusions reached will be useful in determining ways of enhancing the welding process to increase the deposition quality and the general performance of Stellite-coated valve seats (Smoqi et al., 2021).

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It is essential to produce valves with high deposition quality of Stellite powder on valve seats to achieve valves with high wear and tear application performance. Valve seats or the interfaces that do the sealing between the valve and the seat, are chosen for engines and a number of general applications; these are subjected to various usage conditions including high temperature, pressure, and corrosive usage. It is specially declared that cobalt-chromium alloy Stellite has satisfactory wear tendencies and hardness degree, and these qualities do not seize at high temperatures. However, a great difficulty which may hinder the coating of a defect-free Stellite powder on the valve seats is the formation of blow holes while undergoing TIG welding (Ding et al., 2017).

Blow holes, or porosity, is a Weld Defect that indicates small holes or cavities in the weld metal, significantly reducing the welded joint's capabilities and durability. The other common signs of blow holes include a wrong weld setting on parameters such as speed of welds, feeding rate, and welding current. Therefore, the indicants of these parameters are significant in improving the quality of the Stellite deposits and the life span of the valve seats.

The implementation of the Taguchi method of design using robust statistics for a process has been recommended and given a lot of consideration due to its success in identifying the optimal parameters of the process (Li et al., 2006). Taguchi's method uses orthogonal arrays in planning the experiments, which makes it possible to have a very large number of trials while at the same time ensuring that the level of accuracy of the experiment is not compromised. In addition to obtaining the optimum value of process variables, one is also able in this procedure to establish how these variables influence one another and are important in deciding the quality of the welds made (Vora et al., 2021).

The objective of this study is to analyze, avoid and minimize the formation of blow holes so that the deposition quality of Stellite powder on valve seats can be enhanced by comparing various TIG welding characteristics, including weld speed, feed rate, and current intensity (Das et al., 2017). This research will use OVAT analysis together with Taguchi's design strategy to establish the parameter levels that offer enhanced weld quality. The study will address weld quality problems and suggest how to improve Stellite deposition in industrial practices (Prakash et al., 2024).

Optimizing the deposition of Stellite powder on valve seats remains of prudent importance since the improvement of material properties is vital, especially in applications where aggressive stress is prevalent, such as in automobiles and aerospace technology. Reducing blow holes by influencing TIG welding parameters enhances wear, corrosive and heat resilience, improving the service lifespan of valve seats (Cheemalapati et al., 2023).

Experimentation

Design of Experiment

There are numerous methods for optimizing a process, product, or operation. The curing process can be optimized by using a variety of strategies. To obtain statistically significant results, it is occasionally necessary to combine multiple methodologies, which might result in more insightful conclusions and suggestions. Build Test Fix (BTF), Design of Experiment (DOE), and One Variable at a Time (OVAT) are a few widely used techniques in the development of processes or products; BTF is a very antiquated and disorganized methodology. The process of creating a procedure that focuses on improving from the previous experiment is done iteratively (Sahu and Andhare, 2018).

Because it changes several factors at once, DOE is an extremely effective way to examine the impact of parameters. A greater number of novel combinations are needed when more parameters are examined (Durakovic, 2017). DOE depends more on statistical data and is unable to manage specific factors. With the one variable at a time (OVAT) technique, changes are made to one variable at a time while maintaining the same values for the other parameters until the impact of that one parameter is examined (Telford and Uy, 2009).

This approach is incredibly accurate for examining the impact of every parameter at various scales. The three main factors influencing TIG welding were found to be air flow rate, cycle time, and cycle time. The Taguchi approach has been applied to optimize the process parameters in light of the observation. An OVAT analysis was carried out to determine the effective range of parameters for the optimization study. The L9 orthogonal array (OA) has been chosen among the available designs. Below is the standard notation for OA. OA = Ln (Xm).

Where X is the number of levels, m is the number of parameters being studied and n is the number of experiments. From the designs that are accessible for the three levels and three parameters, the OA that requires the fewest experiments to conduct (L9) has been chosen. ANOVA was used to determine how each variable contributed to the final result. Minitab software has been used for analysis (Srivastava et al., 2008).

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Experimental Machine Selection

All the experiments were conducted at Durovalve India Pvt. Ltd. F-57-58, MIDC, Waluj, Aurangabad and Maharashtra-431133.

Figure 1. Tungsten Inert Gas (TIG) welding setup Machine.

Material and Method

Material

Cobalt is the foundation of the alloy known as Stellite 12. In terms of characteristics, it is in the middle of Stellite 6 and 12. It is more resistant to abrasion and low-angle erosion because of its larger concentration of extremely hard carbides (8%) compared to Stellite 6 (4.25%) (Sigmund, 2021).

Because of its increased tungsten content, stellite has greater high-temperature strength and can withstand temperatures of up to 700°C. Because it can withstand both abrasion and corrosion at high temperatures, stellite is frequently used as a cutting tool for carpets, plastics, paper, and wood. The same qualities make it beneficial for industrial mold plungers, pumps, and valve components (Sawant and Jain, 2017).

Methods

Setup phase: Before starting the main experiments, set up the welding equipment and follow the specifications given by the Taguchi L9 array to supply the standardised test materials, for instance, the Stellite powder for deposition in order to maintain consistent parameters across the experiments(Dzukey and Yang, 2019). Execution phase: Each trial is an execution of the experimental run as specified by the L9 orthogonal array deposit of the Stellite powder on valve seats by the TIG welding method, recording the value of the blow holes rate of each experimental run (Chang et al., 2008)

Analysis phase: Use statistical methods to make an analysis of results to identify the main effects and interaction of the welding parameters and make Analysis of Variance (ANOVA) to identify the significance and contribution of the parameter to blow hole formation (Prasad et al., 2011)

OVAT and Taguchi's methods were selected because both correlate with minimal blow holes in TIG welded structures. OVAT technology also enabled the direct assessment of such parameters as weld speed, feed rate, and current. The Taguchi method is cheaper and more efficient to apply since it only requires a minimum of experiments, fitting the bill of an ideal method for

Table 1. Chemical Composition and Physical Properties.

Co	Cr	W	C	Others	Hardness	Density	Melting Range
Base	27-32	7.5-9.5	1.4-2.0	Ni, Fe, Si, Mn	45-51 HRC 435-590 HV	8.53 g/cm3 0.308 lb/in3	1225-1280ºC 2240-2335ºF

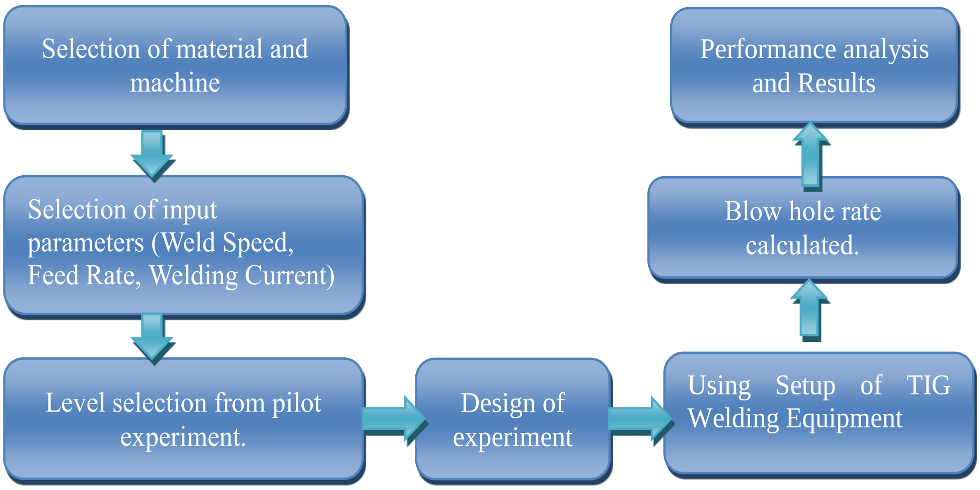

Figure 2. Experimental Procedure flow chart.

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optimizing many parameters (John et al., 2024). These practical benefits of the Taguchi approach over methods such as Response Surface Methodology (RSM) include fewer experiments needed to consider interactions and process variation, which is a cheaper way to increase weld quality (Jain et al., 2024).

easy and uncomplicated method that may be utilized to rapidly find the most relevant aspects (Ilie et al., 2018).

Selection of values

The machine's technical guidelines are used to determine the basic criteria. These criteria are utilised to select the levels of factors for the Tungsten Inert Gas (TIG) welding of various parameters (Tiwari et al., 2014).

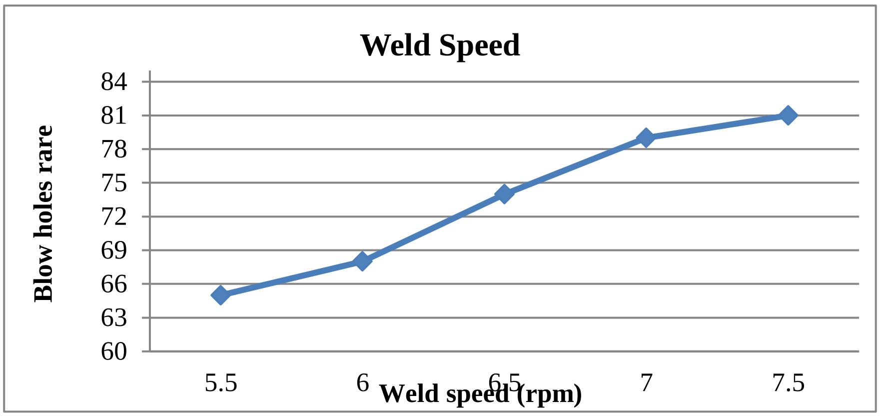

Figure 3. Blow holes rate Vs Weld speed.

Table 2. OVAT for weld speed.

Sr. No.	Weld Speed (rpm)	Feed Rate (mm/min)	Welding Current (A)	Blow Holes (No's)
1	5.5	100	130	65
2	6.0	100	130	68
3	6.5	100	130	74
4	7.0	100	130	79
5	7.5	100	130	81

Method Experimental procedure an outline

OVAT Analyses

One variable at a time, in this analysis, a range of values is taken into consideration in order to determine the true range of the variables in which the desired or optimized value may be discovered. The OVAT study considers the feed, current, speed, and all other parameters, all of which are held constant, and checks the number of blow holes, out of which one thousand are found (Paes et al., 2017).

The one-variable-at-a-time analysis, also known as OVAT analysis, is a statistical method utilized to determine the most significant parameters that impact a specified process or system. The OVAT analysis is an

Weld Speed (rpm): 5.5, 6.0, 6.5, 7.0, 7.5

Feed Rate (mm/min): 100, 110, 120, 130, 140

Welding Current (A): 130, 140, 150, 160, 170

Effect of weld speed on blow holes.

Variation in Blow hole rate with change weld speed is shown in graph 1.

The feed rate and welding current are kept constant, and the weld speed varies from 5.5 rpm to 7.5 rpm. From Graph 1, it has been observed that as weld speed increases with increasing blow hole rates, it also has been observed that the most affected areas and the rate of change in blow hole rates are higher in the region of 6 to 7 rpm. Hence, this level of factor was selected.

Table 3. OVAT for feed rate.

Sr. No.	Feed Rate (mm/min)	Weld Speed (rpm)	Welding Current (A)	Blow Holes (No's)
1	100	5.5	130	65
2	110	5.5	130	75
3	120	5.5	130	82
4	130	5.5	130	85
5	140	5.5	130	86

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Justification: Moreover, according to OVAT analysis, the welding speed produces more blow holes for faster weld pool solidification and excluding the gas. Furthermore, if the speed is high, heat input decreases, resulting in inadequate fused layers and higher formation of defects.

Effect of feed rate on blow holes.

Variation in Blow hole rate with change in feed rate is shown in graph 2.

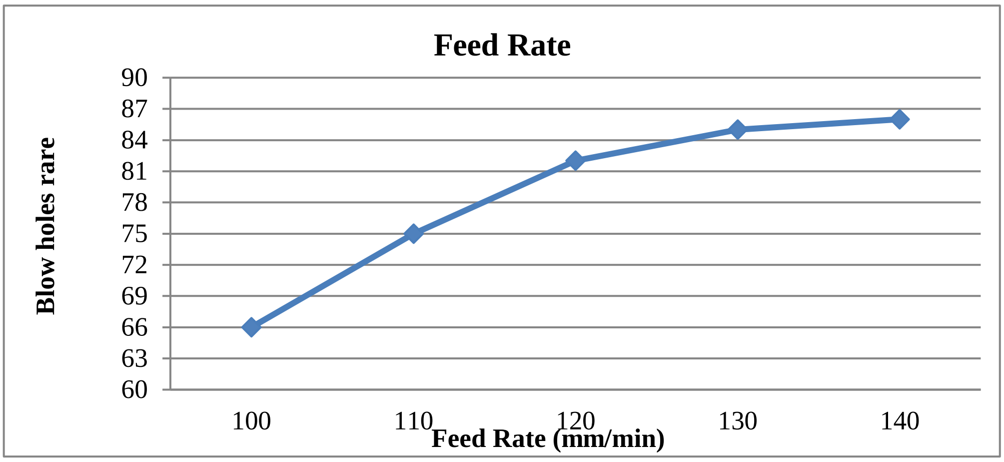

Figure 4. Blow hole rate Vs feed rate.

As the feed rate changed from 100 to 140 mm/min, the weld speed and welding current were maintained at the same levels. Graph 2 shows that as the feed rate increases from 100 to 140 mm/min, the blow hole rate likewise increases. Additionally, it has been noticed that the most affected area and the rate of change of the blow holes rate is greater in the region of 100 to 120 mm/min. Hence, this level of factor has been selected

Justification: In OVAT analysis, an increase in the feed rate produces a high incidence of blow holes because feeding at high rates places a large volume of material in the weld pool, which may not melt and fuse properly. This excess material can seal off the gaseous products, possibly forming within the metal-forming body and causing blow holes. Moreover, an increase in feed rate is said to affect the stability of the weld pool and thus create an environment conducive to defect formations.

Effect of welding current on blow holes.

Table 4. OVAT for welding current

Sr. No.	Welding Current (A)	Weld Speed (rpm)	Feed Rate (mm/min)	Blow Holes (No's)
1	130	5.5	100	65
2	140	5.5	100	63
3	150	5.5	100	57
4	160	5.5	100	54
5	170	5.5	100	55

Variation in Blow hole rate with change in welding current is shown in graph 3.

Feed Rate and weld speed are kept constant and welding current varies from 130 to 170 A. From Graph 3, it has been observed that as welding current increases with increasing blow hole rate, it also has been observed that the most affected area and the rate of change of blow hole rate is higher in the region of 140 to 160 A. Hence, this level of factor has been selected.

Justification: In OVAT analysis, welding current high increases blow holes because it offers the heat required to melt and fuse the material. This leads to an enhanced answer key and fixed weld pool, giving an adequate area for the gas to discharge and minimizing the gas trap issue. However, other bearings showed that a high current leads to overheating and other defects, but in the tested range, the effect of higher current was to minimize blow holes.

Selections of Levels

Results and discussion

Using a statistical method, experiments are conducted effectively. The Taguchi design approach is a statistical technique that yields precise conclusions:

The main purpose of the optimization approach is to:

1. To reduce the amount of Experiments conducted.
2. The influence of a greater number of input variables and their levels may be examined.
3. The optimal amounts of variables may be determined.
4. Residual error can be carried out.

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Table 5. Selections of Levels.

Sr. No	Level 1	Level 2	Level 3
Weld Speed (rpm)	6.0	6.5	7.0
Feed Rate (mm/min)	100	110	120
Welding Current (A):	140	150	160

L9 Orthogonal Array

As a result of its effective and successful design of Experimentation, which reduces the overall number of trials by gathering data, Taguchi is the optimisation strategy that is utilised the most frequently in the Engineering Design industry (Application of Design of Experiments (DOE) using Dr. Taguchi Orthogon., 2014).

Because there are three levels for each parameter, there are a total of three levels. In light of this, the Taguchi L9 orthogonal array is utilised. The findings of the experiments that were carried out after the blow hole rate was determined using Taguchi's L9 orthogonal array are presented in the table under consideration (Lee et al., 2017).

For instance, if it performs an experiment to examine the effect of thirteen different independent variables, each of which has three stated levels, an orthogonal L9 matrix might be the ideal option for it to go with. It is recommended that the L9 OA consider the influence of thirteen independent components, each of which could have three-factor values. Although the assumption of the interaction model is not valid in many instances and there is evidence of interaction, this table gives the impression that there is no interaction between the two parts (Vallejo et al., 2008).

In this investigation, each of the three components, namely, feed, speed and current, is given three levels, and an orthogonal L9 matrix is utilised to carry out the simulations. There is still no content in the fifth column. The orthogonal L9 network was created by utilising the Minitab programme, with the input variables and their respective levels being provided.

Experimental result for blow holes rate

The L9 orthogonal array with repeat measurement of responses for runs one through nine is displayed in Table 6. Minitab software's saturation design flaw is fixed by repeatedly using the response measuring approach. Additionally, it demonstrates that the SN ratios for runs one and ten match the values determined for the repeated measurement. The signal-to-noise ratio values are computed using Minitab software. One can use the S/N ratio to assess how different input parameters affect the

Table 6. Standards L9 Orthogonal Array.

Sr. No	Weld Speed (rpm)	Feed Rate (mm/min)	Welding Current (A)
1	6.0	100	140
2	6.0	110	150
3	6.0	120	160
4	6.5	100	150
5	6.5	110	160
6	6.5	120	140
7	7.0	100	160
8	7.0	110	140
9	7.0	120	150

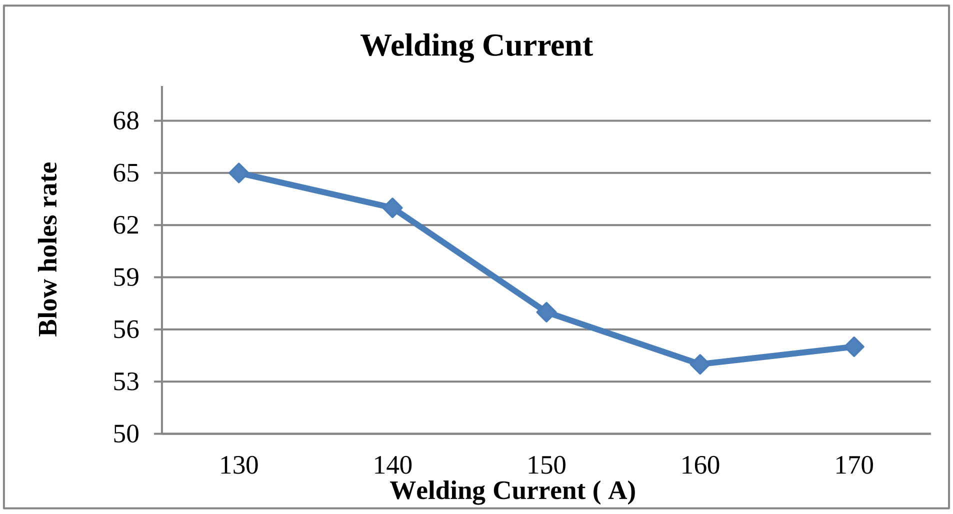

Figure 5. Blow hole rate Vs welding current.

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blow hole rate. A higher S/N ratio indicates an impact of the factor on the blow hole rate (Ragavendran et al., 2019).

Finally, since the principal aim of this work was mainly focused on interpreting the actual effects of the input factors, statistical tools such as the Analysis of Variance (ANOVA) could be employed to set out the pertinent outcomes. Other uses of the data include Developing a model that will predict the rate at which blow holes will occur given the elements that are fed into the model.

utilized throughout the experimental testing. The full SN ratio values represent the SN ratio for the initial test. From the graph, it can be seen that the optimal blow hole rate occurred around the top of the response curve. The optimal input parameters were 6.5 rpm welding speed (level 2), 120mm/min feed rate (level 3), and 150A welding current (level 2).

The graph illustrates the impact of control parameters on valve material. The arrangement of process parameters with the greatest ratio consistently yields the best quality with the least amount of variance. The graph demonstrates how the connection changed as the configuration of the control factor was altered from one level to another.

Table 7. Cumulative data for SN Ratio blow holes rate.

Experiments	Input Factors			Output Responses	
Trial No.	Weld Speed (rpm)	Feed Rate (mm/min)	Welding Current (A)	Blow Holes Rate (No's)	S/N Ratio
1	6.0	100	140	66	-36.3909
2	6.0	110	150	56	-34.9638
3	6.0	120	160	60	-35.5630
4	6.5	100	150	61	-35.7066
5	6.5	110	160	60	-35.5630
6	6.5	120	140	53	-34.4855
7	7.0	100	160	73	-37.2665
8	7.0	110	140	62	-35.8478
9	7.0	120	150	58	-35.2686

Main Effects of Blow holes rate

The S/N ratio response table, which shows the S/N ratio at each level of the control factor, was used to analyze the impact of each control variable (feed, current, and speed) on the blow hole rate. A greater SN ratio with better characteristics that MINITAB determined was

These Taguchi findings are in good accord with the regression analysis. The regression analysis using

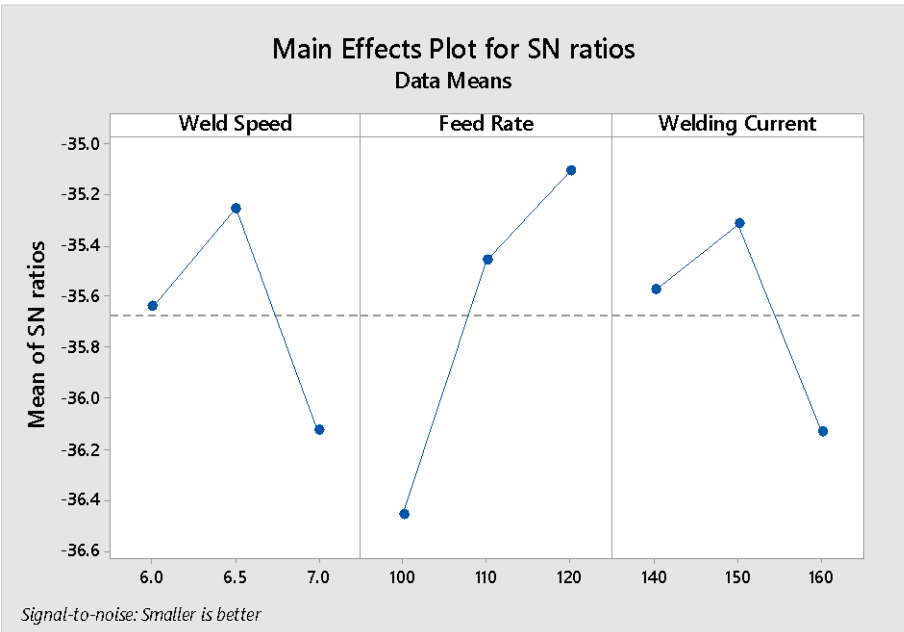

Figure 6. Main effect plots for mean of SN ratio mean of blow holes rate.

Minitab statistical software predicts the ideal amount of observed response based on the principal effect diagrams for factors such as current, speed and feed. A signal-to-noise ratio called the SN ratio lets it see how different inputs change the output reaction. What comes out is the blow holes rate on the material in this case.

Analysis of Variance

Analysis Of Variance is the statistical method employed in this study (ANOVA). ANOVA was used to identify statistically significant machine parameters and the percentage contribution of these parameters to the blow holes rate. ANOVA is a statistical method used in a variety of ways to construct and validate hypotheses for observed data.

Feed Rate (56.61%): The highest contribution, showing it has the most significant impact on reducing blow holes, emphasizing its critical role in weld quality.

Welding Current (20.17%): This shows a significant but lesser effect on blow hole occurrence compared to feed rate and weld speed.

- **S:** This value refer to the standard error of the estimation. It tests the mean squared error of the predicted from the actual values. When substituted with the appropriate label value, S equals 0. 1544, clearly showing that the predicted values are nearly comparable with the actual values.
- **R-Sq:** This gives the coefficient of determination, which refers to the extent of variance in the dependent variable (blow holes rate) that can be accounted for by the independent variables (speed, feed and current). R-Sq, in this case, is 99. 08%. This means that 99. Therefore, the model manages to predict only 08 % of the variation of blow hole rate among the cars in the market.
- **R-Sq(adj):** This is the adjusted coefficient of determination, which is the coefficient of determination, but given as a higher number to punish the model for adding more unnecessary parameters. It offers a better assessment of the model's performance when a new set of data is fed into the model. In this case, R-Sq(adj) is 96 percent higher compared to the initial prediction of 50 percent & 32%. This is very high, implying that the model does a very good job determining the blow-hole rate.

Table 8. ANOVA Result of Blow holes rate.

Source	DoF	Adj SS	Adj MS	F-Value	P-Value	% Contribution
Weld Speed	2	1.15590	0.57795	24.24	0.040	22.28
Feed Rate	2	2.93680	1.46840	61.59	0.016	56.61
Welding Current	2	1.04666	0.52333	21.95	0.044	20.17
Residual Error	2	0.04769	0.02384			
Total	8	5.18705				

The table shows the ANOVA for valve material. The table demonstrates that the Weld Speed (22.28%), Feed rate (56.61%), and welding current (20.17%) have a significant impact on the blow hole rate. Analysis of variance is used to assess the models' significance (ANOVA). This statistical technique is employed in trials when numerous variables are assessed simultaneously to test the null hypothesis. The Fisher (F) test in ANOVA is used to analyse the experiment's variances quickly. The ANOVA analysis's result is shown in the table. The finding that P is less than 0.05 for each of the three parametric sources is made possible by the ANOVA analysis (Sharma et al., 2024).

Thus, it is clear that the nylon66 material is affected by (1) Weld Speed, (2) Feed Rate, and (3) welding current. The degree of influence that each factor has on the outcome is shown by the proportion of its contribution to the total variance in the final column of the cumulative ANOVA table.

The percentage contributions in the ANOVA table were calculated by dividing each factor's adjusted sum of squares (Adj SS) by the total adjusted sum of squares (Total Adj SS) and multiplying by 100.

Weld Speed (22.28%): Indicates a moderate influence on blow hole formation, accounting for about 22.28% of the variability.

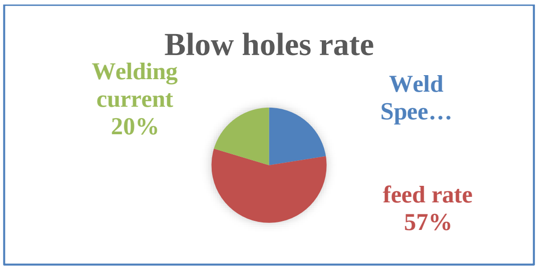

Figure 7. Percentage Contribution of blow holes rate by input parameters.

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Table 9. Model Summary.

S	R-Sq	R-Sq(adj)
0.1544	99.08%	96.32%

Multiple Linear Regression Models

To determine the relationships between (1) the Weld Speed, (2) the feed rate, and (3) the welding current for engine valve deposit material, the statistical software "Minitab" was developed using the multiple linear regression model. Statistically significant terms are included in the model. The final calculated equation is as follows.

Using Minitab software, mathematical models of speed, feed and current computed, and regression analysis is used to determine the expected value of blow holes rate

Regression Equation

Blow Holes = 60.0 + 4.0 [Weld Speed]- 0.50 [Feed Rate] + 0.20 [Welding Current]

Substituting the recorded values of the variables into the preceding equations, it can be shown from regression analysis that Equation has a greater impact on the blow holes rate attempt has been made to keep noise levels consistent during the trial.

Because of this, the number of blow holes increases for the first sample and decreases for the ninth sample. Experiments numbered 1 through 9 comprise the Taguchi design L9 array; each experiment contains a unique mix of parameter levels and various parameter levels. Using a confirmation test, the predicted S/N ratio values were analysed. Table displays the experimental and expected values. As the difference between the experimental and projected values is less than 10%, the experimental work is considered satisfactory (Bradley et al., 1999).

Confirmation Test for blow holes rate

Table 10 compares blow hole rate findings derived from the mathematical model created in the current study with empirically determined values. By comparing the results of values produced from the blow holes rate equation with the confirmation test results, we have determined that the confirmation test validates the equation for values not present in the orthogonal array. Thus, the above-mentioned multiple regression equation

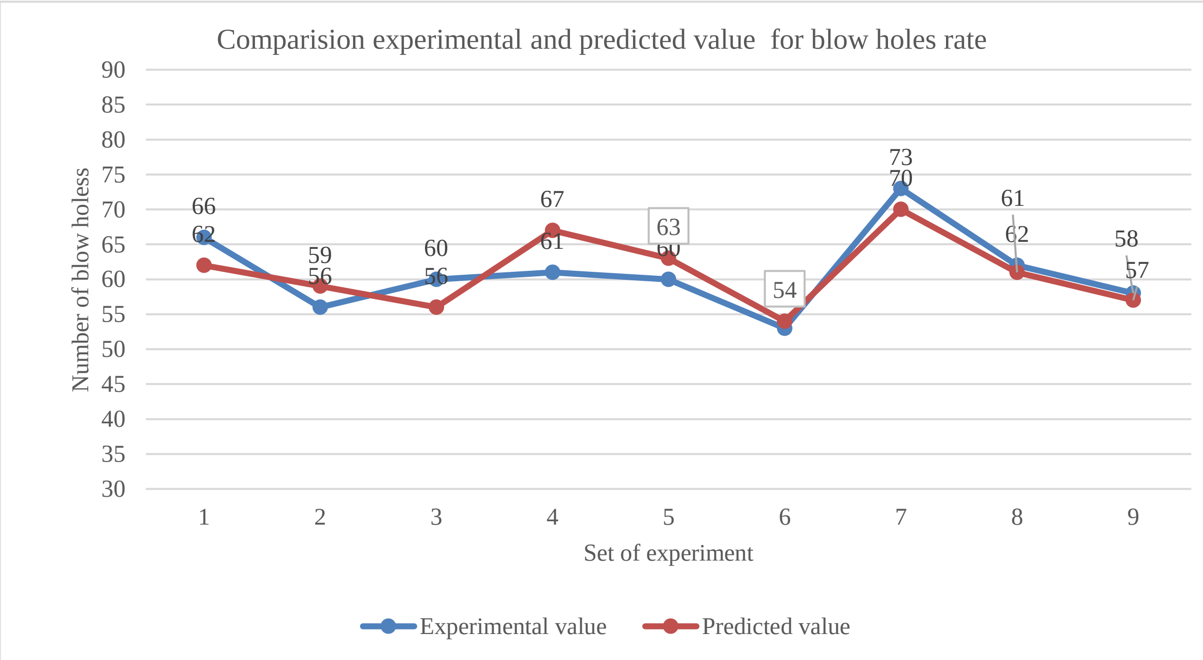

Figure 8. Experimental Vs Predicted blow holes rate.

Comparison of Experimental and Mathematical Analysis of blow holes rate

Taguchi design and ANOVA provide a remarkably exact mathematical model for predicting results. This may be because the parameter level in this project has a very narrow range. In addition, every relates the composite's assessment of blow hole rate to the degree of approximation.

An experiment was conducted on Weld Speed at level 2, Feed rate at level 3 and Welding Current at level 2.

Valid agreement: A small error percentage (<10%) indicates a good agreement between the model prediction

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and the experimental value. In this case, the error percentage of 7.17% is well within acceptable limits.

Table 10. Comparison of Experimental and Predicted blow holes rate.

Sr. No.	Experimental value	Predicted value	Error %
1	66	62	6.54
2	56	59	5.08
3	60	56	7.01
4	61	67	8.95
5	60	63	4.76
6	53	54	0.30
7	73	70	4.28
8	62	61	1.63
9	58	57	1.75

Table 11. Optimum level of parameters.

Sr. No.	Parameter	Optimum level
1	Weld Speed (Level 2)	6.5 rpm
2	Feed rate (Level 3)	120 mm/min
3	Welding Current (Level 2)	150 A

Table 12. Confirmation experiment result.

Parameter	Predicted value	Experimental value	Error %
Blow holes rate	56	52	7.17

There are certain limitations and different interpretations regarding the study. The conclusions are limited to Stellite powder coating; the effect of interaction between the different welding parameters is not fully investigated. There were limitations with internal validity, such as environmental influences and differences in equipment were not controlled and may affect reliability; the sample size may be insufficient to secure reliable generalization. Other welding processes like MIG or laser welding might have different outcomes, and the Stellite powder's characteristics also play an essential role in the weld's quality. It could also be seen that all the optimal welding parameters that were noted here could be different based on the specific welding situation, which further calls for further study. Finally, the fatigue characteristics and reliability of the investigated welded connections under working loads should be studied further.

Conclusions

Based on the analysis and experimentation, the following conclusions can be drawn regarding the effect of welding parameters on blow holes in seat deposit engine valves:

- The proposed control strategies for obtaining the least blow holes in this work entail a slow weld speed, a high feed rate, and a moderate welding current. Namely, the weld speed should not exceed the value of 6. Owing to blow holes if the cutting speed was 0 rpm, feed rate 120 mm/min and welding current 150A.
- The statistical analysis, including the ANOVA, confirmed that feed rate is the most significant factor, followed by weld speed and welding current.
- ANOVA results indicate that feed rate plays a prominent role in determining the blow hole rate. The contribution of weld speed, feed rate and welding speed to the quality characteristics of blow holes is 22.28%, 56.61% and 20.17%, respectively.
- The model summary indicates high predictive accuracy with an R-Sq(adj) value of 96.32%, suggesting that the regression model effectively predicts blow-hole rates based on the input parameters.

Future Scope

In future one may conduct the same work in following different ways,

- Experimentation can be carried out on different material with different input parameters combinations.
- Mixed optimization can be also done.
- The different methodology of analysis and also for optimization can be use.
- In future, an attempt will be made to understand the microstructures through microscopic analysis.
- In the present study, the Taguchi method was used for the optimization of process parameters; one may use other techniques for the same experimental data.

Authors' Contribution

Ravindra L. Karwande planned, conducted the experiments, analyzed the data, conceptualization, methodology and investigation and wrote the original draft and Dr. Ashok J. Keche, was involved in the review and editing of the manuscript and Dr. Santosh P. Bhosle supervised, reviewed and finally approved the manuscript.

Conflicts of Interest

The authors declare no conflicts of interest about the publication of this research paper.

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References

B., Prakash, D., & Dhemla, P. (2024). Assessment of Cement Mortar Strength Mixed with Waste Copper Mine Tailings (CT) by Applying Gradient Boosting Regressor and Grid Search Optimization Machine Learning Approach. *International Journal of Experimental Research and Review, 42*, 183–198. https://doi.org/10.52756/ijerr.2024.v42.016

Bansod, A., Shukla, S., Gahiga, G., & Verma, J. (2023). Influence of filler wire on metallurgical, mechanical, and corrosion behaviour of 430 ferritic stainless steel using a fusion welding process. *Materials Research Express, 10*(3), 036513. https://doi.org/10.1088/2053-1591/acb908

Bharath, R. R., Ramanathan, R., Sundararajan, B., & Srinivasan, P. B. (2008). Optimization of process parameters for deposition of Stellite on X45CrSi93 steel by plasma transferred arc technique. *Materials & Design, 29*(9), 1725–1731. https://doi.org/10.1016/j.matdes.2008.03.020

Bradley, J. S., Reich, R. D., & Norcross, S. G. (1999). On the combined effects of signal-to-noise ratio and room acoustics on speech intelligibility. *The Journal of the Acoustical Society of America, 106*(4), 1820–1828. https://doi.org/10.1121/1.427932

Chang, S.S., Wu, H.C., & Chen, C. (2008). Impact Wear Resistance of Stellite 6 Hardfaced Valve Seats with Laser Cladding. *Materials and Manufacturing Processes, 23*(7), 708–713. https://doi.org/10.1080/10426910802317102

Chaudhary, V., Bharti, A., Azam, S M., Kumar, N., & Saxena, K K. (2021). A re-investigation: Effect of TIG welding parameters on microstructure, mechanical, corrosion properties of welded joints. *Elsevier BV, 45*, 4575-4580. https://doi.org/10.1016/j.matpr.2021.01.007

Cheemalapati, V., Khan, D., & PVSSR, C. (2024). Digital Watermarking Using Hybrid Grasshopper Optimization Algorithm and Genetic Algorithm (HGOAGA). *International Journal of Experimental Research and Review, 42*, 278-291. https://doi.org/10.52756/ijerr.2024.v42.024

Das, S., Banerjee, D., & Mukherjee, S. (2017). Evaluation of Work Posture and Postural Stresses of Welders: A Report. *Int. J. Exp. Res. Rev., 14*, 1-8. https://qtanalytics.in/journals/index.php/IJERR/article/view/1248

Ding, Y., Liu, R., Zhang, Q., Wang, L., & Yao, J. (2017). A composite stellite alloy hard facing with improved laser cladding behavior and wear resistance. *International Congress on Applications of Lasers & Electro-Optics, 508*. https://doi.org/10.2351/1.5138150

Durakovic, B. (2017). Design of experiments application, concepts, examples: State of the art. *Periodicals of Engineering and Natural Sciences (PEN), 5*(3). https://doi.org/10.21533/pen.v5i3.145

Dzukey, G. A., & Yang, K. (2019). Process Parameter Optimization for Selective Laser Melting of 316L Stainless Steel Material using Taguchi's Statistical Design of Experiment Procedure. *International Journal of Engineering and Technology, 11*(1), 6–13. https://doi.org/10.21817/ijet/2019/v11i1/191101014

Ilie, C. O., Marinescu, M., Barothi, L., Vilau, R., & Lespezeanu, I. (2018). Study the parameters of a petrol engine using analysis of variance. *IOP Conference Series: Earth and Environmental Science, 172*, 012028. https://doi.org/10.1088/1755-1315/172/1/012028

Jain, S., & Mulewa, A. (2024). Experimental Analysis of Surface Roughness Optimization of EN19 Alloy Steel Milling by the Cuckoo Search Algorithm. *International Journal of Experimental Research and Review, 38*, 102-110. https://doi.org/10.52756/ijerr.2024.v38.009

John, V., Aggarwal, S., Gupta, D., Anandaram, H., & Joshi, K. (2024). Orthogonal array and artificial neural network approach for sustainable cutting optimization machining of 17-4 PH steel under CNC wet turning operations. *International Journal of Experimental Research and Review, 38*, 61–68. https://doi.org/10.52756/ijerr.2024.v38.006

Kannappan, K. (2014). Application of Design of Experiments (DOE) using Dr.Taguchi -Orthogon.

Kumar, A., Kumar, R., & Kumar, A. (2024). Study of Wear Rate of AA7050-7.5 B4C-T6 Composite and Optimization of Response Parameters using Taguchi Analysis. *International Journal of Experimental Research and Review, 39*(Spl Volume), 73-81. https://doi.org/10.52756/ijerr.2024.v39spl.005

Kumar, A., Sharma, G., & Dwivedi, D K. (2023). TIG spot weld bonding of 409 L ferritic stainless steel. https://www.sciencedirect.com/science/article/pii/S0143749618301052

Kumari, M., Barma, J. D., & Singh, S. (2021). Parametric observation of TIG welding on AISI 304 stainless steel of thickness 5 mm. *Materials, Mechanics &*

Modeling (NCMMM-2020), *2341*, 040013. https://doi.org/10.1063/5.0053278

Lee, L.W., Yeh, S.S., & Lee, J.I. (2017). Application of Taguchi method for determining the best-fitted control parameters of CNC machine tools. *IEEE International Conference on Mechatronics and Automation* (ICMA), 1676–1681. https://doi.org/10.1109/icma.2017.8016069

Li, B., Nye, T. J., & Metzger, D. R. (2006). Improving the Reliability of the Tube-Hydroforming Process by the Taguchi Method. *Journal of Pressure Vessel Technology, 129*(2), 242–247. https://doi.org/10.1115/1.2716427

Mascarenhas, L. A. B., Gomes, J. de O., Portela, A. T., & Ferreira, C. V. (2015). Reducing the Development Life Cycle of Automotive Valves and Seat Valves Using a New Workbench for High Temperature Wear Testing. *Procedia CIRP*, *29*, 833–838. https://doi.org/10.1016/j.procir.2015.01.068

Paes, R., & Throckmorton, M. (2017). The installation and setup of a variable speed drive for optimal performance. *Petroleum and Chemical Industry Conference Europe* (PCIC Europe), 1–8. https://doi.org/10.23919/pciceurope.2017.8015061

Prasad, K. S., Rao, Ch. S., & Rao, D. N. (2011). Prediction of Weld Bead Geometry in Plasma Arc Welding using Factorial Design Approach. *Journal of Minerals and Materials Characterization and Engineering, 10*(10), 875–886. https://doi.org/10.4236/jmmce.2011.1010068

Ragavendran, U., Ghadai, R. K., Bhoi, A. K., Ramachandran, M., & Kalita, K. (2019). Sensitivity analysis and optimization of EDM process parameters. *Transactions of the Canadian Society for Mechanical Engineering, 43*(1), 13–25. https://doi.org/10.1139/tcsme-2018-0021

Sahu, N. K., & Andhare, A. (2018). Design of Experiments Applied to Industrial Process. *Statistical Approaches with Emphasis on Design of Experiments Applied to Chemical Processes*. https://doi.org/10.5772/intechopen.73558

Sawant, M. S., & Jain, N. K. (2017). Investigations on wear characteristics of Stellite coating by micro-plasma transferred arc powder deposition process. *Wear*, 378–379, 155–164. https://doi.org/10.1016/j.wear.2017.02.041

Selvi, S., Sankaran, S. P., & Srivatsavan, R. (2008). Comparative study of hard-facing of valve seat ring using MMAW process. *Journal of Materials Processing Technology, 207*(1–3), 356–362. https://doi.org/10.1016/j.jmatprotec.2008.06.053

Shanmugam, R., & Murugan, N. (2006). Effect of gas tungsten arc welding process variables on dilution and bead geometry of Stellite 6 hard faced valve seat rings. *Surface Engineering*, *22*(5), 375–383. https://doi.org/10.1179/174329406x126726

Sharma, D., Singh, P., & Punhani, A. (2024). Sugarcane Diseases Detection using the Improved Grey Wolf Optimization Algorithm with Convolution Neural Network. *International Journal of Experimental Research and Review, 38*, 246-254. https://doi.org/10.52756/ijerr.2024.v38.022

Sigmund, M. (2021). Heterogenous Weld Heat Resistant Steel with Cobalt Alloy. *Manufacturing Technology, 21*(5), 700–705. https://doi.org/10.21062/mft.2021.069

Smoqi, Z., Toddy, J., Halliday, H. (Scott), Shield, J. E., & Rao, P. (2021). Process-structure relationship in the directed energy deposition of cobalt-chromium alloy (Stellite 21) coatings. *Materials & Design, 197*, 109229. https://doi.org/10.1016/j.matdes.2020.109229

Srivastava, V. C., Mall, I. D., & Mishra, I. M. (2008). Optimization of parameters for adsorption of metal ions onto rice husk ash using Taguchi's experimental design methodology. *Chemical Engineering Journal*, *140*(1–3), 136–144. https://doi.org/10.1016/j.cej.2007.09.030

Tiwari, D., & Srivastava, A. K. (2024). Process Parameter Effects on Powder Mixed EDM Machining Characteristics Using Biocompatible Ti-6Al-4V Alloy. *International Journal of Experimental Research and Review, 41*(Spl Vol), 1-10. https://doi.org/10.52756/ijerr.2024.v41spl.001

Tong, L., Xu, H., Xu, X., Cheng, H., Feng, L., & Chang, J. (2023). Intelligent Testing and Analysis of Dissimilar Steel Welds for Industrial Throttle Flowmeter. *IOS Press, 2023*, 1-11. https://doi.org/10.1155/2023/4006715

Uy, M., & Telford, J. K. (2009). Optimization by Design of Experiment Techniques. *IEEE Aerospace Conference*, 1–10. https://doi.org/10.1109/aero.2009.4839625

Vallejo, G., Fernández, M. P., Ato, M., & Livacic-Rojas, P. E. (2008). A Practical Method for Analyzing Factorial Designs with Heteroscedastic Data. *Psychological Reports, 102*(3), 643–656. https://doi.org/10.2466/pr0.102.3.643-656

Vora, J., Patel, V. K., Srinivasan, S., Chaudhari, R., Pimenov, D. Y., Giasin, K., & Sharma, S. (2021). Optimization of Activated Tungsten Inert Gas

Welding Process Parameters Using Heat Transfer Search Algorithm: With Experimental Validation Using Case Studies. *Metals*, *11*(6), 981. https://doi.org/10.3390/met11060981

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