Statistical and Regression Modeling of Impact Strength and Flexural Modulus in 3D-Printed Polycarbonate/Basalt Fibre Composites

R Endymion Grosious1, Natrayan Lakshmaiya1,a)

1Department of Mechanical Engineering, Saveetha School of Engineering, SIMATS, Chennai -602105, Tamil Nadu, India.

Corresponding authors:a)[natrayanphd@gmail.com](mailto:natrayanphd@gmail.com)

**Abstract:** The study investigates the fused deposition modeling (FDM) approach to examine how process factors impact the mechanical characteristics of 3D-printed 95% polycarbonate (PC) reinforced with 5% basalt fiber. The Taguchi L9 orthogonal array and signal to noise ratio was utilized to optimize three critical parameters: printing speed (15, 20, 25 mm/s), bed temperature (60°C, 70°C, 80°C), and nozzle temperature (200°C, 210°C, 220°C). Flexural modulus and Izod impact strength were chosen as the main response variables and assessed in accordance with ASTM D256. According to ANOVA, the experimental results showed that the nozzle temperature had the greatest impact, accounting for 90% of the Impact strength and 49.95% of the flexural modulus. While the greatest flexural modulus of 2577 MPa was recorded at 200°C nozzle temperature, 60°C bed temperature, and 15 mm/s printing speed, the highest Izod impact strength of 860 J/m was attained at 220°C nozzle temperature, 80°C bed temperature, and 15 mm/s printing speed. With R2 values of 97.48% for flexural modulus and 95.56% for Izod strength, regression models for both characteristics demonstrated a high degree of association. Visual contour graphs demonstrated that while lower nozzle temperatures increase stiffness, higher nozzle and bed temperatures improve impact resistance. These results offer a precise foundation for choosing the best FDM process settings to customize mechanical performance according to application needs.

**Keywords:** Polycarbonate, Basalt fiber, Izod strength, Flexural modulus, Orthogonal array, Signal to noise ratio, ANOVA, Regression model and Contour plot

# Introduction

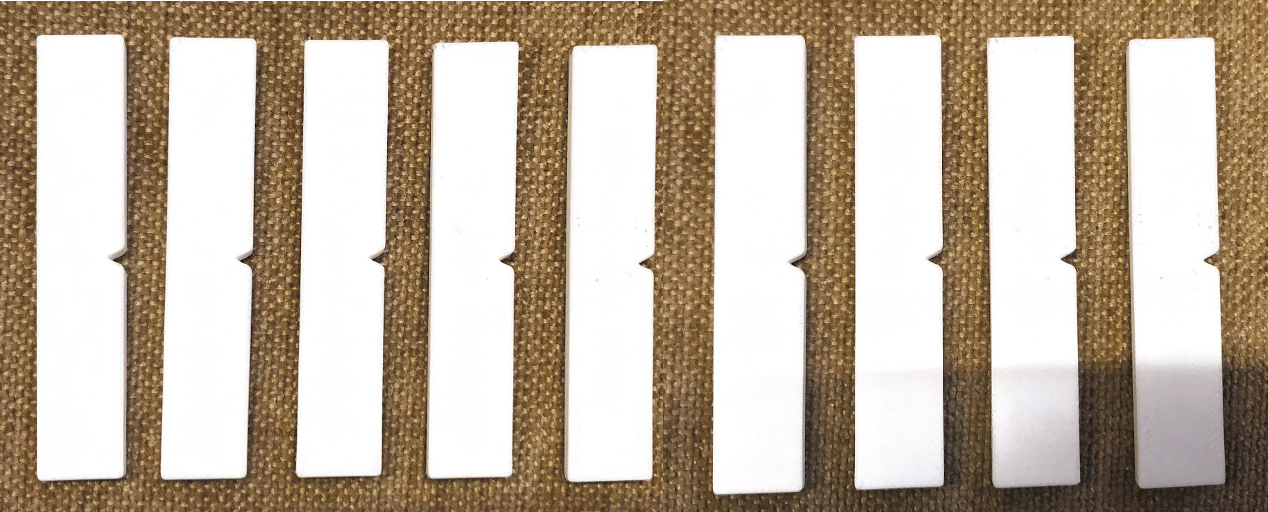
Additive Manufacturing fused deposition modeling is a quick manufacturing process technique. The mix of polycarbonate and basalt fibers works quite well. This combination for Impact strength and Flexural modulus as per ASTM standard has a wide application in the research industry [1]. Izod sample the combination of polycarbonate and basalt fiber provides several mechanical, thermal, electrical, and heat resistant benefits [2]. In all of these features, the strength of the polycarbonate and basalt fiber merged combination is excellent. Polycarbonate materials are typically high stress, high ductility, and high resistance materials. This material has the highest hardness and strength [3]. Basalt fiber is a material with high fire resistance, surface resistance, and electrical resistance. It is also one of the easiest to work with in the materials industry [4]. In this case, combining polycarbonate and basalt fiber is an excellent task for merging and improving the material's strength and quality [5]. This strength and quality are mostly derived from the mix of polycarbonate and basalt fibers. Basically, this combination is pricey, but the yield is incredibly productive [6]. Previous research has not focused on the combined use of polycarbonate and basalt fibers to print Izod samples or their flexural modulus [7]. Previous study on this combination is limited, as it only explains the mechanical characteristics of the Polycarbonate material [8]. However, no detailed study has been done in polycarbonate composite materials to print the Izod sample and flexural modulus. These two qualities are in accordance with the ASTM standard. But this job was not completed in the earlier work [9].

The previous work does not explain the Taguchi method of using Impact strength and flexural modulus for L9 experiment Taguchi design structures to obtain accurate results [10]. The previous research did not focus primarily on Polycarbonate Composite filament. This article includes a literature review that focuses mostly on polycarbonate composite filaments. This study fills a gap in the literature by printing samples of Polycarbonate 95% and 5% Basalt fiber merging combination for Impact strength and flexural modulus that have not been done previously. This printing example uses ASTM standards for Impact strength and Flexural modulus, but does not go into depth regarding earlier work. The previous work on this Izod and flexural modulus did not go into detail about printing samples using an orthogonal array for L9 experiments to design the analysis. Designing the three levels of parameters for nozzle temperature, printing speed, and bed temperature using design structure for Taguchi work is not finished in the previous work, nor is it focused on Impact strength and flexural modulus sample using signal to noise ratio for larger is a better value [11-15]. For the optimization of the polycarbonate and basalt fiber merged printing sample, the analysis of variance (ANOVA) for Impact strength and flexural modulus using the total deformation value, sequence ss value, and coefficient of correlation has not been discussed before. This combination of work does not provide a coefficient of correlation value over the 95% threshold found in previous studies. Regression analysis of the combined polycarbonate and basalt fiber [16-22]. This combined printing of polycarbonate composite samples has not been discussed before. The contour map does not go into great depth regarding how this polycarbonate composite filament operates. The Taguchi method is an optimization approach used to enhance the mechanical behavior of this polycarbonate and basalt fiber combination. There is no detailed discussion of these earlier investigations in this combined contour plot. The optimization approach uses this combined combination to enhance the materials' strength and behavior by raising the bed temperature and nozzle temperature without going into detail about earlier studies [23-29]. These are the gaps in the literature for this work. The objective of this study is to print samples for Impact strength and flexural properties using a merged combination of 95% polycarbonate and 5% basalt fiber. D256 is the ASTM standard in this Izod sample. Accurate designs and buildings are provided by these ASTM standards. Taguchi analysis L9 tests were used in the creation of these combined polycarbonate printing samples, with three distinct levels of parameters for printing speed, bed temperature, and nozzle temperature. These three parameters are designed to increase mechanical strength by utilizing three distinct levels of parameters [30-35]. Additionally, for all three factors, the optimal value is a greater orthogonal array signal to noise ratio. The highest value for the first two parameters is taken into consideration for subsequent work. For flexural modulus and Impact strength samples, the ASTM standard is found using optimal settings. This Taguchi analysis includes nine distinct trials for Impact strength and flexural modulus, nine distinct values, the signal to noise ratio, and the FITS value. Increasing the strength is the finest value for everybody. Analysis of variance (ANOVA) for Impact strength and flexural modulus the optimal value must be attained by a coefficient of correlation more than 95%. Regression modeling has revealed that the optimum strength value was reached by either the nozzle temperature, printing speed, or bed temperature [36-40]. When it comes to Impact strength and flexural modulus, contour plots provide the highest strength values. These two characteristics provide the most strength in this contour plot. The Taguchi approach is essential to this optimization process since it enhances the mechanical behavior of the printed prototypes. Higher nozzle and bed temperatures improve Impact strength in this study's goal of determining both Flexural modulus and Izod strength. A moderate bed temperature and a lower nozzle temperature increase flexural modulus. The main conclusion is that nozzle temperature is the primary element influencing both mechanical attributes. While lower nozzle temperatures are better for stiffness, higher temperatures are best for impact strength [41-45]. These findings can guide the creation of FDM printing settings for polycarbonate-basalt fiber composites based on specific mechanical performance goals. This is a good procedure for improving the mechanical strength and quality. This technique is very helpful for reducing the wastage and manpower cost. this process is helping to improving the productivity of the materials [46-50].

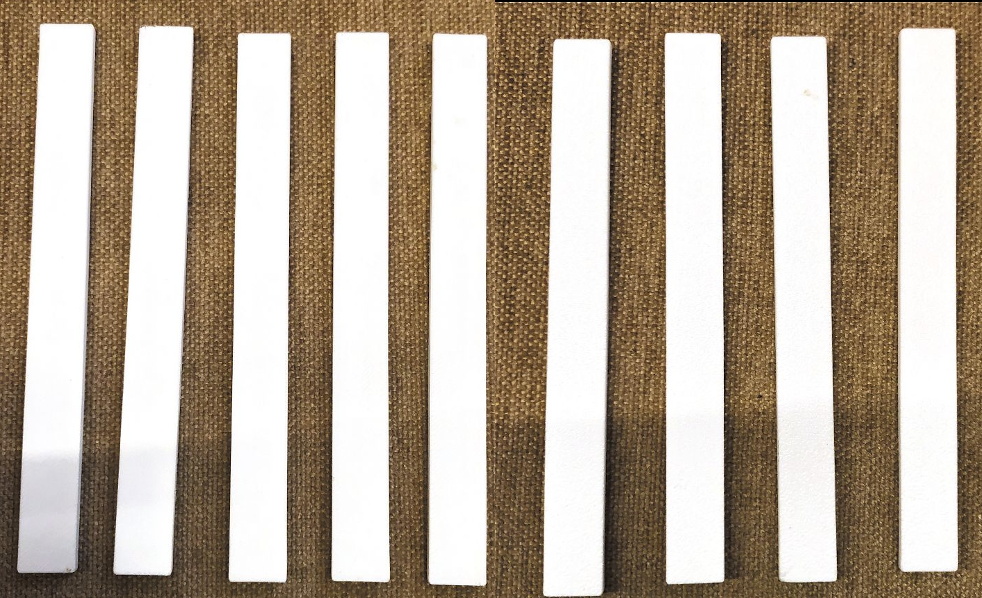
# Materials and Methods

## Materials

The printing sample material for Figure 1 -a is Impact strength samples and Figure 1 -b is a Flexural modulus , both Impact strength and flexural modulus for the combination used in this study is 95% polycarbonate and 5% basalt fibre, as seen in Figure 1 (a and b). According to ASTM standards, this combined combination is used to print Izod samples. D256 is the ASTM standard for Izod samples. These examples are printed using an Ultima Ker printing machine.

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(a)

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**(b)**

**Figure 1: (a)** Polycarbonate composite Izod strength (b) **Polycarbonate composite Flexural modulus**

The parameters and levels 1 through 3 for the three parameters are shown in table 1 of this study. For Levels 1 through 3, the printing speed is 15, 20, and 25 mm/s; the bed temperature is 60, 70, and 80 degrees Celsius; and the nozzle temperature is 200, 210, and 220 degrees Celsius each.

**Table 1: Parameters and Levels**

|  |  |  |  |
| --- | --- | --- | --- |
| **Factor** | **Type** | **Levels** | **Values** |
| Printing speed | Fixed | 3 | 15, 20, 25 |
| Nozzle Temp | Fixed | 3 | 200, 210, 220 |
| Bed Temp | Fixed | 3 | 60, 70, 80 |

## ****Experimental Design****

**In this study Table 2 shows the design for 1 to 9 parameters. The Nozzle Temperature is 200 degrees Celsius, the Bed Temperature is 60 degrees Celsius, and the Printing Speed is 15 mm/s in Experiment 1.20 mm/s is the printing speed in Experiment 2, with a bed temperature of 70 degrees Celsius and a nozzle temperature of 200 degrees Celsius. Printing speed in Experiment 3 is 25 mm/s, with nozzle and bed temperatures of 200 and 80 degrees Celsius, respectively. In Experiment 4, the printing speed is set at 15 mm/s, the bed temperature is set at 70 degrees Celsius, and the nozzle temperature is set at 210 degrees. The bed temperature is 80 degrees Celsius, the nozzle temperature is 210 degrees Celsius, and the printing speed in Experiment 5 is 20 mm/s.** **The printing speed in Experiment 6 is 25 mm/s, the bed temperature is 60 degrees Celsius, and the nozzle temperature is 210 degrees Celsius. The printing speed in Experiment 7 is 15 mm/s, the bed temperature is 80 degrees Celsius, and the nozzle temperature is 220 degrees Celsius. The printing speed in Experiment 8 is 20 mm/s, the bed temperature is 60 degrees Celsius, and the nozzle temperature is 220 degrees Celsius. The printing speed in Experiment 9 is 25 mm/s, the bed temperature is 70 degrees Celsius, and the nozzle temperature is 220 degrees Celsius. These are the parameters are utilized for design.**

**Table 2: Experimental design**

|  |  |  |  |
| --- | --- | --- | --- |
| **Experimental no** | **Printing speed** | **Nozzle Temp** | **Bed Temp** |
| **1** | 15 | 200 | 60 |
| **2** | 20 | 200 | 70 |
| **3** | 25 | 200 | 80 |
| **4** | 15 | 210 | 70 |
| **5** | 20 | 210 | 80 |
| **6** | 25 | 210 | 60 |
| **7** | 15 | 220 | 80 |
| **8** | 20 | 220 | 60 |
| **9** | 25 | 220 | 70 |

## Response measurement

In the present work, flexural modulus and Impact strength are used to quantify response. According to ASTM, the Izod sample in this printing sample is D256. In this Impact strength and flexural modulus, 95% polycarbonate and 5% basalt fibre are combined. Each properties are using signal to noise ratio , larger is better.

# Result and Discussion

## Taguchi analysis

In this work, Table 3 presents the experimental design based on the Taguchi orthogonal array for signal-to-noise (S/N) ratio analysis of impact strength and flexural modulus. At a nozzle temperature of 200 °C, the first three experiments showed consistent impact strength values but varying flexural modulus. Experiment 1 (15 mm/s, 60 °C bed) recorded an impact strength of 852 J/m with a flexural modulus of 2577 MPa, supported by S/N ratios of 58.60 and 68.22. At Experiment 2 (20 mm/s, 70 °C bed), impact strength slightly increased to 853 J/m, while modulus decreased to 2565 MPa. In Experiment 3 (25 mm/s, 80 °C bed), impact strength further improved to 854 J/m, but flexural modulus dropped significantly to 2430 MPa, showing that higher printing speed and bed temperature favor toughness but reduce stiffness.

At a nozzle temperature of 210 °C, the trend continued. Experiment 4 (15 mm/s, 70 °C bed) yielded 855 J/m impact strength and 2465 MPa modulus, while Experiment 5 (20 mm/s, 80 °C bed) achieved 856 J/m and 2520 MPa, indicating a balance between toughness and stiffness. However, Experiment 6 (25 mm/s, 60 °C bed) reached 857 J/m but the modulus dropped sharply to 2330 MPa, confirming that higher speeds reduce structural rigidity. At the highest nozzle temperature of 220 °C, impact strength peaked while modulus showed further reduction. Experiment 7 (15 mm/s, 80 °C bed) gave the highest strength of 860 J/m with a modulus of 2355 MPa, while Experiment 8 (20 mm/s, 60 °C bed) maintained 859 J/m with 2380 MPa modulus. The weakest stiffness occurred in Experiment 9 (25 mm/s, 70 °C bed), where modulus fell to 2000 MPa despite strong impact resistance of 858 J/m. Overall, the results confirm that higher nozzle temperature and moderate printing parameters enhance impact strength, while flexural modulus declines due to reduced material stiffness.

Table 3: Experimental design for signal to noise ratio for Impact strength and Flexural modulus

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Experimental no** | **Nozzle Temp** | **Printing speed** | **Bed Temp** | **Impact Strength (j/m)** | **Flexural modulus MPa** | **S/N Ratio for Impact Strength** | **S/N Ratio for Flexural modulus** |
| 1 | 200 | 15 | 60 | 852 | 2577 | 58.6087919 | 68.22228837 |
| 2 | 200 | 20 | 70 | 853 | 2565 | 58.61898062 | 68.18174739 |
| 3 | 200 | 25 | 80 | 854 | 2430 | 58.62915741 | 67.71212547 |
| 4 | 210 | 15 | 70 | 855 | 2465 | 58.63932229 | 67.83633847 |
| 5 | 210 | 20 | 80 | 856 | 2520 | 58.64947529 | 68.02801082 |
| 6 | 210 | 25 | 60 | 857 | 2330 | 58.65961644 | 67.34711842 |
| 7 | 220 | 15 | 80 | 860 | 2355 | 58.68996902 | 67.43981823 |
| 8 | 220 | 20 | 60 | 859 | 2380 | 58.67986328 | 67.53153914 |
| 9 | 220 | 25 | 70 | 858 | 2000 | 58.66974576 | 66.02059991 |

## Response for signal to noise ratio for Impact strength and Flexural modulus

### Impact strength

In this experiment Table 4 shows that the bigger the signal to noise ratio for Izod strength, the better. In these three levels of characteristics, Level 1 has a nozzle temperature of 58.62 degrees Celsius, a printing speed of 20mm/s, and a bed temperature of 58.65 degrees Celsius. Level 2 nozzle temperature is 58.65 degrees Celsius, printing speed is 58.65 mm/s, and bed temperature is 58.64 degrees Celsius. Level 3 Nozzle Temperature is 58.68 degrees Celsius, Printing Speed is 58.65 mm/s, and Bed Temperature is 58.66 degrees Celsius.

Table 4: Impact strength for response of signal to noise ratio

|  |  |  |  |
| --- | --- | --- | --- |
| **Level** | **Nozzle Temp** | **Printing speed** | **Bed Temp** |
| 1 | 58.62 | 58.65 | 58.65 |
| 2 | 58.65 | 58.65 | 58.64 |
| 3 | 58.68 | 58.65 | 58.66 |
| Delta | 0.06 | 0.01 | 0.01 |
| Rank | 1 | 3 | 2 |

In this experiment figure 2 Graph indicates the Nozzle temperature is displaying the highest rank for Delta is 0.06 , Second highest rank is Bed temperature delta is 0.01 and final lowest rank is Printing speed value is 0.01 delta The delta values for bed temperature and printing speed are the same in this Izod strength.



Figure 2: Graph for Impact strength signal to noise ratio

### Flexural modulus

In this experiment Table 5 shows that the bigger the signal to noise ratio for Flexural modulus the better. In these three levels of characteristics, Level 1 has a nozzle temperature of 68.04 degrees Celsius, a printing speed of 67.83 mm/s, and a bed temperature of 67.70 degrees Celsius. Level 2 nozzle temperature is 67.74 degrees Celsius, printing speed is 67.91 mm/s, and bed temperature is 67.35 degrees Celsius. Level 3 Nozzle Temperature is 67.00 degrees Celsius, Printing Speed is 67.03 mm/s, and Bed Temperature is 67.73 degrees Celsius.

Table 5: Flexural modulus for response of signal to noise ratio

|  |  |  |  |
| --- | --- | --- | --- |
| **Level** | **Nozzle Temp** | **Printing speed** | **Bed Temp** |
| 1 | 68.04 | 67.83 | 67.70 |
| 2 | 67.74 | 67.91 | 67.35 |
| 3 | 67.00 | 67.03 | 67.73 |
| Delta | 1.04 | 0.89 | 0.38 |
| Rank | 1 | 2 | 3 |

In this experiment figure 3 Graph indicates the Nozzle temperature is displaying the highest rank for Delta is 1.04 , Second highest rank is Printing speed delta , value is 0.89 and final lowest rank is Bed temperature delta value is 0.38.



Figure 3: Graph for Flexural modulus of signal to noise ratio

## Analysis of Variance (ANOVA)

### Impact strength

This experiment's Impact strength sample ANOVA is for the combination of polycarbonate and basalt fibre merged combination printing sample. Table 6 displays the nozzle temperature, printing speed, and bed temperature and error total DF is 8, the total sequence SS is 60, and the contribution is 100.00%. The Impact strength S value is 1.1547, the correlation coefficient is 95.56%, the R-sq. (adj) value is 82.22%, the PRESS is 54, and the R-sq. (pred) is 10.00%. The Impact strength ANOVA values are as follows.

Table 6: Impact strength for ANOVA

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Source** | **DF** | **Seq SS** | **Contribution** | **Adj SS** | **Adj MS** | **F-Value** | **P-Value** |
| Nozzle Temp | 2 | 54 | 90.00% | 54 | 27 | 20.25 | 0.047 |
| Printing speed | 2 | 0.6667 | 1.11% | 0.6667 | 0.3333 | 0.25 | 0.8 |
| Bed Temp | 2 | 2.6667 | 4.44% | 2.6667 | 1.3333 | 1 | 0.5 |
| Error | 2 | 2.6667 | 4.44% | 2.6667 | 1.3333 |  |  |
| Total | 8 | 60 | 100.00% |  |  |  |  |

The residual plot graph in Impact strength figure 4 displays the standardized residual frequency of direction from the histogram and the standardized residual for observation order from the versus order. The normal probability plot displays an accurate percentage of the standardized residual, and Versus Fits displays the standardized residual of the accurately fitted value. These are the items that the graph in this Impact strength analysis demonstrates.



Figure 4: Graph for Impact strength ANOVA

### Flexural modulus

This experiment's Flexural modulus ANOVA is for the combination of polycarbonate and basalt fibre merged combination. Table 7 displays the nozzle temperature, printing speed, and bed temperature and error. Total DF is 8, the total sequence SS is 245350, and the contribution is 100.00%. The Flexural modulus S value is 55.6367, the correlation coefficient is 97.48 %, the R-sq. (adj) value is 89.91%, the PRESS is 125366 and the R-sq. (pred) is 48.90%. The Flexural modulus ANOVA values are as follows.

Table 7 : Flexural modulus for ANOVA

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Source** | **DF** | **Seq SS** | **Contribution** | **Adj SS** | **Adj MS** | **F-Value** | **P-Value** |
| Nozzle Temp | 2 | 122558 | 49.95% | 122558 | 61279 | 19.8 | 0.048 |
| Printing speed | 2 | 100824 | 41.09% | 100824 | 50412 | 16.29 | 0.058 |
| Bed Temp | 2 | 15778 | 6.43% | 15778 | 7889 | 2.55 | 0.282 |
| Error | 2 | 6191 | 2.52% | 6191 | 3095 |  |  |
| Total | 8 | 245350 | 100.00% |  |  |  |  |

The standardized residual frequency of direction from the histogram and the standardized residual for observation order from the versus order are shown in the residual plot graph in Flexural Modulus Figure 5. Versus Fits shows the standardized residual of the properly fitted value, whereas the normal probability plot shows an accurate proportion of the standardized residual. The graph in this flexural modulus study illustrates these points.



Figure 5: Graph for Flexural modulus ANOVA

## Regression model

### Impact strength

The Izod impact strength (J/m) of 3D-printed polycarbonate is predicted by this regression equation using the following parameters: bed temperature, printing speed, and nozzle temperature. Every parameter level adds or deducts from the base strength, which is 856 J/m. The strength is increased by 3.000 J/m at a nozzle temperature of 220°C and by 0.667 J/m at a bed temperature of 80°C, whereas it is decreased at lower temperatures such as 200°C or 70°C. Strength is somewhat increased (by +0.333 J/m) at higher printing speeds (25 mm/s) and decreased (by -0.333 J/m) at lower speeds (15 mm/s). A maximum expected strength of 860 J/m is obtained with the ideal parameters.

### Regression Equation

|  |  |  |
| --- | --- | --- |
| Impact strength (j/m) | = | 856.000 - 3.000 Nozzle Temp\_200 + 0.000 Nozzle Temp\_210 + 3.000 Nozzle Temp\_220 - 0.333 Printing speed\_15 + 0.000 Printing speed\_20 + 0.333 Printing speed\_25 + 0.000 Bed Temp\_60 - 0.667 Bed Temp\_70 + 0.667 Bed Temp\_80 |

### Flexural modulus

The flexural modulus of 3D-printed polycarbonate is estimated by this regression equation using the following parameters: bed temperature, printing speed, and nozzle temperature. The basal modulus, after adjusting for each parameter, is 2402.4 MPa. A higher nozzle temperature of 220°C and a printing speed of 25 mm/s considerably lowers the modulus, but a nozzle temperature of 200°C and a printing speed of 20 mm/s raise it by 121.6 MPa and 85.9 MPa, respectively. The result also depends on the temperature of the bed; at 80°C, it increases slightly (+32.6 MPa), while at 70°C, it decreases (-59.1 MPa). The maximum rigidity is achieved with ideal settings.

|  |  |  |
| --- | --- | --- |
| Flexural modulus MPa | = | 2402.4 + 121.6 Nozzle Temp\_200 + 35.9 Nozzle Temp\_210 - 157.4 Nozzle Temp\_220 + 63.2 Printing speed\_15 + 85.9 Printing speed\_20 - 149.1 Printing speed\_25 + 26.6 Bed Temp\_60 - 59.1 Bed Temp\_70 + 32.6 Bed Temp\_80 |

## Contour plot

### Impact strength

In this work , Shades of green are used in the contour plot figure 6 for Impact strength to indicate varying strength levels. Lower Impact strength is shown by lighter green patches (left side), which are usually seen at lower nozzle (200°C) and bed temperatures (60–70°C). Values below 854 J/m are normal. The Impact strength rises as the colours go toward the top and right (higher bed and nozzle temperatures) and become deeper green. At 220°C nozzle temperature and 80°C bed temperature, the strongest area, which is the darkest green area in the upper-right corner, is over 860 J/m. Impact resistance is enhanced by greater printing temperatures, as this colour gradient amply illustrates.



Figure 6: Contour plot for Impact strength

### Flexural modulus

This work is showing the Shades of blue are used to represent different stiffness levels in the contour plot of the flexural modulus in figure 7. With a flexural modulus of over 2500 MPa, the lightest blue regions are found at low nozzle temperatures (200–205°C) and high bed temperatures (75–80°C). A deeper blue tint shifts as the nozzle temperature rises approaching 220°C, signifying a reduction in stiffness. At the bottom-right of the plot, where the nozzle temperature is high and the bed temperature is low, the darkest blue area displays the lowest modulus, approximately 2250 MPa. This colour pattern emphasizes that printed components get firmer when the bed temperature is raised and the nozzle temperature is lowered.



Figure 7: Flexural modulus contour plot

# Conclusion

This study examined the Taguchi method and ANOVA to investigate the effects of nozzle temperature, printing speed, and bed temperature on the Izod impact strength and flexural modulus of 3D-printed polycarbonate 95% with 5% basalt fibre reinforcement. Regression modelling, statistical analysis, and experimental data were used to arrive at the following conclusions: Nozzle temperature had the most impact on the Izod impact strength, accounting for 90% of the total variance, according to the ANOVA. With respective contributions of just 4.44% and 1.11%, bed temperature and printing speed exhibited negligible impacts. With a correlation value (R2) of 95.56% and an adjusted R2 of 82.22%, the Izod model demonstrated an excellent match to the data. The maximum Impact strength of 860 J/m was achieved at 220°C nozzle temperature, 80°C bed temperature, and 15 mm/s printing speed. This combination promoted better interlayer bonding and higher energy absorption during impact. For flexural modulus, nozzle temperature also had the highest effect, contributing 49.95%, followed by printing speed (41.09%), and bed temperature (6.43%). The correlation coefficient (R²) was 97.48%, and the adjusted R² was 89.91%, showing excellent model accuracy. At 48.90%, the predicted R2 was lower, indicating potential for increased predictive power. At 200°C nozzle temperature, 60°C bed temperature, and 15 mm/s printing speed, the maximum flexural modulus of 2577 MPa was measured, suggesting that reduced heat input preserves material stiffness. Contour plots and regression models verified that: Higher nozzle and bed temperatures enhance Impact strength Flexural modulus is improved by a lower nozzle temperature combined with a moderate bed temperature. The key takeaway is that the most important factor affecting both mechanical qualities is nozzle temperature. Higher temperatures are ideal for impact strength, whilst lower nozzle temperatures are better for stiffness. Based on particular mechanical performance objectives, these insights can direct the development of FDM printing parameters for polycarbonate-basalt fibre composites.

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