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Alternative Material for the plastic injection molding of the Kia Rio's ventilation grille

Material alternativo para el moldeo por inyección de plástico de la rejilla de ventilación del Kia Rio

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Abstract

This research was based on the selection of an alternative material for the manufacture by plastic injection of the Kia Rio's ventilation grille. This accessory has a high acquisition cost because the vast majority are imported elements. Therefore, a composite material was sought that can replace the original, which was found in a local environment and is applicable in the plastic injection manufacturing process. The COPRAS multi-criteria method was used to choose the ideal material to replace the original, which was ABS-PC, with PP-20% Bamboo fiber. Finally, once the ideal candidate has been obtained, the next step was to carry out simulations of the plastic injection process with computational fluid dynamics (CFD) analysis software for plastics; these simulations were carried out for the original material. The results obtained by the multicriteria selection criterion showed that PP-20% bamboo fiber is the ideal candidate to replace the original. This result was corroborated by the CFD simulation that demonstrated that it has the best characteristics to be applied in the plastic injection process.

Keywords: COPRAS, computational fluid dynamics, plastic injection molding, bamboo fiber, Ecuador.

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Resumen

Esta investigación se basó en la selección de un material alternativo para la fabricación por inyección de plástico de la rejilla de ventilación del Kia Rio. Este accesorio tiene un alto costo de adquisición porque la gran mayoría son elementos importados. Por lo tanto, se buscó un material compuesto que pueda sustituir al original, que se encuentre en el medio local y que sea aplicable en el proceso de fabricación por inyección de plástico. Se utilizó el método multicriterio COPRAS para elegir el material ideal para sustituir al original, que era ABS-PC, con PP-20% de fibra de bambú. Finalmente, una vez obtenido el candidato ideal, el siguiente paso fue realizar simulaciones del proceso de inyección de plástico con software de análisis de dinámica de fluidos computacional (CFD) para plásticos; estas simulaciones se realizaron para el material original. Los resultados obtenidos mediante el criterio de selección multicriterio mostraron que el PP-20% de fibra de bambú es el candidato ideal para sustituir al original. Este resultado fue corroborado por la simulación CFD que demostró que posee las mejores características para ser aplicado en el proceso de inyección de plásticos.

Palabras clave: COPRAS, dinámica de fluidos computacional, moldeo por inyección de plástico, fibra de bambú, Ecuador.

Introduction

Most of the parts that make up the aesthetics and interior functioning of the vehicles are made of plastics and their manufacturing process is the injection of plastic which requires a high investment capital for production, (Holmes 2020). In Ecuador the importing and assembling companies spent about 1,557 million dollars among all types of auto parts, generally for the assembly of vehicles leaving very little for spare parts and to a lesser extent for the replacement of parts such as vents. In the automotive industry the use of polymers is widespread due to the characteristics they exhibit, such as lightness in weight is a clear benefit for the automotive industry not only because it is possible to reduce the total weight by reducing the consumption of combustible, making systems and components more efficient, (Rivero 2018).

The versatility of polymers in their exceptional chemical, thermal, optical, and mechanical qualities are linked to their chemical composition and internal structure, which has allowed the creation of specialty polymers, (Rivero 2018). In the automotive field many are the polymers used for the development of its components or auto parts and the selection of the same goes according to the application or purpose to be fulfilled, we have the case of internal auto parts such as vents that can be manufactured from polymers as mentioned in (Majewski & Zawadzki 2013), Acrylonitrile-Butadiene-Styrene (ABS) and ALPHA (ABS-Polycarbonate), for its good properties in terms of rigidity, toughness, dimensional stability, resistance to chemicals and good quality of surfaces, (Bhuvanesh Kumar & Sathiya 2021).

Additive Manufacturing (AM) is the significantly progressing field in terms of methods, materials, and performance of fabricated parts. Periodical evaluation on the understanding of AM processes and its evolution is needed since the field is growing rapidly. To address this requirement, this paper presents a detailed review of the Additive Manufacturing (AM) methods, materials used, and challenges associated with them. A critical review of the state of art materials in the categories such as metals and alloys, polymers, ceramics, and biomaterials are presented along with their applications, benefits, and the problems associated with the formation of microstructures, mechanical properties, and controlling process parameters. The perspectives and the status of different materials on the fabrication of thin-walled structures using AM techniques have also been discussed. Additionally, the main challenges with AM techniques such as inaccuracy, surface quality, reinforcement distribution, and other common problems identified from the literature are presented. On the whole, this paper provides a comprehensive outlook on AM techniques, challenges, and future research directions, (Bhuvanesh Kumar & Sathiya 2021).

Seeing these characteristics in properties that polymers have, the automotive industry has looked for a new type of composite material, (Rajak et al. 2019). This, combines matrix (plastic), reinforcing material (fibers or particles) and additives), which forms a new material with properties superior to the original ones, these materials are known as composite materials (Chen et al. 2009; Mansor et al. 2013; Mansor et al. 2014; Mansor et al. 2019; Ramesh 2019; Seldon y Abilash 2020).

Thus, one of the manufacturing processes used in the automotive industry for work with polymers is the injection molding of thermoplastics as mentioned in Hong, Kim, & Cho (2020) since it is the only process that facilitates the mass production of products with various geometries and good dimensional stability, so it is important to consider the type of plastic injector machines that exist in the country (Sin et al. 2012; Maghsoudi et al. 2017; Serban, Lamanna, & Opran 2019).

The advantage of computational advances today has made it possible to carry out simulations of injection processes to understand the process before performing it (Ahmed Ali et al. 2015). For the present study we will use a CAE simulation software to analyze the plastic injection process with the selected materials (Henning et al. 2019). To perform the simulation will be considered the type of meshing the criterion used to perform the calculations, and variables such as the fluidity of the polymer, the injection temperature, mold temperature, etc. for the simulation by plastic injection (Hentati et al. 2019).

The multicriteria and weighting methods allow to obtain data from a wide variety of candidates and obtain the best of them (Di Fratta et al. 2020). Entropy tells us that entropy has a lot to do with the uncertainty that exists in any experiment or random signal, standard deviation is the separation that exists between any value of the series and the mean (Deb 2021). Statistical variation is characterized by intuiting the variations of the objects under analysis within a range of interval or study variables, VIKOR and COPRAS (Martínez et al. 2018; Parbat & Chakraborty 2021). The objective of this study is to obtain an alternative material that can be obtained in the medium and manufactured locally to replace the original ABS-PC material with which the KIA RIO ventilation mask is manufactured so we will use multi-criteria methods and simulations to obtain the ideal candidate (Bhuvanesh Kumar & Sathiya 2021)

Methodology

In Latin America most of the vehicles that circulate are imported and very few are assembled (Biggart & Guillén 2011). For this reason, the polymer parts that are part of these vehicles are not easy to obtain in the country and their costs increase, so three alternatives of composite polymeric materials are analyzed to replace the original and obtain the best of them. The first step was to obtain the essential characteristics of the vent and according to its requirements the characteristics are: good rigidity, thermoplastic, impact resistance, mild aging, fluidity index, injection mold processing, density, fluidity index and cost (Mourtzis et al. 2019). Considering the above characteristics, three candidates were selected to allow the manufacture of the ventilation mask in Ecuador: 1) Polypropylene – Fiberglass, 2) Polybutylene Terephthalate – 20% Fiberglass and 3) Polypropylene – 20% Bamboo Fiber (MontavaJordà et al. 2019; Rasana et al. 2019).

The standard deviation or standard deviation is a measure that offers information about the mean dispersion of a variable. The standard deviation is always greater than zero. To execute the Standard Deviation method the following steps must be performed:

First step: We build the decision matrix so we will use the matrix developed for the Entropy method.

Second step: We calculate the standard deviation with equation 6:

$$\sigma j = \sqrt{\frac{\sum_{i=1}^{m} (x_{ij}-x_j)^2}{m}} \quad (6)$$

Third step: We obtain the weights for criteria using the equation 7:

$$wj = \frac{\sigma_j}{\sum_{i=1}^{m} \sigma_j} \quad (7)$$

Statistical variation method

This method is characterized by intuiting the variations of the objects under analysis within a range of interval or study variables, bearing in mind that the variation experienced by the variable is subject to the value of the mean. This will allow us to form a decision matrix that fits numerically and identify the result that is closest to the ideal value, to execute the statistical variation method, the following steps must be executed:

First step: For the development of the statistical variation method, we apply the matrix of the entropy method using the equation 8:

$$P_{ij} = \frac{x_{ij}}{\sum_{i=1}^{m} \mathrm{x}_{ij}}$$
(8)

Second step: We normalize the matrix through equations 9 and 10:

$$P_{ij} = \frac{x_{ij}}{\mathrm{x}_{ij}max}$$
(9)

$$P_{ij} = \frac{\mathrm{x}_{ij}min}{\mathrm{x}_{ij}}$$
(10)

Third step: We calculate the statistical variation using the equation 11:

$$V_j = \frac{\sum_{i=1}^{m}(p_{ij}-p_j)^2}{\sum_{i=1}^{m} \mathrm{x}_{ij}}$$
(11)

Fourth step: We obtain the weights of the endpoints using the equation 12:

$$w_j = \frac{\mathrm{v}_j}{\sum_{i=1}^{m}\mathrm{v}_j}$$
(12)

VIKOR Method

In the VIKOR method the solutions must be defined separately, for the positive ones they are evaluated with a maximum value (100) and the negative values with a lower evaluation in the system (0), is the algorithm proposed by VIKOR and the following steps must be followed:

First step: We define the initial decision matrix using the one performed in the Entropy method.

Second step: We normalize the decision matrix using the equation 13:

$$r_{ij} = \frac{a_{ij}}{\sqrt{\sum_{i=1}^{m} a^2\, ij}}$$
(13)

$$V_j = \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1n} \\ r_{11} & r_{22} & \cdots & r_{2n} \\ \vdots & & & \\ r_{m1} & r_{m2} & \cdots & r_{mn} \end{bmatrix}$$

Third step: the standardized matrix of weights was calculated using the equations 14:

$$v = (wr)$$
(14)

$$V_j = \begin{bmatrix} w_1 r_{11} & w_2 r_{12} & \cdots & w_n r_{1n} \\ w_1 r_{21} & w_2 r_{22} & \cdots & w_n r_{2n} \\ w_1 r_{m1} & w_2 r_{m2} & \cdots & w_n r_{mn} \end{bmatrix}$$

Fourth step: the difference between positive and negative values were calculated with the equations. 15 and 16:

$$A* = \{\max i\, M_{ij} \mid j \in J), (\min i\, M_{ij} \mid j \in J')\} = \{M_1{}^{max}, M_2{}^{max}, \cdots, M_n{}^{max}\}$$

(15)

$$A- = \{\max i\, M_{ij} \mid j \in J), (\min i\, M_{ij} \mid j \in J')\} = \{M_1{}^{max}, M_2{}^{max}, \cdots, M_n{}^{max}\}$$

(16)

Fifth step: the optimal solutions that will determine the value range in each criterion were calculated using the equations 17, 18 and 19:

$$U_i = \sum_{i=1}^{m} \frac{w_f(f_j{}^{max} - f_{ij})}{(f_j{}^{max} - f_j{}^{min})}$$
(17)

$$R_i = maxj\left[\frac{w_f({f_j}^{max} - f_{ij})}{({f_j}^{max} - {f_j}^{min})}\right]$$

(18)

$$V_i = \frac{\alpha(U_i - U_{min})}{(U_{max} - U_{min})} + \frac{(1-\alpha)(R_1 - R_{min})}{(R_{max} - R_{min})}$$

(19)

Sixth step: The results are positioned in an ascending way from 1 to 7, with 1 being the value closest to zero. This value close to zero is the optimum in the VIKOR method.

COPRAS Method

This method allows us to find the best values that guide the ideal results, applying the algorithm of the method is obtained with the following steps:

First step: We develop the decision matrix for which we use the normalized matrix of the VIKOR method.

Second step: the normalized decision matrix was defined by applying the equation 20:

$$r_{ij} = \frac{a_{ij}}{\sum_{j=1}^{m} a_{ij}}$$

(20)

$$R_{ij} = \begin{bmatrix} r_{11} & r_{12} & \cdots \\ r_{21} & r_{22} & \cdots \\ \vdots & & \\ r_{m1} & r_{m2} & \cdots \end{bmatrix}$$

Third step: the standardized matrix of weights was carried out using the equation 21:

$$V_{ij} = (w_i)(r_{ij})$$

(21)

$$V_{ij} = \begin{bmatrix} w_1 r_{11} & w_2 r_{12} & \cdots \\ w_1 r_{21} & w_2 r_{22} & \cdots \\ w_1 r_{m1} & w_2 r_{m1} & \cdots \end{bmatrix}$$

Fourth step: the normalized weights for each criterion were obtained by applying the equations 22 and 23:

$$S_{+i} = \sum_{j=1}^{m} V_{+ij}$$
(22)

$$S_{-i} = \sum_{j=1}^{m} V_{-ij}$$
(23)

Fifth step: the performance index of each alternative was calculated by applying the equation 24:

$$Q_i = S_{+i} + \frac{\sum_{j=1}^{m} S_{-i}}{S_{-i} \sum_{j=1}^{m} \frac{1}{S-1}}$$
(24)

Sixth step: tiered performance was calculated using the equation 25:

$$U_i = \frac{Q_i}{max} * 100$$
(25)

Seventh step: The highest value is considered the best option.

Results

Table 1 shows the candidate materials and the characteristics with which the calculations of the weighting methods and multi-criteria methods will be carried out, and the letters represent the characteristics selected for the analysis of each material.

Table 1. *Criteria matrix*

$ kg¹	Density (Kgm³)	MFI (gr 10min)	TS (Mpa)	EB (%)	Mod. Elas. (GPa)	F. strength (MPa)	IR (Kj m²)	MT (°C)	GTT (°C)
A1	A2	A3	A4	A5	A6	A7	A8	A9	A10
3.0	1.15	19	45	60	23	80	0.587	270	129
2.2	1.42	13	85	6	4.4	138	71	220	135
4.9	1.46	16	46	6	3.4	78	37	260	210
1.2	1.00	18	30	4	3	138	50	130	140

The first line of result is ABS-PC material; second line is PP/ fiberglass (m1); third line is PBT / fiberglass (m2), and fourth line is PP / bamboo fiber (m3).

Calculation of the Entropy Method

Table 2 shows the normalized decision matrix for the entropy method according to equation 1 and the entropy values (ex), criterion diversity (Dj) and weights Normalized (Wj) by equations 2, 4 and 5.

Table 2. *Normalized decision matrix Pij and values of ej, Dj, Wj based on entropy method*

	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10
	0,2	0,3	0,2	0,5	0,3	0,4	0,3	0,4	0,2	0,4
	0,5	0,3	0,3	0,2	0,3	0,3	0,2	0,2	0,4	0,1
	0,1	0,2	0,3	0,1	0,3	0,2	0,2	0,3	0,2	0,4
	A1	**A2**	**A3**	**A4**	**A5**	**A6**	**A7**	**A8**	**A9**	**A10**
Ej	0,8	0,9	0,9	0,9	0,9	0,9	0,9	0,9	0,9	0,938
Dj	0,137	0,012	0,008	0,082	0,015	0,012	0,058	0,032	0,014	0,062
Wj	0,31	0,027	0,019	0,184	0,034	0,027	0,132	0,074	0,032	0,143

Calculation of the Standard Deviation Method

For the development of the standard deviation method, we use the matrix elaborated in the entropy method and using the equation 6 the standard deviation (σj) of the values was obtained as well as the weights of each criterion (wj) with the use of equation 7 (Supplementary material).

Comparison of results of the Weighting Methods

In Table 3, we present the weights of each criterion for the three weighting methods used, from this table we will use the values obtained from the standard deviation method and the criteria that will be entered for the analysis will be the density (A2), creep index (A3) and glass transition temperature (A10).

Table 3. *Comparison of results of the weighting methods*

W1 A1	*W2* A2	*W3* A3	*W4* A4	*W5* A5	*W6* A6	*W7* A7	*W8* A8	*W9* A9	*W10* A10
0,31	0.02	0.019	0.184	0.034	0.027	0.132	0.074	0.032	0.143
0,01	0.001	0.014	0.164	0.006	0.004	0.202	0.1	0.202	0.292
0,22	0.049	0.031	0.168	0.059	0.041	0.101	0.092	0.048	0.187

E: The first line results in for entropy, the second line is for standard deviation, and the third line for standard variation

COPRAS multi-criteria method

We elaborate the decision matrix represented in table 4 and we will assign each material that is part of the study with a letter being M1 the PP / Fiberglass, M2 the PBT / Fiberglass and M3 PP / Bamboo Fiber

Table 4. *COPRAS method decision matrix*

A1	A2	A3	A4	A5	A6	A7	A8	A9	A10
2.21	1.42	13	85	6	4.4	138	71	220	135
4.92	1.46	16	46	6	3.4	78	37	260	210
1.25	1.01	18	30	4	3	138	50	230	140

The first line result is for M1, the second line is for M2, and the third line is for M3

Based on the COPRAS method decision matrix, the values were normalized by applying the equation 20. After the normalization the values (S +) and (S-) which are the sums of the weighted values were calculated. The priority depending on the proposed materials (Qi) and (Ui) the performance. For the calculations were apply the equations 22, 23, 24 and 25 respectively.

Table 5. *Calculation Si +, Si-, Qi, Ui and Ranking of the COPRAS Method*

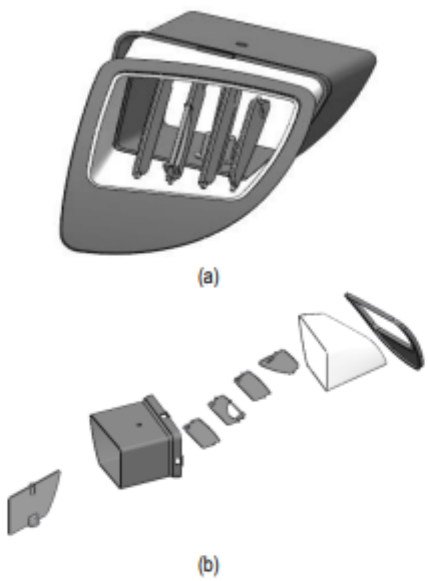
Material	Si+	Si-	Qi	Ui (%)	Ranking
M1	0,126	0,273	0,309	82,62	2
M2	0,055	0,203	0,247	66,04	3
M3	0,127	0,203	0,374	100	1

From the results obtained in table 5 we observe that PP/20% bamboo-fiber was the best candidate to replace the original obtained by the COPRAS method.

Ventilation grille modeling

The first step was to graph and model all the elements that are part of the ventilation grill using computer-aided drawing software (Fig. 1).

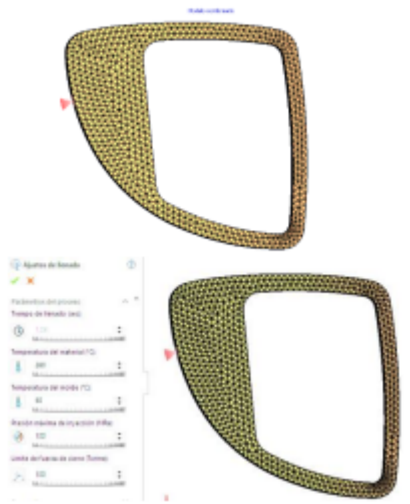
Figura 1. Ventilation Grille for (a) complete modeling and (b) exploded view



Simulation of the plastic injection process

To simulate plastic injection molding, we used the plug-in called Plastics from the SolidWorks software and even though it has a library with a large amount of composite polymers, for our analysis it was necessary to enter the values of PP-20% bamboo fiber (Ekinci et al. 2022). The simulation was carried out with the original material, the best candidate, and the worst candidate to corroborate the results obtained from the multi-criteria method and the sequence followed for each element and material to be analyzed is represented below (see Fig. 2). Where the hybrid tetrahedral mesh was chosen, the plastic injection point and the data for the filling process.

Figura 2. Element mesh, plastic injection point and filling parameters



The results of the simulation will be presented for each element of the vent and depending on the most important characteristics during the plastic injection process such as: filling time (Fig. 3), pressure at the end of the filling (Fig. 4), temperature at the end of filling (Fig. 5), front flow temperature (Fig. 6), the shear stress at the end of filling (Fig. 7), shear stress (Fig. 8). All the values of each element are present in table 6.

Figura 4. Mask (a) ABS, (b) PBT-Fiberglass, and (c) PP-20% Bamboo fiber.

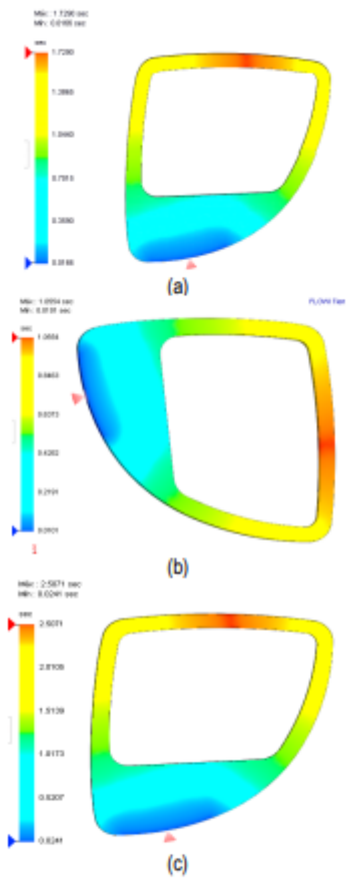


Table 6. *Values of each element during the plastic injection process*

Material	ABS-PC	PBT-30% Fiberglass	PP-20% Bambo fiber
Fill time in Seconds	1,78	1,08	2,05
Pressure at the end of filling (MPa)	87,68	100,58	8,09
Temperature at the end of filling (°C)	260,37	260,50	230,02
Flow front temperature (°C)	260,38	260,70	230,03
Shear Stress MPa	3.62	0,36	0.08
Shear Stress for inlet cavity MPa	8.43	3,85	0.09

Figura 4. Air passage regulation flap (a) ABS, (b) PBT-Fiberglass, and (c) PP-20% Bamboo fiber

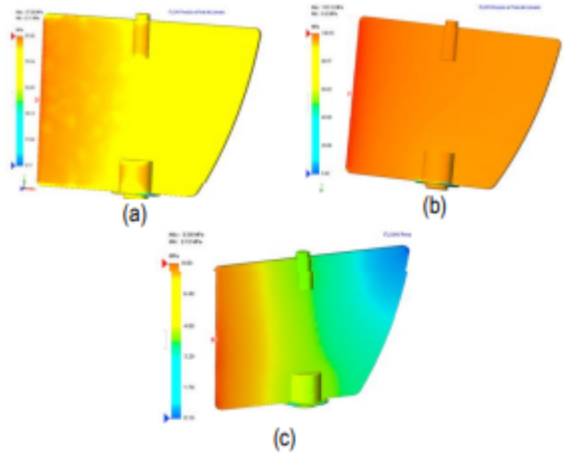


Figura 5. Fin 1 (a) ABS, (b) PBT-Fiberglass and (c) PP-20% Bamboo fi

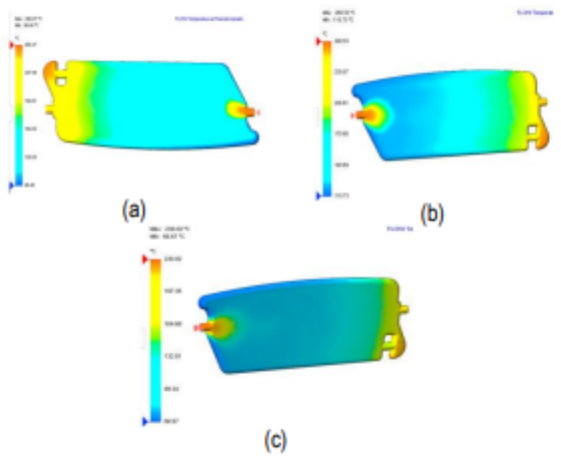


Figura 6. Fin 2 (a) ABS, (b) PBT-Fiberglass and (c) PP-20% Bamboo fiber

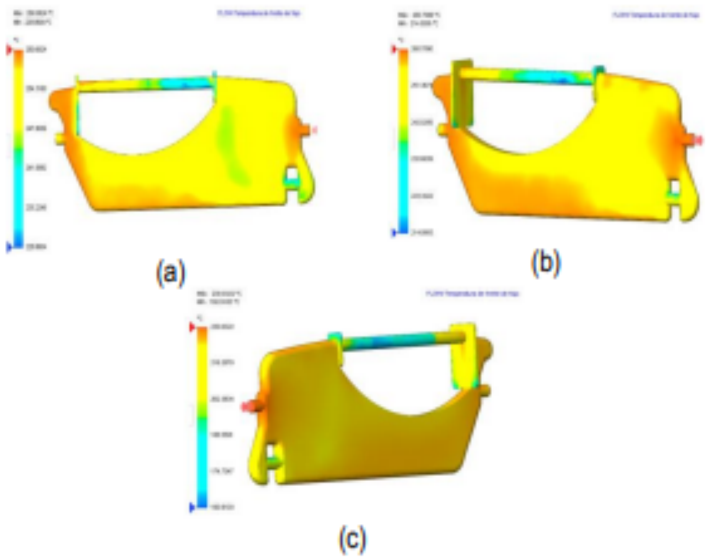


Figura 7. Fin 3 (a) ABS, (b) PBT-Fiberglass and (c) PP-20% Bamboo fiber

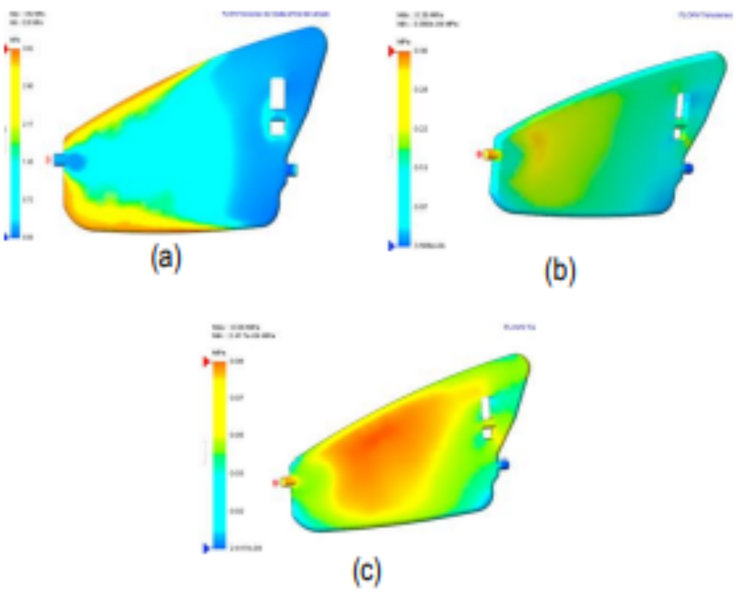
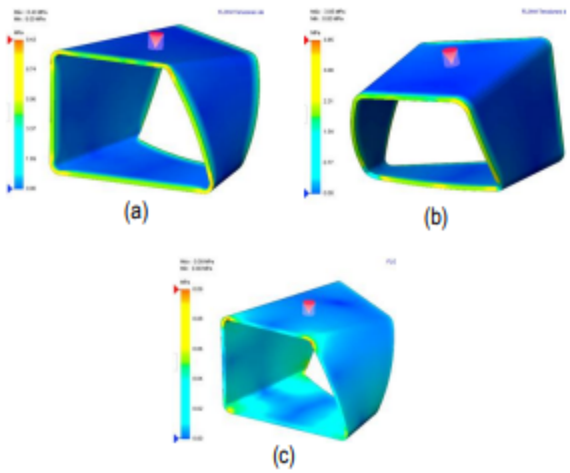


Figura 8. Inlet cavity (a) ABS, (b) PBT-Fiberglass and (c) PP-20% Bamboo fiber



A code was used to identify each element that is part of the ventilation grille: ventilation mask (1), geometry flap 1 (2), geometry flap 2 (3), geometry flap 3 (4) and cavity (5). Fig. 9 shows a comparison of the filling time for all the materials for the ventilation grill, and we can see that the PBT-20% fiberglass is the best of the three with an average time of 0.824 seconds.

Figura 9. Fill time for each material and grid element simulated. Blue line represents ABS PC Orange line represents PBT 30% Fiberglass, and grey line represents PP-20% Bambu fiber

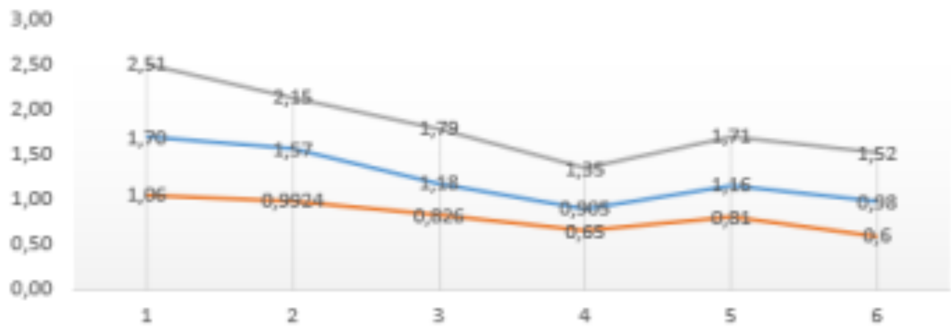


Fig. 10 shows the graph of the pressure at the end of the filling, obtaining that the best material is PP-20% bamboo with an average pressure of 7.2 MPa.

Figura 10. Pressure at end of fill for each material and grid element simulated

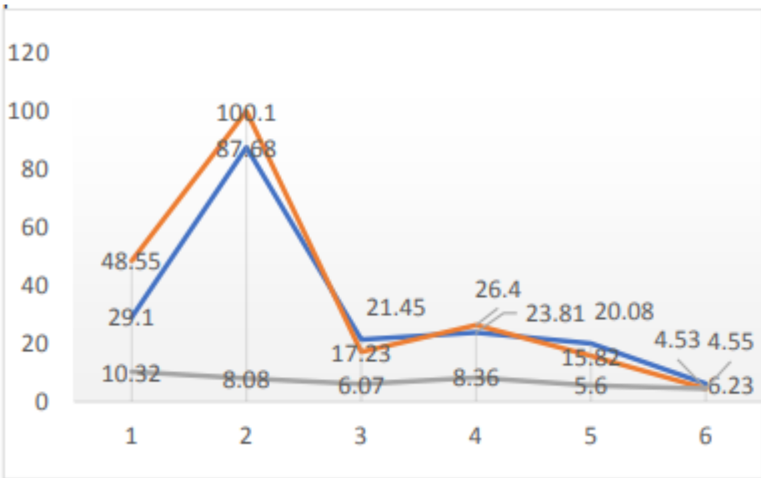


Fig. 11 shows the graph of the temperature at the end of the filling, obtaining that the best material is PP-20% bamboo with an average temperature of 230 ° C.

Figura 11. End-of-fill temperature for each simulated grid material and element

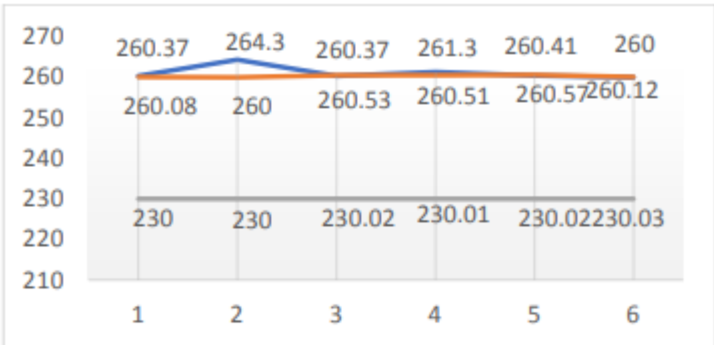


Fig. 12 shows the graph of the flow front temperature, obtaining that the best material is PP-20% bamboo with an average temperature of 230 ° C and remaining constant throughout the injection process.

Figura 12. Flow front temperature for each material and simulated grid element

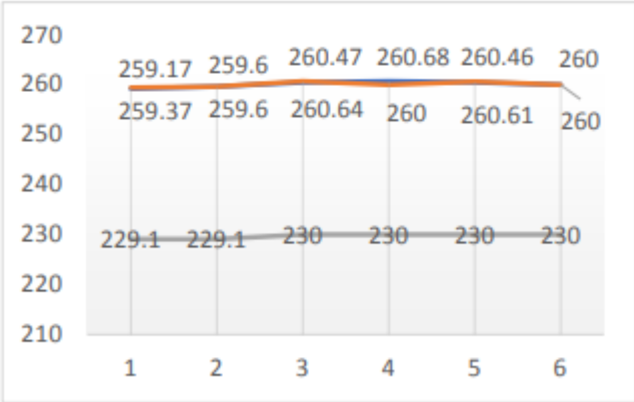
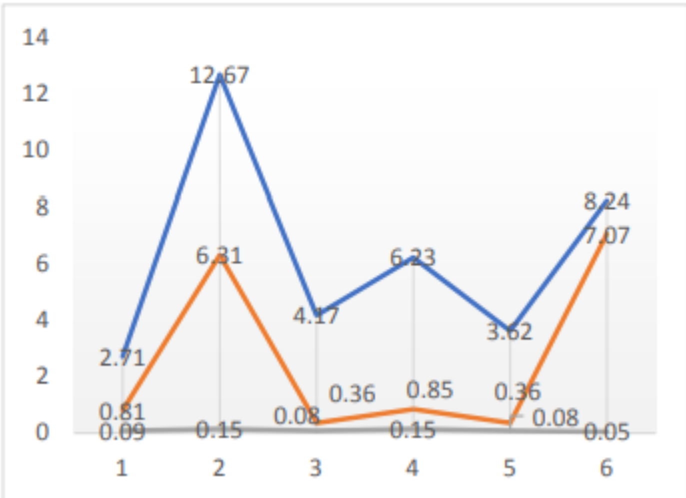


Fig. 13 shows the shear stress in which it is observed that PP20% bamboo fiber is the best material with an average tension of 0.1 MPa, showing that the pieces obtained from this material have less brittleness in comparison.

Figura 13. Shear stress at end of fill for each material and simulated grid element



From the exposed results we can determine that the PP-20% of Bambu fiber is the best candidate to replace the ABS-PC for the elaboration of the ventilation mask of the KIA RIO 2018, the same that is corroborated by the COPRAS multi-criteria method where PP-20% bamboo fiber was the best candidate.

For the study conducted is planned the choice of an alternative composite material for the manufacture of the ventilation grille of the Kia Rio 2018, on which in an investigative manner many options of variables are analyzed to decide the suitable candidate from a variety of composite materials with different raw materials as base element and different filler materials that can be obtained in the local environment. Therefore, a research methodology was planned for the correct analysis and initiation of the selection of materials, defining the characteristics that the candidate materials must meet as a minimum to be part of the analysis.

With the advancement of interdisciplinary approaches in today's modern engineering, current efforts in optimal composite design include the search for material selection protocols that can simultaneously consider a range of mechanical / electrical / chemical cost criteria over a set of alternative material options, and take into careful consideration the environmental aspects of the final products, including recycling and end-of-life disposal options, [30-36]. All this makes use of MCDM to obtain the optimal selection that best solves the conflicts that may occur depending on the different variables that are analyzed for the different materials (Tannaz et al. 2020).

According to what was planned in the study, several candidates are established for analysis according to their physical, mechanical, thermal properties, costs, availability in the local environment and being a composite material. The characteristics were studied variables and were used to analyze the candidate materials. In this case the candidate materials were Polypropylene with 20 Glass fiber, Polybutylene Terephthalate with 20% glass fiber and Polypropylene with 20 Bamboo fiber, from which the ideal material was selected to replace the original one. The first tool of use that was proposed was the decision making by the multicriteria method, but before applying the MCDM, the candidate materials must be evaluated as weighting weights for each of their characteristics. For this reason, the standard deviation method has been used since it offers more notorious information of the results in comparison to the other weighting methods such as entropy and standard variation. Therefore, the standard deviation results were used for the analysis by MCDM.

Obtained the weighting values for each of the variables, the selection by the multicriteria method gives the importance to each of the variables of analysis being a very valuable option for the proper selection of the material because it considers the alternatives in a more critical way allowing us to obtain the best result, (Dahooie et al. 2019). Having obtained the weights of the variables by the standard deviation weighting method, was applied for the study of the selection of the material by the COPRAS multicriteria method, in which a valuation over 100% is made where the winner is the one that obtains this value. For this case the material that obtained the maximum value was the Polypropylene with 20% of Bamboo fiber followed by the Polypropylene with glass fiber obtaining 82.62% and finally the Polybutylene Terephthalate with 20% glass fiber obtaining 66.04%.

Conclusions

The use of the multi-criteria method COPRAS allowed to obtain the ideal candidate to replace the original material thanks to the analysis from various points of view pointing out as the winner with a maximum of 100% Polypropylene with 20% bamboo fiber, it is the ideal material to replace the Original because bamboo fiber can be obtained in the country in several provinces of Ecuador, which will avoid the import of raw materials that are not obtained locally.

The COPRAS multi-criteria method and the simulation showed that PP-20% bamboo fiber is the ideal material for the elaboration of the ventilation grille as a replacement for ABS-PC, showing that the MCDM is an ideal tool to choose an ideal candidate among several alternatives.

The use of SolidWorks software was a very useful tool that allowed the 3D modeling of the ventilation grille and in turn each of the elements that form it for its subsequent plastic analysis. The simulation of the plastic injection molding process performed to the different elements with the original material, the ideal replacement material and the less ideal one corroborated in most of the study variables that the PP-20 bamboo fiber material is the ideal candidate to replace the original one.

The materials that were selected for the research showed that they all have the potential to be used in the manufacture of plastic accessories in the automotive industry, it is recommended to carry out future research with these materials with the adaptation of other natural fibers in their polymeric base. It is also recommended that, based on the research, a comparison be made between the plastic injection molding manufacturing process and the additive manufacturing process for the manufacture of auto parts that do not require the use of natural fibers in their polymeric base. Of auto parts that do not require mass production.

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