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Mechanical Properties Analysis of Arm Rest Components Using Bamboo Composites Material

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Abstract. The development of automotive technology led to the utilization and use of composite materials in Indonesia as a substitute for metal and wood. Composite materials are widely used in several industries such as the automotive, aerospace, marine and infrastructure industries. Composite materials have also been used widely for applications in the military field. A composite material is a material that is formed from a combination of two or more forming materials through an inhomogeneous mixture, where the mechanical properties of each of the forming materials are different. The purpose of implementing bamboo composites in the automotive industry is to provide an alternative material that is eco-friendly. Besides, bamboo composites also have high mechanical properties, low density, resistance to corrosion, and easy fabrication. This thesis research method is conducted by simulating the arm rest components in the Autodesk Fusion 360 application using composite based material with Balcooa bamboo as reinforcement and Polypropylene as the matrix. Arm rest component simulation is done with static stress analysis and thermal analysis and the results of the bamboo composite arm rest simulation will be compared with the ABS arm rest. Through the simulation results on the components and analysis of the results, it can be concluded that bamboo composites can replace the ABS material in the arm rest components, although there is no significant difference in the mechanical properties of bamboo composite and ABS materials. Keywords: Composites, Automotive, Bamboo, Polypropylene, Arm Rest, ABS, Autodesk Fusion 360.

INTRODUCTION

The development of automotive technology led to the utilization and use of composite materials in Indonesia as a substitute for metal and wood. Composite materials are widely used in several industries such as the automotive, aerospace, marine and infrastructure industries. Composite materials have also been used for manufacturing military applications. The use of natural fiber composites in vehicles can reduce their overall weights so that it can reduce fuel consumptions. In the interior of vehicles, natural fiber composites are usually applied to make spare tire covers, door inner panels, roof inner panels and seat backs [1], [2]. Composite is a material that is formed from a combination of two or more forming materials through an inhomogeneous mixture, where the mechanical properties of each of the forming materials are different. The main factors in the use of composite materials are their low density, high specific mechanical properties, performance comparable to metals, corrosion resistance and easy fabrication [3], [4]. Bamboo fiber reinforced composite material is an alternative material that is advantageous when compared to other alternative materials. Apart from the highly specific mechanical properties of bamboo fiber, bamboo fiber materials are also environmentally friendly. Through this research, a 3-D model of the arm rest component will be designed using the Autodesk Fusion 360 application. The analysis will then be conducted to determine the mechanical properties of the composite bamboo armrest components through static simulation stress and thermal stress.

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METHOD

Comparative studies are carried out by analyzing several international journals of bamboo-based composite materials. Through references to the international journals, data collection was done in accordance with the topics discussed as supporting data. Secondary data collection in the form of physical and mechanical properties of bamboo and ABS, material treatment on test, standardization of test and simulation variants will be the basis for the analysis of the thesis. Simulations made with Fusion 360 will be analyzed and material comparisons are then reviewed in the form of tables and bar charts.

Bamboo Composite Data Preparation

Through journal analysis related to bamboo composites, Balcooa Bamboo (Bambusa Balcooa) and polypropylene (Repol H110MA) types were used. The bamboo is extracted from its fibers using a semi-pilot extraction machine. Bamboo culms in the shape of cylinders are cut to a length of 1-1.5 cm and a width of 10 mm. The melt mixing of bamboo fibers with polypropylene is then done using a two-roll open mill machine (Pyrotech Engineer, Delhi) with the compression molding method [5], [6]. In the process of preparing bamboo composites, good methods and treatments can improve the mechanical properties of the material [7], [8], [9].

Preparation of Arm Rest Components

The process of making a 3-D image of the arm rest component is done using the Autodesk Fusion 360 software application with the following specifications: Length 405 mm, width 60 mm and height 85 mm.

FIGURE 1. Arm rest and component design

Simulation Process

The following steps are performed after the simulation of 3-D image processing in Autodesk Fusion 360:

a. As an initial step, select the simulation menu, then select the study properties with the static stress simulation type (Table 1).
b. Select the material used. In this case the material used is the bamboo composite with balcooa bamboo fiber as reinforcement and polypropylene as a matrix. Composite volume ratio in this study was 30% fiber and 70% polypropylene.
c. Select the part that will be constrained, then the load selection will be adjusted.
d. Select the part to be given load on static loads. Load selection will be adjusted. In this study, the load used was 250N, 500N, 750N, 1000N [5], [6], [7].

TABLE 1. Mechanical properties of Bamboo-PP [5], [6], [7]

Density	931 kg/m^3
Young's Modulus	2.13 GPa
Poisson's Ratio	0.4
Yield Strength	22.56 MPa
Ultimate Tensile Strength	32.22 MPa

e. For the final step, select the result, then the results of the material testing simulation will appear. The results of the test simulation will be reviewed according to this thesis research

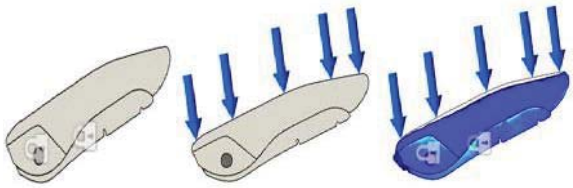


FIGURE 2. Step of the simulation process of components

RESULTS AND DISCUSSION

Simulation Data Results

Component testing simulations were carried out with loading variants of 250N, 500N, 750N, and 1000N [5], [6], [7]. Analysis related to bamboo composite testing is used to determine the mechanical properties of the material [8-10]. The following are types of simulations carried out in the study: Von Mises stress, safety factor, material displacement, 1st and 3rd principal stress, and thermal. The Von Mises yield criteria states that if a material is given a load equal to or greater than the loading limit, then the material will yield [7], [11-14]. Von Mises simulation were performed for the purpose of knowing the yield rate of a material through the load variants. The following below are the results of the Von Mises simulation:

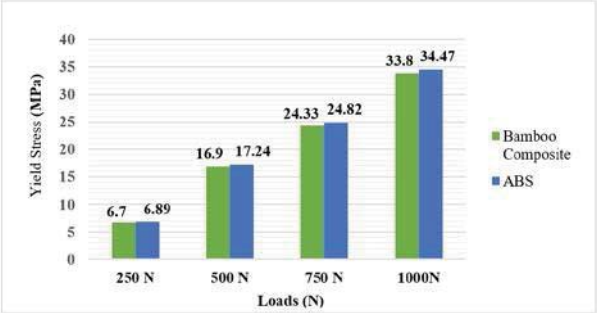
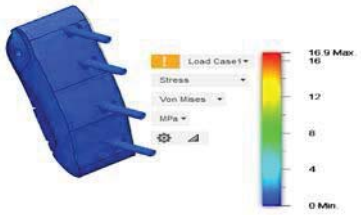
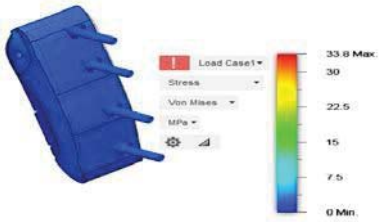


FIGURE 3. Yield stress relation with load variant

Based on the simulation results in Table 2. and the presentation of the data through the bar diagram in Figure 4, the results of the Von Mises stress value are as follows: the yield stress value increases directly proportional to the load, besides the Von Mises stress value for the abs material approaches the yield strength value. This indicates that the ABS material is more prone deformable.

TABLE 2. Von Mises of bamboo composite simulation result

Load	Bamboo Composite Materials	ABS Materials
250N		
500N		
750N		
1000 N		

Simulation Results of 1st Principal Stress and 3rd Principal Stress

The 1st principal stress simulation aims to determine the value of the maximum tensile stress of a material, while the 3rd principal stress simulation aims to determine the maximum compressive stress of a material. The following below are the simulation results for the arm rest component (Table 3 and Table 4). Through the simulation of 1st principal for bamboo and ABS composites in Table 3 and the bar chart in Figure 4, it can be noticed that bamboo composites have a maximum tensile stress value that is greater than ABS material. It can also be seen that although the difference in tensile stress between bamboo composites and ABS material is not significantly different, bamboo composite has a maximum tensile stress that is better than ABS material when given a variety of tensile loads. From the 3rd Principal simulation of bamboo and ABS composites in Table 4 and the bar chart in Figure 5, it can be perceived that the bamboo composite arm rest component also shows a greater compressive stress than the ABS material in the given compressive loading variant. In this case, the bamboo composite also has a better maximum compressive load capacity when compared to the ABS material [11-14].

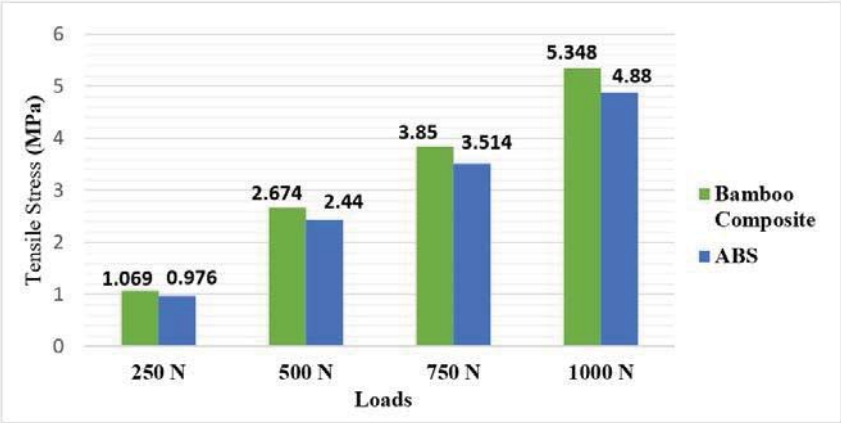


FIGURE 4. Bar chart of 1st principal bamboo composite and ABS materials

TABLE 3. 1st Principal and 3rd principal of bamboo composite simulation result

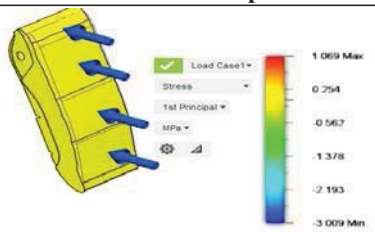
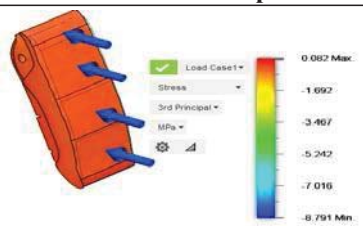
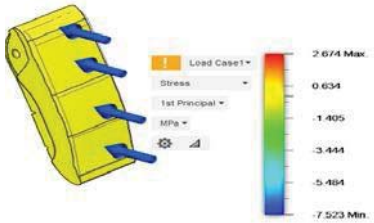
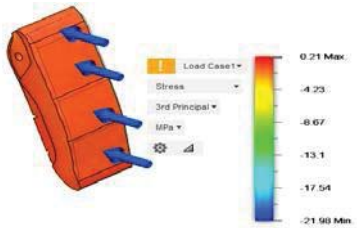
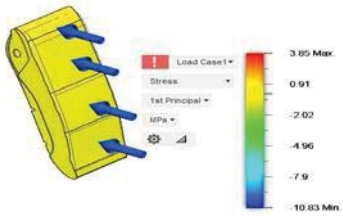
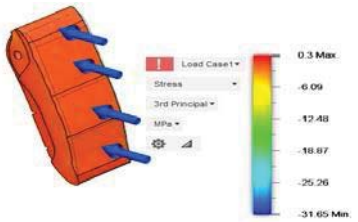
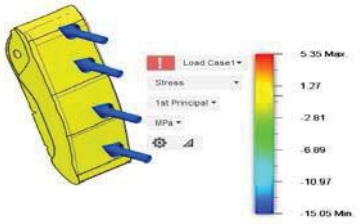
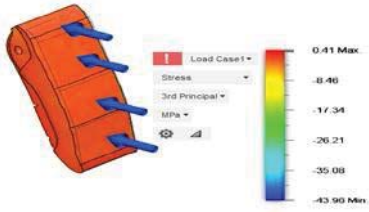
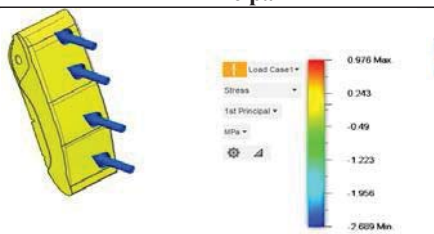
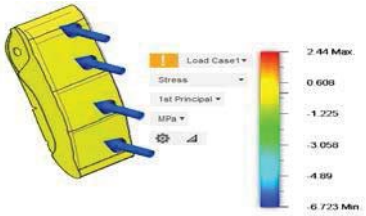
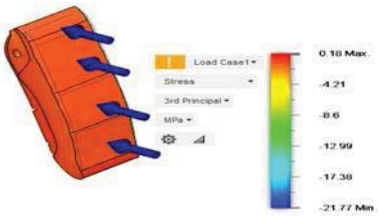
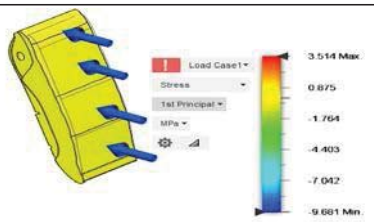
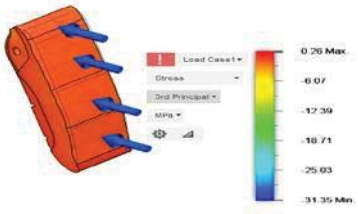
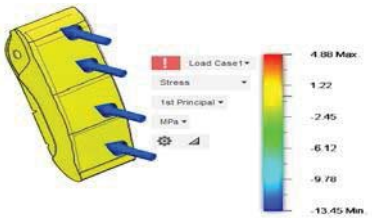
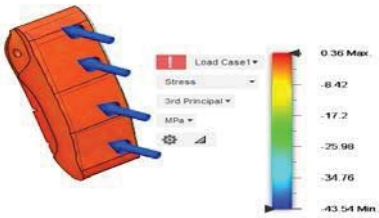
Load	1st Principal	3rd Principal
250 N		
500 N		
750 N		
1000 N		

TABLE 4. 1st Principal and 3rd principal of ABS simulation result

Load	1st Principal	3rd Principal
250 N		
500 N		
750 N		
1000 N		

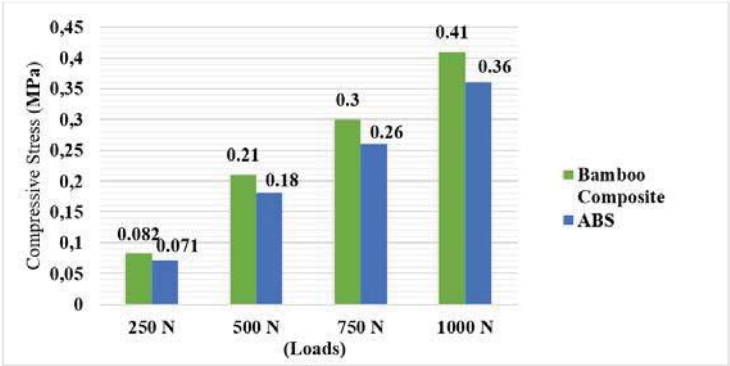
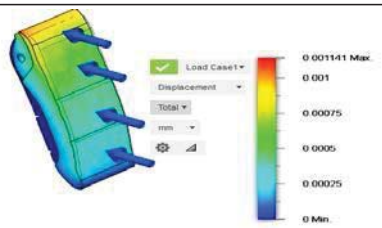
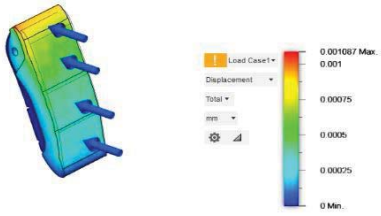
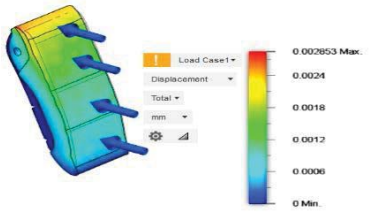
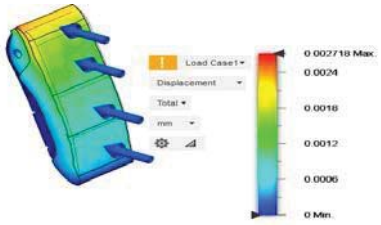
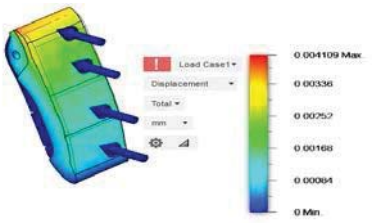
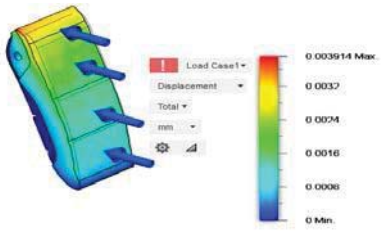
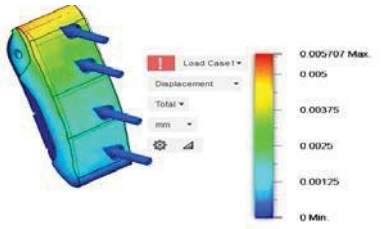
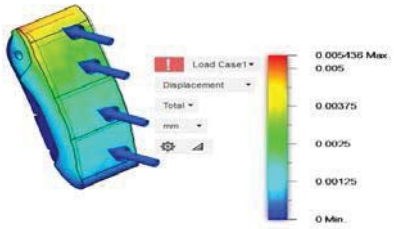


FIGURE 5. Bar chart of 3rd principal bamboo composite and ABS materials

Displacement of Simulation Results

This simulation aims to show displacement/amount of distortion from the initial shape that occurs in the material at the time of loading. The following below are the result of the displacement simulation:

TABLE 5. Displacement simulation result of bamboo composite and ABS Materials

Load	Bamboo Composite Materials	ABS materials
250N		
500N		
750N		
1000N		

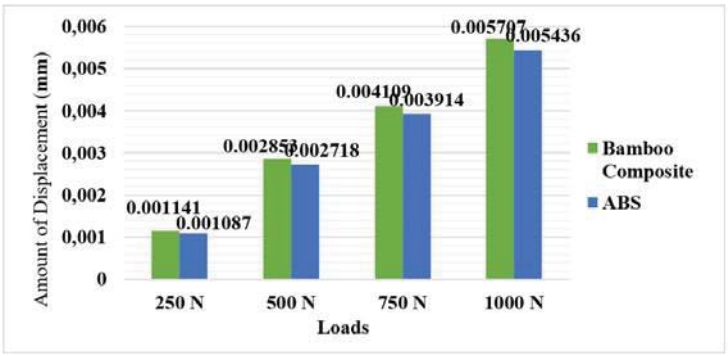


FIGURE 6. Bar chart displacement simulation of composite bamboo and ABS materials

In table 5 and the bar chart in Figure 6, the simulation results show the displacement in components from the initial shape caused by loading. The value of the displacement that occurs in the material increases in direct proportion to the loading variant.

CONCLUSION

Based on the results of the Von Mises simulation with the load of 500 N, the stress value is 16.9 MPa for bamboo composites and 17.24 MPa for ABS. The Von Mises stress on ABS material is close to the yield strength value of the material. The load variants given are also directly proportional to the results of the yield stress value on the components. This shows that ABS material is more deformable than bamboo composite material. Based on the simulation results of 1st principal and 3rd principal stress, bamboo composites also show better maximum tensile stress and maximum compressive stress capacity when given the load variant when compared to ABS material. Through the simulation results on the components and analysis of the results, it can be concluded that bamboo composites can replace the ABS material in the arm rest components, although there is no significant difference in the mechanical properties of bamboo composite and ABS.

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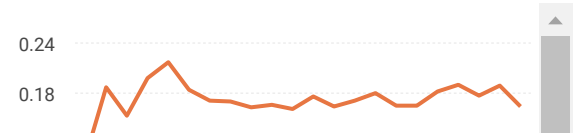

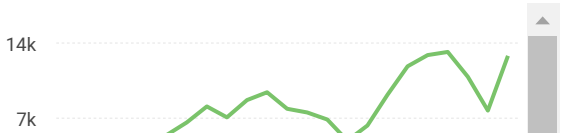

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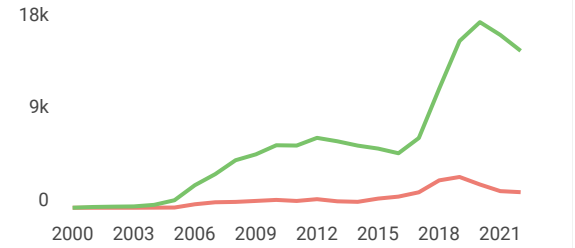

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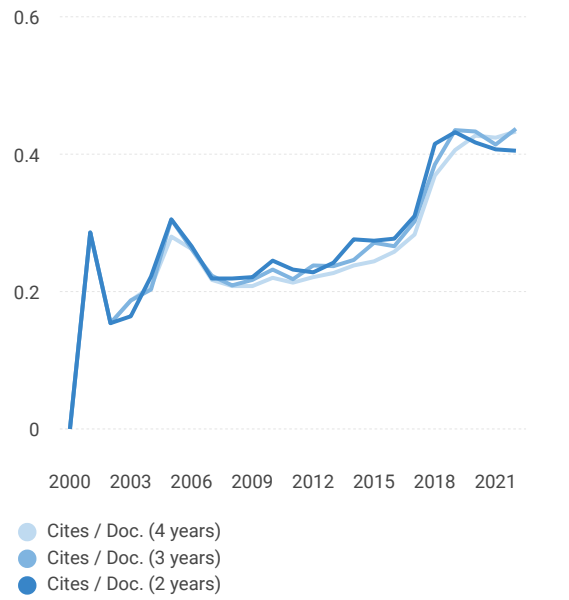

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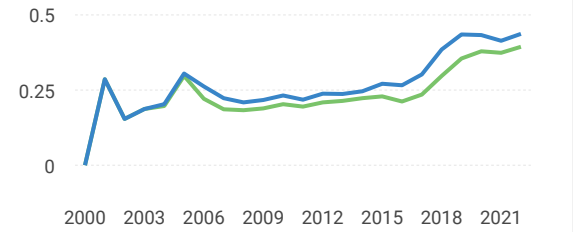

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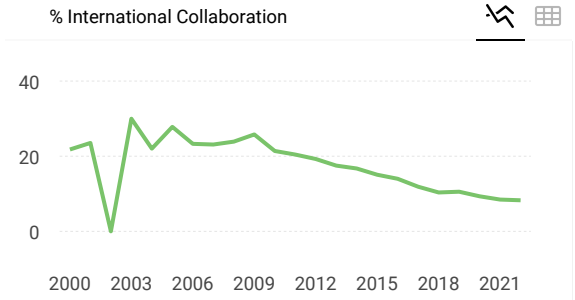

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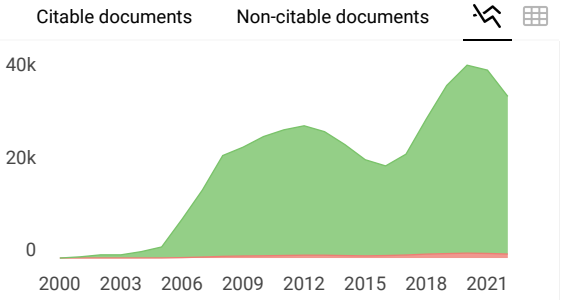

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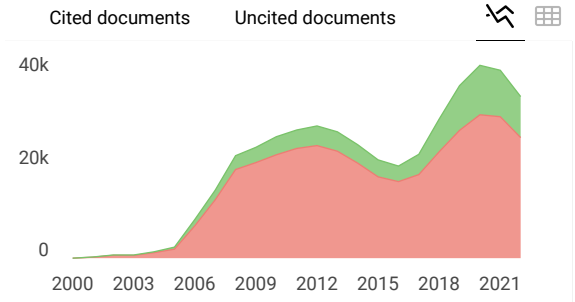

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