Journal Of Metallurgical Engineering And Processing Technology, Vol. 4, No. 1, August 2023, pp. 57-65
P-ISSN: 2723-6854, E-ISSN: 2798-1037

The Influence of Stirring Speed on Tensile strength of Fiberglass Composite using VARI Method

Farhan Rasyid Hidayat[1], Ferry Setiawan[1], Dhimas Wicaksono[1]
[1] Teknik Dirgantara, Jl. Parangtritis No.KM, RW.5, Druwo, Bangunharjo, Kec. Sewon, Kabupaten Bantul, Daerah Istimewa Yogyakarta, 55187.
E-mail: 190102019@students.sttkd.ac.id [1]
+62 897-2173-119

Abstract

This study investigates the influence of stirring speeds variation (50 rpm, 100 rpm, and 150 rpm) on tensile strength of fiberglass composite fabricated by Vacuum Assisted Resin Infusion (VARI) method. The VARI process involves injecting resin into dry fibers placed inside a plastic bag under low pressure, ensuring complete wetting of the fibers. The research aims to identify the optimal stirring speed for composite production by performing tensile tests. Results show that the stirring speed of 150 rpm yields the highest tensile strength, while the 50 rpm variation exhibits the lowest. Photomicrographs reveal the presence of voids in certain area , impacting composite density. The study concludes that stirring speed significantly affects tensile strength and density.
Keywords: *Vacuum Assisted Resin Infusion, Composite, Fiberglass, Physical Metallurgy*

A. Introduction

Global competition in the industrial world today demands innovations in materials engineering that can meet various needs. One innovation in the field of materials engineering is the production of composites. Composites are a new type of engineered material consisting of two or more materials, each with different chemical and physical properties, combined and bonded together in the final composite material (Faruk et al., 2014). Due to differences in constituent materials, strong bonding is necessary, thus requiring the addition of a wetting agent (Robert & Brown, 2004).

The composite production process itself varies, but the process chosen for this research is the Vacuum Assisted Resin Infusion (VARI) method. In the VARI process, dry fibers are placed between a fixed mold and a plastic bag, then resin is injected after creating a low-pressure environment inside the plastic bag. The process continues until all fiber are saturated with resin (Maung et al., 2020).

Compared to conventional processes such as RTM (Resin Transfer Molding), the VARI process is more cost-effective as it does not involve high pressure. Additionally, the VARI process can reduce the occurrence of contamination, which often happens in non-vacuum processes, resulting in suboptimal composite material properties (Goren & Atas, 2008).

Vacuum infusion is a manufacturing method especially in the field of composites that is currently developing. The resulting effect of this technology is to create a composite product that is lightweight, strong and economical. . Composite materials are generally applied to the automotive, aerospace and shipping industries.

Several studies have been carried out related to the process of making composite products in the environment of Mechanical Engineering Students at the Islamic University of Indonesia. The research includes making motorcycle windshields, car mirror covers and flower vases. In the research process, the tools and materials used were not significantly different. The differences that occur from some of these studies include variations in composite materials and the composition of the binding elements (Setyawan, 2019).

In the research process, there were several obstacles in the vacuum process. One of the obstacles that occurs is the occurrence of a blockage at the inlet of the vacuum tube hose. This is due to a blockage by the resin which is also sucked in and hardens in the inlet hole of the vacuum tube (Setiawan & Ardianto, 2018).

This study aims to explore the effect of variations in stirring speed (50 rpm, 100 rpm, and 150 rpm) in the manufacture of fiberglass composite materials using the *Vacuum Assisted Resin Infusion* method. In addition, this study also aims to determine optimal stirringspeed. In this study, the object studied was a composite reinforced by fiberglass, and variations in stirring were carried out at low and high speeds according to a predetermined time limit. Polyester resin is used as the matrix in the composite, and a tensile test will be carried out on the composite specimen. In addition, the calculation of the density of the composite will be carried out based on the results of micro-photo analysis.

B. Research Methods

in this study, the vacuum infusion method was used, where the researcher made a specimen using the Vacuum Assisted Resin Infusion (VARI) process. In the VARI process, mixing the catalyst with the vacuumized resin is used. Then the resin and catalyst that has been mixed until evenly distributed throughout the mold, then fiber is given randomly until it covers the resin and catalyst mixture, then the rest of the resin and catalyst mixture is given again over the fibers until it evenly covers all fibers. After the specimen is made, impact testing is carried out to determine the mechanical strength of the specimen being tested. Then analyze the impact testing data using the equations used and displayed in the form of graphs and tables. This study was used to determine the effect of fiberglass composites with the vacuum infusion method on the impact strength test.

The process of composite manufacturing often commences with the crucial step of fiber determination. This time, we will focus on the meticulous steps involved in preparing fiberglass fiber before it is processed into high-quality composites. All these stages are executed meticulously to ensure a strong and durable end result.

The initial step in this process involves acquiring the necessary fiberglass fiber. The fibers are purchased from a materials store in Yogyakarta with dimensions of 2x1 meters. Consistent fiber dimensions are key to obtaining uniform and reliable composite outcomes.

Once the required fiberglass fiber is obtained, the next step is to cut and shape the fiber to fit the dimensions of the vacuum infusion specimen mold. Precision in cutting and shaping the fiber ensures optimal resin distribution in the subsequent stages.

The mold to be used is also prepared carefully. The mold's edges are cut to allow for the entry and exit of air. Subsequently, the mold is coated with wax mold release to prevent the upcoming resin from adhering to the mold surface.

The next critical step is the random arrangement of the fibers. The fiberglass fibers are placed within the mold in 7 layers. This process ensures an even fiber distribution, providing the necessary strength and reliability in the composite.

A carefully positioned hose connecting the air inlet and outlet is installed, followed by the placement and sealing of a plastic bag using taffy-like adhesive to prevent air leakage into the mold.

The mixing of resin and catalyst is a crucial step. Resin and catalyst are mixed in a 10:1 ratio based on resin weight. This mixture is stirred using a mixer for about 2 minutes to ensure thorough blending.

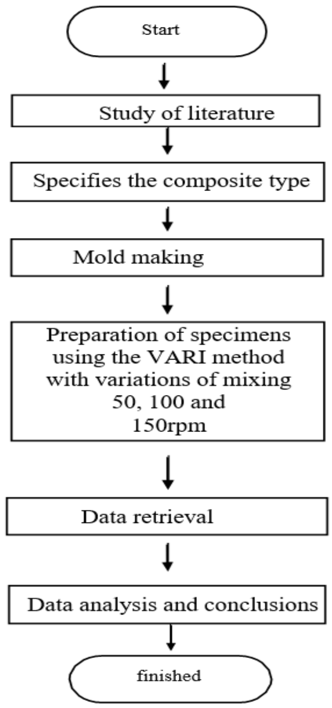
The thoroughly mixed resin is then poured into the prepared mold. The vacuum infusion machine is activated to initiate the process of placing the resin into the fiber.

The inlet hose is connected to the mold, allowing the resin to flow smoothly. As the resin starts to flow through the hose, it is sealed using the taffy-like adhesive to prevent air from entering the mold. The vacuum machine is activated to ensure proper vacuum pressure is established.

The subsequent process involves waiting for approximately an hour to allow the composite to cure. After reaching the desired hardness, the plastic bag is removed, and the composite is lifted from the mold.

Once the composite is successfully extracted from the mold, the next step is to shape the material to ASTM test dimensions. This involves using a milling machine and abrasive paper to achieve the appropriate dimensions before testing is conducted.

Through this process, the composite specimen is ready for tensile testing. All testing data is meticulously recorded for further evaluation. This entire sequence of steps underscores the importance of fiber determination as a critical foundation in creating high-quality composites with the desired strength and performance.



Journal Of Metallurgical Engineering And Processing Technology, Vol. 4, No. 1, August 2023, pp. 57-65
P-ISSN: 2723-6854, E-ISSN: 2798-1037

Figure 1. Flowchart

C. Results and Discussion

1. Tensile Test

The tensile test results of fiberglass composites at various stirring speed are shown in Table 1 are From the table it can be seen that the specimen with the best performance is found in the specimen of the 150 rpm variation, where the load that can be held reaches 469.5 kgf. So for maximum tensile strength produces 123.2 MPa. Then on specimens with variations in rotational speed of 50 rpm the best performance is found in specimen 2, where the load that can be carried reaches 300.01 kgf.

So for the tensile strength it produces 75.3 MPa . In specimens with variations in rotational speed of 100 rpm the best performance is found in specimen 3, where the load that can be carried reaches 425.03 kgf. then the tensile strength produces 103.5 MPa . And lastly, on specimens with variations in rotational speed of 150 rpm, the best performance is found in specimen 1, where the load that can be carried reaches 469.55 kgf. then the tensile strength produces 123.2 MPa.

Table 1. Tensile Test Data

speed variations	Part	Area (mm²)	Max Force (kgf)	Break Force (kgf)	Yield Strength (Mpa)	Tensile Strenght (Mpa)
50 rpm		38,47	261,63	252,01	55,89	66,68
		42,80	328,94	300,01	74,23	75,31
		42,15	305,24	289,95	61,48	71,00
Averages		41,14	298,60	280,66	63,87	71,00
100 rpm		31,76	339,76	339,76	76,68	104,93
		36,27	296,10	294,19	71,09	80,02
		40,46	425,03	425,03	96,20	103,51
Averages		36,16	353,63	352,99	81,32	96,15
150 rpm		42,23	469,55	469,55	99,73	99,83
		43,10	410,27	410,27	84,53	93,35
		32,22	404,82	404,82	114,14	123,17
Averages		39,18	428,21	428,21	99,47	105,45

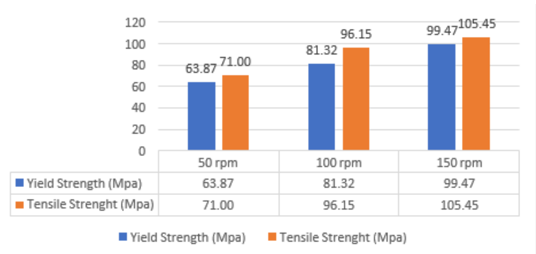


Figure 2. Tensile Test Graph

In Figure 2, the graph of the average tensile strength shows the results of the tensile test of each variation, totaling 9 specimens. The speciment produced with stirring speed of 150 rpm result in highest tensile strength at average value of 105.5 MPa while the lowest tensile was obtained with an average value of 71.00 MPa at speed of 50 rpm.

In the Figure 3. Before embarking on the tensile testing phase, it's essential to investigate the specimen to understand the inherent characteristics of the material before subjecting it to significant tensile forces. This step is crucial in comprehending the initial nature of the material before it undergoes substantial stress.

To begin, the specimens produced through the composite fabrication process are prepared. This involves extracting the composite from the mold after the curing process is complete. At this stage, all the steps outlined in the composite fabrication process should have been meticulously adhered to.

Subsequently, the generated specimens are visually examined to ensure there are no defects or shortcomings in their formation or manufacturing process. The surface of the specimens is inspected to confirm that the resin and fibers are uniformly distributed, without areas that are too thin or void.

The next step involves scrutinizing the texture and surface structure of the specimens. This can be done with the naked eye or by utilizing a microscope if necessary. During this stage, any deviations, cracks, or suspicious structural alterations can be identified before the tensile test is conducted. The specimens should also be weighed to measure their mass accurately. This information will be valuable in calculations and analyses during the upcoming tensile testing.All of these steps aim to acquire a comprehensive understanding of the initial condition of the specimens before subjecting them to tensile testing. This information will aid in interpreting the tensile test results and comprehending how the material responds to external tensile loads. Thus, investigating the specimens before the tensile test is anpivotal phase in a meticulous and comprehensive material testing process.

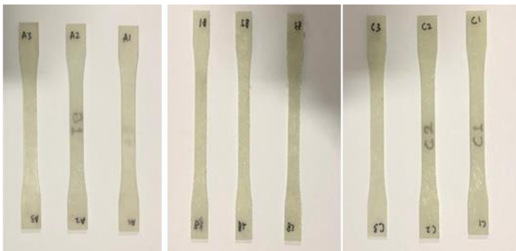


Figure 3. Specimens Before Tensile Testing

Figure 4. Specimens After Tensile Testing

In Figure 4. Tensile test specimens have results where the highest yield strength is obtained by specimens with a variation of 150 rpm and as the stress increases, the yield strength value increases. And for the tensile strength of the material or tensile which has the highest value in the test obtained by the specimen with a variation of 150 rpm.

2. Photo micrographs

Photo micrographs in Fig 5-7 show the fiberglass is randomly distributed in resin matrix. Voids are traced in the specimens.

Upon a close examination of Figure 5, one can readily discern the distinct voids distributed throughout the material. These voids appear as gaps or cavities within the otherwise compact structure. This observation, tied to the 50rpm rotational variation, offers a crucial

Journal Of Metallurgical Engineering And Processing Technology, Vol. 4, No. 1, August 2023, pp. 57-65
P-ISSN: 2723-6854, E-ISSN: 2798-1037

understanding of the material's behavior under specific conditions.

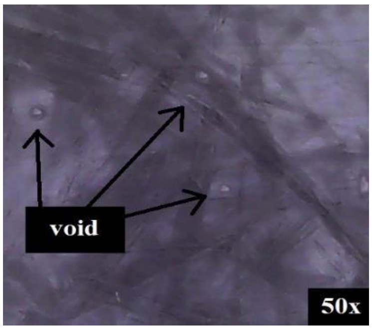


Figure 5. There are many voids (50rpm variation)

Upon close examination of Figure 6, it becomes evident that the fibers are evenly blended with the resin, forming a balanced matrix. Random fibers are also distributed throughout the component. This observation, linked to the 150rpm rotational variation, provides valuable understanding of how fiber distribution impacts material characteristics under specific conditions.

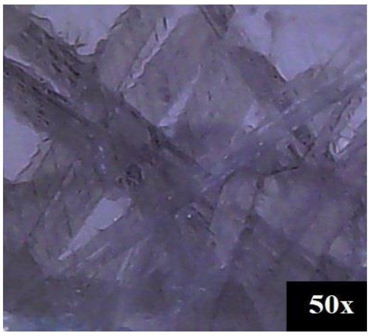


Figure 6. It can be seen that the fibers are evenly mixed with resin and random fibers (150 rpm variation)

Figure 7 provides a discerning perspective on the specimen being examined, highlighting a significant aspect of its composition. This particular figure, extracted from a meticulous analysis, showcases a noteworthy observation: the lack of uniform mixture between the fiber and resin, attributed to the prominent voids present both in the central region and along the edges. This observation is linked to a variation in rotational speed of 100 revolutions per minute (rpm).

Upon a closer inspection of Figure 7, it becomes evident that the fiber and resin are not homogeneously blended as intended. Instead, large voids are visibly present within the material, notably in the central area and extending towards the edges. This insight, correlated with the 100rpm rotational speed variation, imparts crucial understanding regarding the consequences of inadequate mixing in the composite fabrication process.

The presence of such significant voids can profoundly affect the material's structural integrity and overall performance. Voids within the composite can create weak points, diminishing load-bearing capabilities and potentially leading to premature failure. The non-uniform distribution of fiber and resin undermines the composite's ability to withstand mechanical stresses.

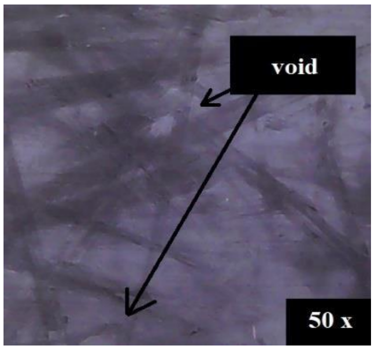


Figure 7. It can be seen that the fiber and resin are not mixed due to the presence of large voids in the middle and on the edges (100 rpm variation)

Conculusion In Figure 5., Figure 6. and Figure 7. you can see some results of micro-photos showing the presence of voids in certain variations, namely, the 50 and 100 rpm variations. In accordance with the test results for calculating the density of specimens with more voids, the density is lighter because voids provide air space for the specimen, which results in the specimen being lighter or having a lower density compared to specimens that do not have voids.

3. Density

The results of weighing and the volume of each specimen are shown in Table 2. Determination of the density is determined by dividing the mass of the results of the scales by the volume of the results of measuring the dimensions of the specimen. An indication of a lighter mass due to the presence of voids in the specimen.

Table 2. Density Calculation

No	Speciment	W (gr)	V (cm³)	Densiy (gr/cm³)	Averages (gr/cm³)
1	A1	8,9	10,032	1,01	1,01
2	A2	9,9	10,032	1,2	
3	A3	8,9	10,032	1,1	
4	B1	10,2	10,032	1.02	
5	B2	11,3	10,032	1,13	1,09
6	B3	11,2	10,032	1,12	
7	C1	12,1	10,032	1,21	
8	C2	12,1	10,032	1,21	1,17
9	C3	11	10,032	1,10	

Table 2 shows that the specimen with the lowest density is found in the 50 rpm variation, while the 150 rpm variation has the highest density in accordance with the results of photomicro graphs which tend to display little voids thereby increasing the weight of the specimen.

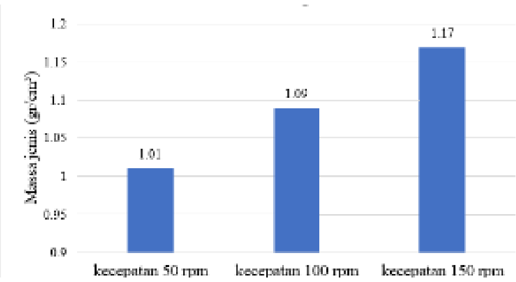


Figure 8. Density Comparison

In Figure 8, it can be seen that the specimen with the 50 rpm variation has the lightest density (1.01 gr/cm^3)among the other specimens, while the heaviest specimen is at the 150 rpm variation, which has density of 1.17 gr /cm³. In accordance with the results of the previous microphoto test, the specimen with the most voids was owned by the 50 rpm variation and the specimen that had no voids was owned by the 150 rpm variation.

D. Conclusion

This study evaluates the effect of stirring speed on the tensile strength of the composite. The results of the tensile test showed that the 150 rpm variation had the highest tensile strength, while the 50 rpm variation had the lowest tensile strength. This shows that the stirring speed affects the increase in the tensile strength of the composite. The results of photo micrographs indicate that low mixing speed causes more voids in the composite compared to high speed, which can reduce tensile strength because it creates voids in the material. The density test also shows that the presence of voids will decrease the density value of the composite due to air voids in it, while reduced voids will increase the density of the composite due to reduced air voids in the material structure.

References

Faruk, O., Bledzki, A. K., Fink, H. P., & Sain, M. (2014). Progress report on natural fiber reinforced composites. *Macromolecular Materials and Engineering*, *299*(1), 9–26. https://doi.org/10.1002/mame.201300008

Goren, A., & Atas, C. (2008). Manufacturing of polymer matrix composites using vacuum assisted resin infusion molding. *Archives of Materials Science and Engineering*, *34*(2), 117–120.

Maung, P. P., Htet, T. L., & Malysheva, G. V. (2020). Simulation and optimization of vacuum assisted resin infusion process for large-sized structures made of carbon fiber-reinforced plastics. *IOP Conference Series: Materials Science and Engineering*, *709*(2). https://doi.org/10.1088/1757-899X/709/2/022041

Peters, R. J. B., Bouwmeester, H., Gottardo, S., Amenta, V., Arena, M., Brandhoff, P., Marvin, H. J. P., Mech, A., Moniz, F. B., Pesudo, L. Q., Rauscher, H., Schoonjans, R., Undas, A. K., Vettori, M. V., Weigel, S., & Aschberger, K. (2016). Nanomaterials for products and application in agriculture, feed and food. *Trends in Food Science and Technology*, *54*, 155–164. https://doi.org/10.1016/j.tifs.2016.06.008

Robert, B., & Brown, E. B. (2004). *TEKNOLOGI MATERIAL KOMPOSIT By: Nurun Nayiroh A. Pengertian Material Komposit (komposit) Komposit*. *1*, 1–14.

Setiawan, F., & Ardianto, H. (2018). Karakteristik Sifat Mekanis Kekuatan Tarik Komposit Nanopartikel Daur Ulang PET dengan Limbah Abu Bagase Boiler. *Teknika STTKD: Jurnal Teknik, Elektronik, Engine*, *Vol. 5(2)*(2), Pp. 30-44.

Setyawan, A. D. (2019). *Perancangan Dan Pembuatan Filter Resin Untuk Proses Pembuatan Komposit Dengan Metode Vacuum Infusion*. https://dspace.uii.ac.id/handle/123456789/13898

Alamsyah, Alamsyah Hidayat, Taufik Iskandar, Arif Nur (2020) . Pengaruh Perbandingan Resin Dan Katalis Terhadap Kekuatan Tarik Komposit Fiberglass-Polyester Untuk Bahan Pembuatan Kapal.

ANTON J. Hartono. (1992). Mengenal keramik canggih cerdas dan biokeramik / Anton J. Hartomo. Yogyakarta:: Andi Offset,.

Fandhy Rusmiyanto , (2007), Pengaruh fraksi volume serat terhadap kekuatan tarik dan kekuatan bending komposit nylon/epoxy resin serat pendek random.

Goren, A , (2008). Manufacturing of polymer matrix composites using vacuum assited resin infusion moulding.

Gibson, O.F , (1994), Mechanics of Composite Material, MC Graw Hill, New York..

Mathew, D. R , (1994). Composit Matarial: Engineering and Science. . London: Chapman and Hall.

Mortars. Journal Material Research , 645-649.

Putranto, Beny , (2011) . Perancangan Alat Uji Impak Charpy untuk Material Komposit Berpenguat Serat Alam (Natural Fiber).

Ryan, M , (2022). Tinjauan Intesitas Prosedur Produk Atap Genteng Berbahan Komposit Fiberglass. Jurnal Ilmiah Mahasiswa Teknik.

Sadrach Alendo Putra (2022) . Pengaruh

FLAY ASH Pada Komposit Epoxy Hardener Dengan Variasi Putaran Terhadap Kekuatan Tarik.

Salamun, B. A , (2017). PERANCANGAN DAN PEMBUATAN ALAT VACUUM INFUSION. Yogyakarta: UMY.

Setiawan F, A. H. (2018). Karekteristik Sifat Mekanis Kekuatan Tarik Komposit Nano Partikel Daur Ulang PET Dengan Limbah Abu Bagase Boiler. 30-44.

Syahputra (2020) . Tugas Akhir Pengaruh Tingkat Kevacuman Terhadap Kekuatan Tarik Impact Komposit yang diperkuat dengan Serat kaca.