Nano World Journal

https://doi.org/10.17756/nwj.2023-s3-150

Research Article

Open Access

Examining the AA7475 + ZrN + Fly Ash Reinforcement Composite CNC Machining Material Removal Rate Using High Speed Steel and Novel TiAlN Coated WC Tools

Doddala Nitheesh and P. Thamizhvalavan*

Department of Mechanical Engineering, Saveetha School of Engineering, Saveetha Institute of Medical and Technical Sciences, Saveetha University, Chennai, Tamil Nadu, India

***Correspondence to:**
P. Thamizhvalavan
Department of Mechanical Engineering,
Saveetha School of Engineering,
Saveetha Institute of Medical and Technical Sciences,
Saveetha University,
Chennai, Tamil Nadu, India.
E-mail: thamizhvalavanp.sse@saveetha.com

Received: July 31, 2023
Accepted: November 01, 2023
Published: November 03, 2023

Citation: Nitheesh D, Thamizhvalavan P. 2023. Examining the AA7475 + ZrN + Fly Ash Reinforcement Composite CNC Machining Material Removal Rate Using High Speed Steel and Novel TiAlN Coated WC Tools. *Nano World J* 9(S3): S842-S846.

Published by United Scientific Group

Abstract

By contrasting two different types of tools on the reinforcing composite (Lightweight material AA7475 + ZrN + fly ash), the goal of this work is to develop a good MRR. The novel material AA7475 + ZrN + fly ash manufactured by stir casting technique. The casted composite was pre-processed for removing surface irregularities and did workpieces for CNC machining. 16 were determined to be the necessary sample size for each group, therefore the same procedure was followed. For green production (dry machining), the spindle rotational speed (m/min), depth of machining (mm), and feed level (mm/rev) at four levels in 16 different combinations. MRR comparison of the functionality of high speed steel (HSS) and TiAlN coated WC tools on machined surfaces. With the use of SPSS software, the MRR of samples was statistically evaluated by group. The p value for these results is 0.000 ($p < 0.05$), indicating that there was a statistically significant difference between the two groups. This demonstrates that the observations are statistically independent and made without violating any rules. In comparison to samples prepared with HSS tools, samples prepared with WC tools coated with TiAlN have a higher mean material removal rate. Within the limits of this investigation, TiAlN coated WC tool yields higher MRR than HSS tool.

Keywords

High speed steel tool, TiAlN coated WC tool, Light weight material, AA7475, Titanium diboride, Boron carbide, CNC machining, Material removal rate, Novel material, Green manufacturing, Stacking sequence

Introduction

This study is near investigating and evaluating the MRR of the milled AA7475 surfaces and the use of HSS tool and TiALN coated WC tool [1]. The important gain of these paintings is to cut back the product's cost, growth of the same old MRR and growth in the meeting fee.

Composites of light weight material novel AA7475 + ZrN+ fly ash is regularly applied with inside the vehicle sectors and aerospace, and it are regularly applied with inside the fabrication of ribs of the wings in aero vehicles [2]. Studies on the AA7475 + ZrN + fly ash reinforcement composite have resulted in around 260 papers on Google student and 71 papers on Technology Direct over the past five years. This usage will enhance the manufacturing components within in a way that also increases the quality of the items.

Currently low weight and minimal energy of the aluminum alloys are progressed with the aid of using mission reinforcement tactics [3]. The reinforcement procedure is a technique to combine the tough ceramic debris in unique weight possibilities into base materials. Reinforcement tactics grow the energy of the elements and enlighten every property, specifically mechanical

properties, thermal and electric properties [4]. Particle size and reinforcing levels are the main determinants of how a material's properties vary. Silicon carbide, titanium carbide, titanium nitride, titanium diboride, boron carbide, zirconium nitride, aluminum oxide, and other strong materials constitute the most common trash. In comparison to other elements like the severity of the reduction and the reducing velocity, the feed fee becomes the most important characteristic of the output response of surface roughness [5].

Further the exquisite floor end become acquired with the ingesting of the bottom electricity level. Development of stir casting course presents the wholesome care to reinforcement procedure, the stir casting procedure is operated at chronic velocity with assigned term. Uniform velocity and stuck term make a constant aggregate of the bottom cloth with strengthened debris [6]. Our group has large information and studies experience that has translated into excessive fine courses like. Hence, In these studies blending four wt% of titanium diboride (ZrN) and three wt% of boron carbide (fly ash) into AA7475 aluminum alloy homogeneously with the aid of using stir casting tactic [7].

The machinability research to be conducted. Economically additionally, effective machining is regularly finished at CNC Green machining. No literature become determined at the machinability of novel material AA7475 + 4% of ZrN + 3% of fly ash cloth, specifically CNC milling. This looks at addresses the machinability of AA7475 + 4% of ZrN + 3% of fly ash cloth in CNC milling [8].

Materials and Methods

The Saveetha Institute of Medical and Technical Sciences in Chennai, which houses the Saveetha School of Engineering, conducted this study. Since no human samples were used in this study for testing, ethical approval was not necessary. In this experiment, two groups the control group (HSS tool) and the experimental group (TiAlN coated WC tool) are compared. Since there should be 16 different groups, there should be 16 samples for each group. using an open-source sample size calculation tool, the specified sample size was determined.

The sample means are 0.9675 for the conventional approach and 0.9773 for the suggested approach, with a g-power of 85% and an alpha level of 0.05 [9]. The reinforcement materials and aluminum were purchased from Bhandari Metals and Alloys in Chennai, Tamil Nadu, India. The novel material AA7475 + 4% ZrN + 3% fly ash was stirring cast into an aluminum steel matrix at the Metmech casting plant in Chennai, Tamil Nadu, India (Figure 1).

The matrix used is: AA7475 (3.2 kg, 93%), titanium diboride ZrN (0.13 kg, 4%) and boron carbide fly ash (0.096 kg, 3%). The specimens have been organized through reducing the casting with assistance of wire reduce discharge machining. The 16 samples are shown in figure 2, which shows the samples organised with dimensions of 50 × 50 × 10 mm. The images taken a) before and b) after machining show that the contour profile was machined at the top floor of each specimen [10]. A 200 mm rectangular contour with a five mm depth was machined; the sharp edges are well-machined for smooth

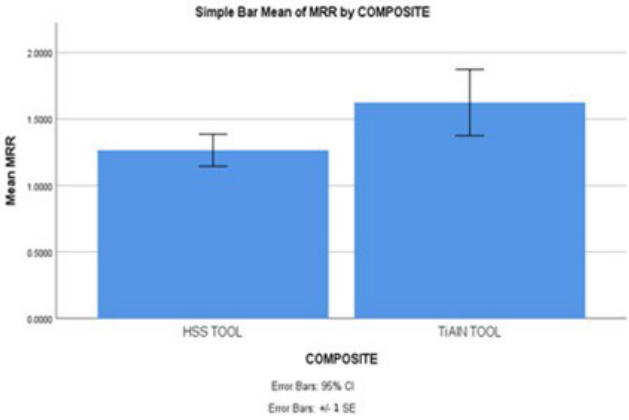

Figure 1: Stir casting process.

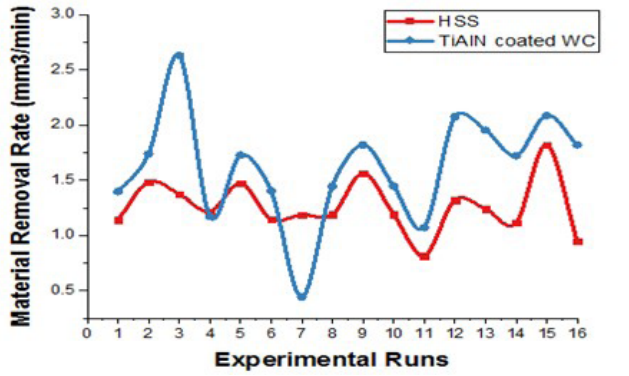

Figure 2: Shows the samples before and after machining with 16 different combinations of input parameters.

curve edges.

With the use of CNC vertical machines, all contour profiles must be produced. Despite using the same painting material for each group, organization B is an intervention organization through which samples are to be machined with TiAlN lined WC devices with sixteen distinct combos of enter parameters as accompanied for the manage organization. Used for conducting machining experiments is the Vertical Milling Centre YCM-EV 1020A, spindle speed 45-1,000 RPM, spindle nose taper BT40, and spindle motor (Standard) (cont./15 min.) 5.5 - 7.5 kW. The weights of the pattern before and after machining are entered into equation 1 to determine the MRR. Weight loss from machining = Volume of cloth removal rate after the pattern has been machined for a predetermined amount of time, the fabric's density is considered to calculate the MRR using the pattern's weights before and after machining [11]. The way they behaved consistently and frequently was taken into account for avoiding mistakes. The entry specifications shown in table 1. When given the settings for the CNC green machining operation, during CNC machining, this artwork had 3 parameters and 4 steps removed. The experimental research summary of the material removal rate (MRR) using gear, notably HSS and TiAlN lined WC, was presented in table 2.

Statistical analysis

'IBM SPSS information 26' programme is used

to administer statistical analysis. The objective pattern examination was carried out to assess the strategies used by each management organisation and intervention organisation. Reduction speed, feed rate, reduction intensity, and MRR are the independent variables. The use of impartial samples and statistical tests like the t-test was undertaken. They had an impact, and as a result the evaluating approach bar graph had been acquired [12].

Results

The calculated Material Removal rate (MRR) price for samples of each organization (sixteen samples in keeping with organization) are statistically analysed. The intervention organization (TiAlN coated WC) imply (1.53217 mm^3/min) is considerably decrease than the imply (1.25950 mm^3/min) of the manipulate a system of checks (HSS). As a result, the MRR significantly improved when using TiAlN coated WC devices as opposed to samples that were machined using conventional HSS tools. The specification of the applied inputs from the sixteen test types is provided in table 1. The MRR of samples that were machined with the help of HSS tools is shown in table 2. an MRR of samples that have been machined utilising tools made of HSS. The MRR ranges in value between 0.44 and 2.632. Table 3 is famous for the results of the t-test, including means, current deviation, and current deviation errors of TiAlN coated WC device and HSS organisations. The results of the Independent pattern check to look at the significance check are shown in table 4. The creation of a unique, light-weight fabric using AA7475, 4% ZrN, and 3% fly ash is shown in figure 1. Figure 2 displays photographs of the 16 specimens before and after machining, during which the contour profile was machined on the top floor of each specimen. With a five mm depth, a 200 mm rectangular contour was machined; the sharp edges are correctly machined for simple curve edges. CNC vertical machines will be used to machine all the contour profiles. Figure 3 shows the 16 experimental runs with the material removal rate response price. Figure 4 displayed the examination of organisational mean at the 1 modern deviation level.

Table 1: Machining parameters.

Factors	Level 1	Level 2	Level 3	Level 4
Cutting speed (rpm)	500	700	900	1100
Feed (mm/min)	2	4	6	8
Depth of cut (mm)	0.2	0.4	0.6	0.8

Table 2: Material removal rate obtained by using HSS tool and TiAlN coated WC tool.

Exp. Runs	Cutting speed (rpm)	Feed (mm/min)	Depth of cut (mm)	Material removal rate (mm^3/min)	
				HSS	TiAlN coated WC
1	500	2	0.2	0.78	1.456
2	500	4	0.4	0.784	1.321
3	500	6	0.6	0.845	1.234
4	500	8	0.8	0.794	1.012
5	700	2	0.4	0.876	1.341
6	700	4	0.2	0.823	1.471
7	700	6	0.8	0.789	1.198
8	700	8	0.6	0.889	1.278
9	900	2	0.6	0.926	1.561
10	900	4	0.8	0.863	1.21
11	900	6	0.2	0.884	1.456
12	900	8	0.4	0.897	1.564
13	1100	2	0.8	0.985	1.61
14	1100	4	0.6	1.12	1.546
15	1100	6	0.4	1.067	1.621
16	1100	8	0.2	0.998	1.676

Discussion

The highest MRR was determined to be 1.484 (mm^3/min) using the HSS device with conditions of 500 m/min of speed, four mm of intensity of reduction, and 0.four mm/rev of feed. The highest MRR was measured with a titanium carbonitride lined WC cutter at 2.632 (mm^3/min) with a 500 m/min speed, a 6 mm intensity of reduction, and a 0.6 mm/rev feed. The computed results show that TiAlN lined WC devices provide superior MRR than HSS devices.

The significance test result is substantially less than 0.05 ($p < 0.05$). The results might be approved. When an increased MRR is offered by an excessive lowering velocity, reduced reducing intensity, and excessive feed [13].

Table 3: Results of a t-test for a sample of the composite material AA7475 + ZrN + fly ash that was machined using two different techniques. HSS and TiAlN coated WC tools are used to machine group A samples and group B samples, respectively. The proposed method's sample means (Group B) are much lower than those obtained using the traditional HSS tool in sample group A.

	Composite	N	Mean	Std. deviation	Std. error mean
MRR	HSS	16	0.895	0.1021045	0.88981
	TiAlN coated WC	16	1.4096	0.188444	1.39722

Table 4: Results of independent samples tests for CNC milling of the reinforced composite material made of AA7475, ZrN, and fly ash using traditional HSS tools (Group 1) and a suggested TiAlN-coated WC tool (Group 2). Because the significance value of 0.042 is less than 0.05, the obtained results are statistically significant.

	F	Sig.	t	df	Sig. (2 tailed)	Mean difference	Std. error difference	95% confidence interval of the difference	
MRR								Lower	Upper
Equal variances assumed	4.64	0.042	-1.6	22	0.117	-0.272667	0.167014	-0.61922	0.073886
Equal variances not assumed			-1.6	13.95	0.125	-0.272667	0.167104	-0.631182	0.085849

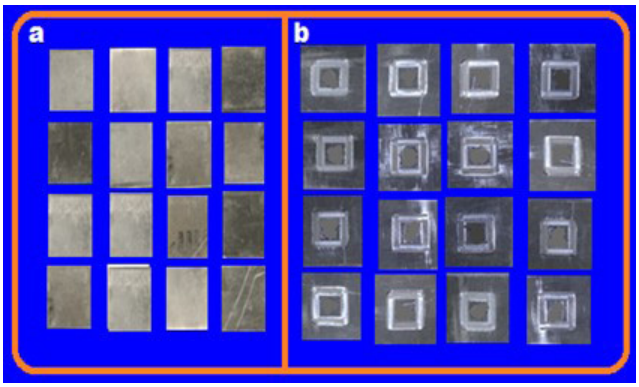

Figure 3: Shows the output variance when changing the inputs in 16 different combinations throughout the course of 16 trial runs. While experiment 7 produced low MRR for the coated tool, experiment 3 displays a greater MRR.

Figure 4: Demonstrates the G graph for coated and uncoated tool cutters' dominance in material removal rate. The TiAlN coated WC cutter from these cutters produced excellent MRR despite variations in cutting speed, feed, and cut depth.

They exhibit deft statistical significance with a significance truly well worth $p < 0.05$ when compared to the HSS device, the MRR of the composite was dramatically reduced when the TiAlN lined WC device was used. Additionally, unit intensity of reduction and feed fee are two criteria that have been affecting MRR. MRR will also grow if feed price and reduction intensity rise. [14] supported this it is frequently said that MRR turned into stepped forward with the aid of using 29.78% with the usage of TiAlN lined WC device than traditional HSS device. Way to the use of a minimum variety of enter parameters also utilization of lined carbide device in CNC green machining turned into applied newly organized bolstered composites (Novel material AA7475 + ZrN + fly ash). Additionally, this discovery proved that the TiAlN lined WC device is suitable for this specific composite to induce maximised MRR since enlarged MRR is required for each utility to induce stepped forward MRR. Due to the TiAlN lined WC device's widespread use for CNC machining, particularly contour milling with this widest possible range of input parameters.

This work examines experimental evaluation of the CNC (VMC) drilling process to assess the influence of decreasing parameters to get the highest quality of drilled holes on material, of which improved speed, better feed rate, and decreased intensity of reduce delivers maximised MRR for this composite. Oftentimes, Taguchi L9 is effectively used to measure the impact of the approach parameters on the output variables. These findings could allow the meeting of squeeze solid additives with better stages of MRR. During these studies, handiest 3 elements particularly squeeze pressure, die preheating temperature, and dye fabric are taken into consideration [15, 16].

From the aforementioned considerations, it is evident that in addition to well-known entrance characteristics (feed, velocity, and intensity of decline), device hardness and lowering region temperatures have a considerable impact on MRR. Because the TiAlN lined WC device is so much more difficult to use than the HSS device, the outcomes were better (an extended MRR).

Though the outcomes stepped forward considerably these studies capabilities have some limitations. As this observe centered on green production it would not bear in mind coolant outcomes on MRR however coolant will considerably contribute to decreasing the MRR. The observation turned into restricted to the use of TiAlN lined WC device to increase MRR. Hence this observe will be prolonged with the aid of using thinking about particularly lined more difficult equipment apart from that taken into consideration at some point of this observe additionally as along with cooling outcomes like moist machining, minimum liquid amount cooling, cryogenic cooling, and many others for growing the MRR values furthermore.

Conclusion

The CNC milling of novel material AA7475 + ZrN + fly ash reinforcement composite with HSS and TiAlN coated WC gear was compared for increasing MRR according to the rules of this study. The outcome shows that the institution's sample-processing method used machines with TiAlN covered WC devices resulted in significantly less floor roughness than HSS tool. Consequently, MRR was enhanced on average by a factor of 20.94%.

Acknowledgements

None.

Conflict of Interest

None.

References

1. Sathish T, Sunagar P, Singh V, Boopathi S, Al-Enizi AM, Pandit B, et al. 2023. Characteristics estimation of natural fibre reinforced plastic composites using deep multi-layer perceptron (MLP) technique. *Chemosphere* 337: 139346. https://doi.org/10.1016/j.chemosphere.2023.139346
2. Sathish T, Maheswari SU, Balaji V, Nirupama P, Panchal H, et al. 2023. Coastal pollution analysis for environmental health and ecological safety using deep learning technique. *Adv Eng Softw* 179: 103441. https://doi.org/10.1016/j.advengsoft.2023.103441
3. Thanikodi S, Britto AS, Dattu VS, Al Obaid S, Alfarraj S, et al. 2023. Machining and mechanical characterization of friction stir processed

(FSP) surface hybrid composites (AA8014 + TiB 2+ ZrO_2). *Int J Adv Manuf Technol* 2023: 1-8. https://doi.org/10.1007/s00170-023-12198-z

4. Sathish T, Kamaraj L, Mohanavel V, Jazaa Y, Qahtani F, et al. 2023. A novel technique implementation to fabricate and analysis of AZ91D with TiN through FSP. *Int J Adv Manuf Technol* 2023: 1-6. https://doi.org/10.1007/s00170-023-12024-6
5. Thanikodi S, Saragada DV, Kumar ME, Akram PS, Rathinasamy S, et al. 2023. Optimizing reinforcement quantity and synthesizing parameters of iron/fly ash/CNT nanocomposite. *Int J Adv Manuf Technol* 2023: 1-9. https://doi.org/10.1007/s00170-023-11842-y
6. Babu SV, Ushasree J, Soundararajan M, Dubey S, Sathish T, et al. 2023. Comparative analysis of load transfer efficiency in plain and continuously reinforced concrete pavements. *Mater Today Proc*. In Press. https://doi.org/10.1016/j.matpr.2023.08.075
7. Ravindran S, Mohanrajhu N, Urade AD, Gori Y, Kumar RR, et al. 2023. Study of microstructural, chemical and microhardness characterization of stainless steels. *Mater Today Proc*. In Press. https://doi.org/10.1016/j.matpr.2023.06.388
8. Balamurugan K, Shanmugam V, Palani G, Sundarakannan R, Sathish T, et al. 2023. Effect of TiC/RHA on solid particle erosion of Al6061 hybrid composites fabricated through a 2-step ultrasonic-assisted stir casting process. *J Mater Res Technol* 25: 4888-4900. https://doi.org/10.1016/j.jmrt.2023.06.225
9. Parthiban A, Sathish S, Suthan R, Sathish T, Rajasimman M, et al. 2023. Modelling and optimization of thermophilic anaerobic digestion using biowaste. *Environ Res* 220: 115075. https://doi.org/10.1016/j.envres.2022.115075
10. Saravanan R, Sathish T, Vijayan V, Rajkumar S, Sharma S, et al. 2023. Eco-friendly MoS2/waste coconut oil nanofluid for machining of magnesium implants. *Rev Adv Mater Sci* 62(1): 20220296. https://doi.org/10.1515/rams-2022-0296
11. Jegan CD, Selvakumaran T, Karthe M, Hemachandu P, Gopinathan R, et al. 2023. Influences of various metal oxide-based nanosized particles-added algae biodiesel on engine characteristics. *Energy* 284: 128633. https://doi.org/10.1016/j.energy.2023.128633
12. Sivasankar GA, Moorthy CB, Kaliappan S, Sathyamurthy R, Sathish T, et al. 2023 Sustainable nano-added biofuel production from borassus flabellifer oil for conventional internal combustion engines. *Energy* 282: 128381. https://doi.org/10.1016/j.energy.2023.128381
13. Vijayalakshmi A, Meena RS, Domakonda VK, Rao AV, Sathish T, et al. 2023. Maximizing sustainable hydrogen and ZnO nanoparticles production from goshala wastes with nanoparticles of $ZnSO_4$ and $NaBH_4$. *Fuel* 349: 128625. https://doi.org/10.1016/j.fuel.2023.128625
14. Sajjad MO, Sathish T, Saravanan R, Asif M, Linul E, et al. 2023. Combustion, performance and emission discussion of soapberry seed oil methyl ester blends and exhaust gas recirculation in common rail direct fuel injection system. *Energy* 278: 127763. https://doi.org/10.1016/j.energy.2023.127763
15. Sathish T, Saravanan R, Sharma K, Zahmatkesh S, Muthukumar K, et al. 2023. A novel investigation on medical and non-medical mask performance with influence of marine waste microplastics (polypropylene). *Mar Pollut Bull* 192: 115004. https://doi.org/10.1016/j.marpolbul.2023.115004
16. Sathish T, Ağbulut Ü, George SM, Ramesh K, Saravanan R, et al. 2023. Waste to fuel: synergetic effect of hybrid nanoparticle usage for the improvement of CI engine characteristics fuelled with waste fish oils. *Energy* 275: 127397. https://doi.org/10.1016/j.energy.2023.127397