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Novel improvement of surface roughness for AA6020 using AlTiN coated HSS tool in comparison with uncoated HSS tool using surface roughness tester.

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Abstract

Aim: The Main motive of this research is to detect surface roughness using surface roughness tester and analyse the enhancement of surface roughness for AA6020 using AlTiN coated HSS tool and compare the results with uncoated HSS tool. **Materials and Methods:** In this investigation, AA6020 of length 20mm and diameter 25mm is used. There are 2 groups in this research, the experimental group which is the AA6020 samples drilled with AlTiN coated HSS tool and control group which is the AA6020 samples drilled with uncoated HSS tool. According to the calculation of G power, the sample size is derived to be 20 per group which makes the total sample size to be 40. The surface roughness test is carried out according to the ASTM standards.**Results:** An analysis of the results of surface roughness, it is observed that the average surface roughness for experimental group(AA6020 drilled with AlTiN coated HSS drill) is 1.36065µm. and for control group(AA6020 drilled with uncoated HSS drill) is 2.05065µm . On comparison of the results using ANOVA test f/or both the groups, it is noted that there is a significant decrease in surface roughness in the experimental group with significance level of 0.00 (P<0.05). **Conclusion:** Within the limitations of this study, we can conclude that AA6020 drilled with AlTiN coated HSS drill gives better results for surface roughness than AA6020 drilled with uncoated HSS drill.

Keywords: Novel Aluminium alloy, AA 6020, CNC drilling, coated HSS drill, Surface Roughness, ANOVA test, SPSS software.

DOI: 10.47750/pnr.2022.13.S03.018

INTRODUCTION

Business Aluminum composite 6020 (AA6020) is a medium strength amalgam with adequate formability,greatweldability and heavenly erosion opposition. AA6020 is utilized as a primary amalgam,and it is the most normal composite utilized for machining purposes (Jaeggi et al. 2022) . Nonetheless , AA6020 grade has great properties like lightweight,consumption obstruction ,flexibility, formability and conductivity. However on the other hand it has low hardness(Leão et al. 2021) . Because of these properties,the working spaces of AA6020 should be picked effectively (Sandeep Kumar Ravesh November- December 2012) . Novel aluminiumalloy combinations are regularly utilized for a gigantic scope in numerous applications like auto businesses, aviation, transport enterprises and rail lines(Kant and Goel 2021).

Based on the past 5 years of literature research, it is found 850 papers in google scholar and 1000 papers in science direct based on surface roughness. Lately, interest for microparts and parts have expanded in various modern areas. Instances of such parts incorporate, however are not restricted to, the accompanying connectors, symptomatic gadgets, microreactors, clinical inserts, microengines, switches, micropumps, drug conveyance frameworks, and printing heads(Zhu 2008). One significant use of miniature processing is the assembling of waveguides for gigand terahertz application.With expanding recurrence, the frequency is moving toward the lower µm-reach and surface quality become progressively significant(Yuan, Ohmori, and Lv 2012)

(Yuan, Ohmori, and Lv 2012). The waveguide proficiency is affected essentially by the surface roughness. Surface roughness altogether impacts the reflection and influences the sign commotion proportion(Singh et al. 2021). It was investigated that the exact control of the assembling system is important to guarantee the dependable manufacture of these parts.(Ashwath and Anthony Xavior 2016). One of the best pieces of literature for this research is (Singh et al. 2021)Our team has extensive knowledge and research experience that has translate into high quality publications(Bhansali et al. 2021; Jayanth et al. 2021; Sudhakar, Ravel, and Perumal 2021; Sathiyamoorthi et al. 2021; Deepanraj et al. 2021; Raju et al. 2021; Arun Prakash et al. 2020; Kamath et al. 2020; Shanmugam et al. 2021; Rajasekaran et al. 2020; Adhinarayanan et al. 2020; Rajesh et al. 2020; Aurtherson et al. 2021)

The miniature processing interaction can be just downsized somewhat. Nonetheless, new difficulties emerge on the innovative and on the material part when a basic grade of scaling down is reached (Almulhim et al. 2021). Thus the affecting variables and their conduct on microscale should be concentrated exhaustively. Various factors impact surface uprightness, for example instrument properties,cutting boundaries, workpiece properties utitized GRP to accomplish enhancement of drilling measure exhibition attribute for example hardness greatest, unpleasantness normal and roundness(Leão et al. 2021).

MATERIALS AND METHODS

The fabrication and machining for research has been carried out in Saveetha industries, Saveetha School of Engineering, Saveetha University, Saveetha Institute of Medical and Technical Science, Thandalam, Chennai, utilizing the facilities in the mechanical department. In this research, the AA 6063 was used as the base metal. The experimental setup was carried out in (Super Jobber) CNC drilling center using an AlTiN coated HSS drill and an Uncoated drill. The experimental setup of the CNC drilling center was shown in Fig.1. Using a value of 80 percent in the G power calculator with standard deviation (0.05) and mean (0.2) , the obtained sample count was 20 per group (Jaeggi et al. 2022). A total of two groups were used for this research (control group and intervention group).

There are 2 groups in this research, the experimental group which is the AA6020 samples drilled with AlTiN coated HSS tool and control group which is the AA6020 samples drilled with uncoated HSS tool. According to the calculation of G power, the sample size is derived to be 20 per group which makes the total sample size to be 40. The surface roughness test is carried out according to the ASTM standards.

In this investigation the chemical composition is shown in Table 1.Super Jobber CNC drilling machine was used for conducting this investigation. Fig. 1 shows the cnc drilling machine setup.The 8mm of diameter AlTiN Coated and 8mm of diameter AlTiN Uncoated HSS Drill Bits are Used. Totally 20 samples were carried out in each group.Fig. 2 shows the samples drilled with Coated HSS Drill bit and Uncoated HSS Drill Bit the preparation of samples and CNC drilling of the samples as per design are carried out at Saveetha industries, Saveetha school of engineering, Saveetha institute of medical and technical science, Chennai. Utilizing the faculties in the department of mechanical engineering.

For machining tests in the control group, an AA6020 rod of 25mm diameter is separated to the length of 20mm. Then, at that point an uncoated HSS drill instrument of 8mm width is utilized for machining the samples by varying the speed and the feed rate in the CNC drilling focus. The uncoated drill instrument displayed in Fig.2 A sum of 20 samples were drilled Fig.3 shows the drilled samples of the uncoated instruments. The examples in the trial group were machined comparatively as that of the control group, yet an AlTiN covered with HSS drilled instrument 8mm breadth is utilized.

An entire sample was drilled utilizing these devices. Fig.4 shows the drilled samples of the HSS Coated drill tool.the surface roughness of the example where obtained utilizing a surface roughness analyzer. The surface roughness analyzer was displayed in Fig.5. The tests were directed on 20 samples in each gathering according to ASTM D7127 - 17 norm displayed in Fig.6.

Statistical analysis

The SPSS programming Group was used in this exploration for factual investigation. The ANOVA test (analysis of variance) in SPSS software is used for statistical analysis. The Group 1 and Group 2 values have been plotted. The cutting speed (m/min) and feed rate (mm/rev) are independent and the surface roughness is a dependent variable ((Singh et al. 2021)).

RESULTS

In this investigation the correlation was made on surface roughness machined tests of AlTiN coated HSS Drill Bit as (experimental group) and samples of Uncoated HSS Drill Bit (Control Group) Fig.7 shows the graph value of Surface Roughness of Experimental Group and control group. Table 2 showed the mean value of the surface roughness for the experimental group and it is observed to be 1.36065 µm. and the mean value of surface roughness for the control group was observed to be 2.05065 µm. Table 3 shows the mean descriptive values of surface roughness for the AlTiN coated and Uncoated drill. The 0.00 ($P<0.050$) has obtained a statistical significance value for this investigation. From the obtained values it clearly shows that the experiential group has better surface completion contrasted with the control group and it shows the outcomes acquired from the ANOVA test in SPSS software.

DISCUSSION

The samples machined utilizing AlTiN Coated HSS Drill Bit (Experimental Group)have better surface completion contrasted with the Uncoated HSS Drill Bit (Control group) Table 3 have explained detail which shows the mean value of surface roughness value for the Experimental Group and Control Group.Table 4 assist with understanding the analysis of variance (ANOVA TEST) Between both the groups. It is likewise tracked down that the surface roughness mean of the experiential group is better compared to the Control Group in surface roughness analyzer and in the statistical analysis.(Juijerm 2007).

Concentrated on the impact of utilization of cutting fluids during machining cycles of business matured solidified AA6020 -T6 grade. They revealed that the devices with the interior cooling framework are extremely successful when contrasted with exemplary instruments(Vargel 2020).The aluminum compound isn't fit for changing the mechanical properties of cutting devices (Sandeep Kumar Ravesh November- December 2012). Drilling utilizes grease at low rate while wet work at low rate surpassing 300l/h.by changing wet to MQL condition, it is conceivable to lessen cost,just as to accomplish the three mains that wet cutting speed 400 m/min provide values of surface roughness, Ra=0.2µm,and MQL provided similar results to it. Surface roughness value of Ra=1.5µm after dry drilling of 6020 series aluminum alloys with F=0.07 mm/rev, VC=400 m/min and AP=1.5mm.The Mean Values of Ra and Rzrespectively ,0.44µm and 2.73µm were obtained during testing.An accomplished surface roughness higher than qualities found in this work Ra=1.0µm and Rz=10µm.since a more noteworthy feed rate was utilized F=0.2 mm/fire up. As currently seen, F was the most significant boundary.(Al-Tameemi et al. 2021); (Luo et al. 2021)

During machining of aluminum the burr is formed at a high rate, and it affects the surface of the material,(Grzesik 2016) which is the limitation of this research. The surface finish can be better if changing the parameters and tool in AA 6020 is studied and will be developed in future(Liu et al. 2020).ays of supportability (monetary,natural and social). A drilling of AA6020 by drilling of cutting speed (50 - 400 m/min) and feed rate 0.15 mm/rev and it was concluded.The surface finish in the aluminum alloy has been studied and can be developed in the future.

CONCLUSION

Within the limitations of the study, the recognition of surface roughness during CNC Drilling of tests utilizing the the mean value of the surface roughness for the experimental group and it is observed to be 1.36065 µm. and the mean value of surface roughness for the control group was observed to be 2.05065 µm. From the obtained results the AA 6020 samples machined using AlTiN Coated HSS Drill bit has lower Surface roughness than the samples drilled utilized the Uncoated HSS Drill bit. As per the ANOVA test on the superficial level in surface roughness among the Uncoated HSS Drill and Coated HSS Drill are drilled samples has a critical mean distinction of is observed.

DECLARATIONS:

Conflict of Interests:

The authors of this paper declare no conflict of interest.

Authors' Contribution

Author LR was involved in data collection, data analysis, and manuscript writing. Author BR was involved in conceptualization, data validation and critical review of the manuscript.

Acknowledgment

The authors would like to express their gratitude towards Saveetha School of Engineering, Saveetha Institute of Medical and Technical Sciences (Formerly known as Saveetha University) for providing the necessary infrastructure to carry out this work successfully.

Funding:
We thank our financial sponsors for the financial support that enabled us to complete this study.

1. Veekay Process Pvt. Ltd…
2. Saveetha School of Engineering.
3. Saveetha Institute of Medical and Technical Sciences.
4. Saveetha University.

REFERENCE

1. Adhinarayanan, Rajesh, AravindhRamakrishnan, GopalKaliyaperumal, Melvinvíctor De Poures, Rajesh Kumar Babu, and DamodharanDillikannan. 2020. "Comparative Analysis on the Effect of 1-Decanol and Di-N-Butyl Ether as Additive with diesel/LDPE Blends in Compression Ignition Engine." *Energy Sources, Part A: Recovery, Utilization, and Environmental Effects*, June, 1–18.
2. Almulhim, Khalid, Abdul Samad Khan, HananAlabdulghani, Sara Albasarah, Yousif Al-Dulaijan, and Faisal D. Al-Qarni. 2021. "Effect of Ageing Process and Brushing on Color Stability and Surface Roughness of Treated White Spot Lesions: An in Vitro Analysis." *Clinical, Cosmetic and Investigational Dentistry* 13 (October): 413–19.
3. Al-Tameemi, Hamza A., Thamir Al-Dulaimi, Michael Oluwatobiloba Awe, Shubham Sharma, Danil Yurievich Pimenov, Ugur Koklu, and Khaled Giasin. 2021. "Evaluation of Cutting-Tool Coating on the Surface Roughness and Hole Dimensional Tolerances during Drilling of Al6061-T651 Alloy." *Materials* 14 (7). https://doi.org/10.3390/ma14071783.
4. Arun Prakash, V. R., J. Francis Xavier, G. Ramesh, T. Maridurai, K. Siva Kumar, and R. Blessing Sam Raj. 2020. "Mechanical, Thermal and Fatigue Behaviour of Surface-Treated Novel Caryota Urens Fibre–reinforced Epoxy Composite." *Biomass Conversion and Biorefinery*, August. https://doi.org/10.1007/s13399-020-00938-0.
5. Ashwath, P., and M. Anthony Xavior. 2016. "Processing Methods and Property Evaluation of Al2O3 and SiC Reinforced Metal Matrix Composites Based on Aluminium 2xxx Alloys." *Journal of Materials Research*. https://doi.org/10.1557/jmr.2016.131.
6. Aurtherson, P. Babu, Bhanu Teja Nalla, Karthikeyan Srinivasan, Kulmani Mehar, and Yuvarajan Devarajan. 2021. "Biofuel Production from Novel Prunus Domestica Kernel Oil: Process Optimization Technique." *Biomass Conversion and Biorefinery*, May. https://doi.org/10.1007/s13399-021-01551-5.
7. Bhansali, Karan J., Kamlesh R. Balinge, Subodh U. Raut, Shubham A. Deshmukh, M. Senthil Kumar, C. Ramesh Kumar, and Pundlik R. Bhagat. 2021. "Visible Light Assisted Sulfonic Acid-Functionalized Porphyrin Comprising Benzimidazolium Moiety for PhotocatalyticTransesterification of Castor Oil." *Fuel* 304 (November): 121490.
8. Deepanraj, B., N. Senthilkumar, D. Mala, and A. Sathiamourthy. 2021. "Cashew Nut Shell Liquid as Alternate Fuel for CI Engine—optimization Approach for Performance Improvement." *Biomass Conversion and Biorefinery*, February. https://doi.org/10.1007/s13399-021-01312-4.
9. Grzesik, Wit. 2016. *Advanced Machining Processes of Metallic Materials: Theory, Modelling, and Applications*. Elsevier.
10. Jaeggi, Marco, Sharon Gyr, Monika Astasov-Frauenhoffer, Nicola U. Zitzmann, Jens Fischer, and Nadja Rohr. 2022. "Influence of Different Zirconia Surface Treatments on Biofilm Formation in Vitro and in Situ." *Clinical Oral Implants Research*, February. https://doi.org/10.1111/clr.13902.
11. Jayanth, BellappuVenkat, Melvin Victor Depoures, GopalKaliyaperumal, DamodharanDillikannan, DilipsinghJawahar, KumaranPalani, and Ganesha Prasad MeravanigeeShivappa. 2021. "A Comprehensive Study on the Effects of Multiple Injection Strategies and Exhaust Gas Recirculation on Diesel Engine Characteristics That Utilize Waste High Density Polyethylene Oil." *Energy Sources, Part A: Recovery, Utilization, and Environmental Effects*, June, 1–18.
12. Juijerm, Patiphan. 2007. *Fatigue Behavior and Residual Stress Stability of Deep-Rolled Aluminium Alloys AA5083 and AA6110 at Elevated Temperature*. kassel university press GmbH.
13. Kamath, Manjunath, Subha Krishna Rao, Jaison, Sridhar, Kasthuri, Gopinath, Sivaperumal, and ShantanuPatil. 2020. "Melatonin Delivery from PCL Scaffold Enhances Glycosaminoglycans Deposition in Human Chondrocytes – Bioactive Scaffold Model for Cartilage Regeneration." *Process Biochemistry* 99 (December): 36–47.
14. Kant, Rama, and HimanshiGoel. 2021. "In Situ Electrochemical Impedance Spectroscopic Method for Determination of Surface Roughness and Morphological Convexity." *Journal of Physical Chemistry Letters*, October, 10025–33.
15. Leão, Cecília Sued, Amanda Cunha Regal de Castro, Flavio Mendonça Copello, Carlos Nelson Elias, Terumitsu Sekito Junior, and Eduardo Franzotti Sant'Anna. 2021. "Comparison of Feldspathic Veneer Surface Treatments on Ceramic Bracket SBS, ARI and Surface Roughness after Different Debonding/polishing Methods: An in Vitro Study." *International Orthodontics / College Europeen D'orthodontie*, October. https://doi.org/10.1016/j.ortho.2021.08.006.
16. Liu, Jintong, Anan Zhao, Piao Wan, Huiyue Dong, and Yunbo Bi. 2020. "Modeling and Optimization of Bidirectional Clamping Forces in Drilling of Stacked Aluminum Alloy Plates." *Materials* 13 (12). https://doi.org/10.3390/ma13122866.
17. Luo, Haitao, Jia Fu, Tingke Wu, Ning Chen, and Huadong Li. 2021. "Numerical Simulation and Experimental Study on the Drilling Process of 7075-t6 Aerospace Aluminum Alloy." *Materials* 14 (3). https://doi.org/10.3390/ma14030553.
18. Rajasekaran, S., D. Damodharan, K. Gopal, B. Rajesh Kumar, and Melvin Victor De Poures. 2020. "Collective Influence of 1-Decanol Addition, Injection Pressure and EGR on Diesel Engine Characteristics Fueled with diesel/LDPE Oil Blends." *Fuel* 277 (October): 118166.
19. Rajesh, A., K. Gopal, De Poures Melvin Victor, B. Rajesh Kumar, A. P. Sathiyagnanam, and D. Damodharan. 2020. "Effect of Anisole Addition to Waste Cooking Oil Methyl Ester on Combustion, Emission and Performance Characteristics of a DI Diesel Engine without Any Modifications." *Fuel* 278 (October): 118315.
20. Raju, P., K. Raja, K. Lingadurai, T. Maridurai, and S. C. Prasanna. 2021. "Glass/Caryota Urens Hybridized Fibre-Reinforced nanoclay/SiC Toughened Epoxy Hybrid Composite: Mechanical, Drop Load Impact, Hydrophobicity and Fatigue Behaviour." *Biomass Conversion and Biorefinery*, March. https://doi.org/10.1007/s13399-021-01427-8.
21. Sandeep Kumar Ravesh, Dr T. K. Garg. November- December 2012. "Prepration& Analysis For Some Mechanical Property Of Aluminium Based Metal Matrix Composite Reinforced With Sic & Fly Ash." *International Journal of Engineering Research and*

Applications 2 (6): 727–31.
22. Sathiyamoorthi, Ramalingam, Gomathinayakam Sankaranarayanan, Dinesh Babu Munuswamy, and Yuvarajan Devarajan. 2021. "Experimental Study of Spray Analysis for Palmarosa Biodiesel-diesel Blends in a Constant Volume Chamber." *Environmental Progress & Sustainable Energy* 40 (6). https://doi.org/10.1002/ep.13696.
23. Shanmugam, Rajasekaran, DamodharanDillikannan, GopalKaliyaperumal, Melvin Victor De Poures, and Rajesh Kumar Babu. 2021. "A Comprehensive Study on the Effects of 1-Decanol, Compression Ratio and Exhaust Gas Recirculation on Diesel Engine Characteristics Powered with Low Density Polyethylene Oil." *Energy Sources, Part A: Recovery, Utilization, and Environmental Effects* 43 (23): 3064–81.
24. Singh, Yogendra Pratap, Sudip Dasgupta, Rakesh Bhaskar, and Ashish Kumar Agrawal. 2021. "Monetite Addition into Gelatin Based Freeze-Dried Scaffolds for Improved Mechanical and Osteogenic Properties." *Biomedical Materials* , October. https://doi.org/10.1088/1748-605X/ac2e17.
25. Sudhakar, M. P., Merlyn Ravel, and K. Perumal. 2021. "Pretreatment and Process Optimization of Bioethanol Production from Spent Biomass of GanodermaLucidum Using Saccharomyces Cerevisiae." *Fuel* 306 (December): 121680.
26. Vargel, Christian. 2020. *Corrosion of Aluminium*. Elsevier.
27. Yuan, Ju Long, Hitoshi Ohmori, and Bing Hai Lv. 2012. *Ultra-Precision Machining Technologies, CJUMP2011*. Trans Tech Publications Ltd.
28. Zhu, Ping. 2008. "Impact of Land-Surface Roughness on Surface Winds during Hurricane Landfall." *Quarterly Journal of the Royal Meteorological Society*. https://doi.org/10.1002/qj.265.

TABLES AND FIGURES

Table 1. Process parameters and levels for machining in CNC Drilling center.

S.NO	PARAMETER	LEVELS			
		A	**B**	**C**	**D**
1	**Speed (**rpm)	800	1000	1500	1800
2	**FEED RATE** (mm/rev)	0.15	0.2	0.25	0.3

Table 2. Surface Roughness for AlTiN Coated and Uncoated HSS Drill bit

S.NO	SPEED (rpm)	FEED RATE (mm/rev)	SURFACE ROUGHNESS OF UNCOATED HSS DRILL (µm)	SURFACE ROUGHNESS OF AlTiN COATED HSS DRILL (µm)
1	800	0.15	2.021	1.321
2	800	0.2	2.033	1.345
3	800	0.25	2.037	1.309
4	800	0.3	2.045	1.356
5	800	0.35	2.049	1.367
6	1000	0.15	2.052	1.354
7	1000	0.2	2.059	1.378
8	1000	0.25	2.063	1.366
9	1000	0.3	2.067	1.369
10	1000	0.35	2.072	1.371

11	1500	0.15	2.022	1.337
12	1500	0.2	2.014	1.349
13	1500	0.25	2.082	1.362
14	1500	0.3	2.055	1.384
15	1500	0.35	2.027	1.375
16	1800	0.15	2.093	1.389
17	1800	0.2	2.059	1.394
18	1800	0.25	2.097	1.303
19	1800	0.3	2.012	1.385
20	1800	0.35	2.054	1.399

Table 3. The mean descriptives obtained for surface roughness.

Descriptives								
Surface roughness								
	N	**Mean**	**Std. Deviation**	**Std. Error**	**95% Confidence Interval for Mean**		**Minimum**	**Maximum**
					Lower Bound	**Upper Bound**		
Uncoated HSS drill	20	2.0507	.02235	.00500	1.9397	1.9606	1.92	2.00
AlTiN Coated HSS drill	20	1.1307	.01623	.00363	1.1260	1.1411	1.11	1.17
Total	40	1.7057	.41395	.06545	1.4095	1.6742	1.11	2.00

Table 4. One-way ANOVA test represents the significance value for AlTiN coated HSS and Uncoated drills. It is observed that on performing One-Way ANOVA, there is a statistical significant difference for surface roughness ($p= 0.00$, $p<0.05$).

ANOVA TEST					
SURFACE ROUGHNESS					
	Sum of Squares	**df**	**Mean Square**	**F**	**Sig.**
Between Groups	4.761	1	4.761	7109.014	.000
Within Groups	.025	38	.001		
Total	4.786	39			

Fig. 1. CNC Drilling Machine setup

Fig. 2. AlTiN Coated HSS Drill

Fig. 3. Uncoated HSS drill

Fig. 4. Samples drilled using Uncoated drill.

Fig. 5. Samples drilled using AlTiN coated HSS drill.

Fig. 6. Mitutoyo surface roughness tester

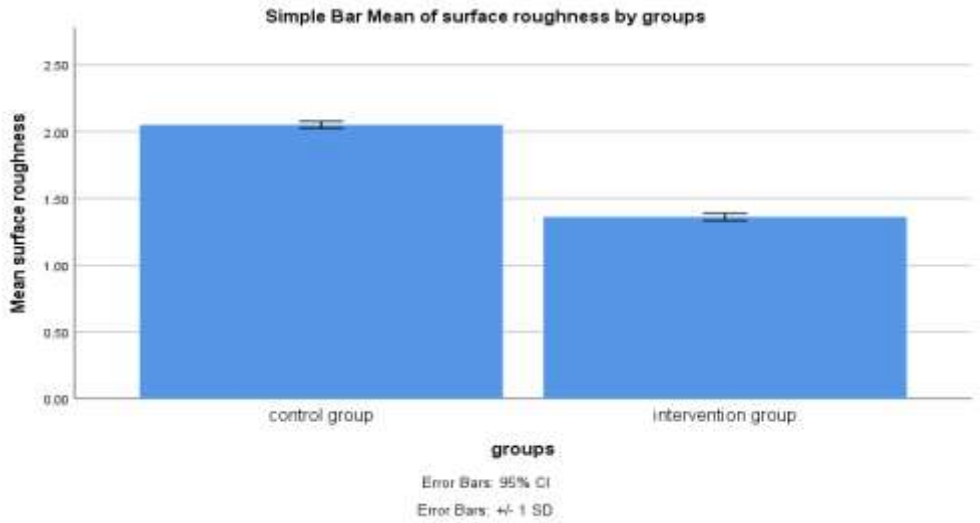

Fig. 7. Bar chart shows the comparison between mean values of surface roughness for samples machines by AlTiN coated HSS drill and AA 6020 samples machined by Uncoated HSS drill. The obtained value of AA 6020 samples machined using AlTiN coated drill is higher than the AA 6020 samples machined using UNcoated drill. X-axis: Mean surface roughness of AA 6020 samples utilized with AlTiN coated vsUncoated drill. Y-axis: values of groups ± 1 SD.