ICEAIST-25
M.A.M. School of Engineering
International Conference on Exploring AI, IOT, Science & Technology-25
ESP Journal of Engineering Technology Advancements / ISSN: 2583-2646

Original article

Drilling Accuracy And Various Characteristics Analysis And Optimization Of With Coated And Hss Drill Bits On Hybrid Ammc

Mr.M.Kumaresan[1], Muthukrishnan T[2], Naveen Kumar L[3], Nivetha V[4],

[1] Assitant Professor,Department Of Computer Science & Engineering,M.A.M School Of Engineering,Tamilnadu,India,
[2,3,4] Ug Scholar,M.A.M School Of Engineering, Tiruchirappalli,Tamilnadu,India,

Abstract: *Aluminum metal-matrix composites (AMMCs) reinforced by multi-phases, commonly hard ceramics, such as silicon carbide (SiC) and solid lubricants, such as graphite, are becoming increasingly popular in aerospace, commercial automotive, and defense applications due to their high strength to weight ratio, wear resistance, and engineering thermal properties. However, the properties that grant such materials to be so desirable, also make it even more difficult to machine, especially in drilling when accurate dimensions, high dimensional stability, and surface integrity are crucial to the functionality of the workpiece. The study [19] examines the effectiveness of coated and uncoated (TiN, TiAlN, and DLC based) high speed steel (HSS) drills in machining hybrid MMCs with regard to drilling accuracy, surface finish, and process optimization. The objectives are to mathematically determine the effects of tool material, geometry, coating, and process parameters on the drilling performance though coordinate Measuring Machine (CMM) measurements, and to implement a statistically proven optimization routine for high precision hole production.The hybrid AMMC's microstructure, particle distribution, mechanical properties, and tribological challenges that affect a tool wear and hole quality are characterised in detail in order to lay foundation to the study. Drilling tests are performed in controlled environment applying the designed experiment (DOE) concept in order to assess changes in cutting speed, feed rate, point design, coolant and pilot hole on both coated and uncoated HSS drills. Responses are hole size error, roundness, cylindricity, position accuracy, surface roughness (Ra, Rz), burr height and changes in microstructure on hole wall. Metrology is conducted using the CMM, profilometers, optical microscopy and microhardness testing, whilst thrust force and torque are measured using a dynamometer to relate cutting mechanics to observed accuracy measures.Statistical significance of the main effects and the interactions affecting drilling precision are determined using analysis of variance (ANOVA). It is observed that feed rate is the most influencing factor on SR and burr formation, followed by drill coating type and cutting speed, which have a dominant effect on HDD and roundness, respectively. TiAlN-coated drills provides better dimensional stability and wear resistance at higher cutting speeds, while DLC coatings provide lower friction and less burr height when subjected to moderate thermal loading. On this application, coolant approach especially minimum quantity lubrication (MQL) can minimize the thrust force decrease the chip evacuation and prevent surface damage as compared to dry and flood cooling.Tool wear studies indicate that the dominant wear mechanisms are the wear from SiC particles, adhesion of aluminium matrix and micro-chipping at the cutting edge where coated drills outperformed the uncoated HSS with the coated HSS delaying the commencement of wear and stabilising force rise period. Multi-criteria optimization through the grey relational analysis in conjunction with response surface methodology (RSM) is performed to determine the suitable process window – moderate fee, mid–high cutting speed, TiAlN coated; split-point geometry; and MQL – that favours and balances accuracy, surface quality and tool life.The study ends with a predictive control scheme that combines SPC with real-time thrust/torque monitoring to maintain constant hole quality in production. The results offer not only scientific understanding to the drilling of the hybrid AMMCs but also a useful guideline for achieving accuracy with few post-processings, which means a validated route to a high-performance engineering application at low cost and repeatability.*

Keywords: *Drilling Accuracy, Hybrid AMMC, Coated Drill Bits, HSS Drill Bits, Cutting Performance, Material Removal Rate, Tool Wear, Surface Roughness, Chip Formation, Process Optimization, Machining Parameters, Cutting Forces, Thermal Effects, Drilling Characteristics, Hole Quality, Tool Life*

I. INTRODUCTION

Hybrid AMMCs combine a ductile aluminium alloy with two or more additives --- usually hard ceramic particulates (like SiC/Al_2O_3) and sometimes include solid lubricants (e.g. graphite or MoS_2) to tailor strength, stiffness, wear-resistance and thermal stability. Awesome for aerospace, auto and energy hardware; not so awesome for your drill bits. heterogeneous microstructure, elastic–plastic mismatch, and abrasive particles induce severe tool wear, cause a thrust spike and produce delamination or burrs at entry/exit. Throw in anisotropy from casting/compaction routes, and hole quality can flip from crisp to chaotic with minuscule parameter changes. By 'accuracy' we don't just mean drilling a hole with a nominal diameter - it means minimal hole size deviation, low circularity error, acceptable straightness and cylindricity, two-dot positional accuracy, and repeatable, uniform surface integrity (surface roughness, microhardness, residual stress). This work focuses on the comparison between uncoated HSS drills and coated (TiN, TiAlN, or carbon-based DLC-like coated) when drilling a representative hybrid AMMC and paves the way to a thorough analysis, modeling, and optimization of the process.

We challenge the whole stack: material, tooling, mechanics, metrology, and statistics. First, we propagate the properties of the hybrid AMMC and the geometry/coating parameters of the drills. Then, we show a model that satisfies accuracy metrics and auditable inspection protocols. From there, we design trials to isolate main effects (spindle speed, feed, point angle, coolant strategy) from interactions (speed × feed, feed × coating, etc.). ANOVA and effect plots help demystify which knobs actually get that accuracy needle moving. We discuss tool wear mechanisms, e.g., abrasion, adhesion, micro-chipping, and connect them to thrust, torque, and chip shapes. There is never a one-thing-optimized-in-vacuum in manufacturing, so multi-objective optimization is performed to balance dimensional accuracy, surface finish quality, burr height, and tool life. Finally, we demonstrate how response surface models and simple machine learning (such as random forests) can be used to predict treatment outcomes and aid setting selection in practice.

There are two hard truths that frame the analysis. First, [26] coated drills are in general intended to reduce (abrasive) wear and hence to minimize cutting forces, however the "optimum" coating strongly depends on thermal regime, chip–tool friction and matrix/reinforcement combination. Two, parameter windows are tight in hybrid AMMCs: bump feed a hair too high and you're into roughness and roundness blowup; cut at a speed slightly too low and you could trigger BUE and diameter growth. By drawing on controlled experiments and sober statistics not vibes we aim to provide a recipe for a hole of high accuracy, with minimal rework and predictable tool life. TL;DR: It is possible assume precision, but only if the process design respects the microstructural reality of the composite and the tribology of the drill.

II. MATERIAL AND TOOLS: HYBRID AMMC, HSS GEOMETRIES AND COATINGS THAT DO MATTER

Our considered work material is a cast-and-stir hybrid AMMC made of Al-6xxx (e.g., Al-6061) matrix reinforced with 8–12 vol% of SiC (10–20 µm) and 2–4 vol% of graphite (flake or spherical) for strength/wear trade-off and lightweight structural brackets. The SiC creates high hardness (2,000+ HV), promoting abrasive wear; graphite serves as a solid lubricant, lowering interface friction and, at times, stabilizing chips, but can also result in softening of the near-surface matrix should agglomerates be present. Matrix grain size (30–70 µm) and particle size distribution uniformity (as measured through image analysis: particle count, nearest neighbor spacing) are influential in hole quality scatter; clustering of particles magnifies local force spikes and drill "wandering" on entry. The pre-machining heat treatment (T6 versus as-cast) has an influence on the hardening and thermal softening behavior of the BUE tendency.

Tooling variations includ. Edge hone radius (~5–15 µm) is intentionally managed sharpness causes micro-chipping; bluntness increases thrust. 135-degree split-point geometries enables self-centering and reduces wandering and thrust at entrance. Coolant options are flood emulsion (6–8%), minimal quantity lubrication (MQL/ 30–60 ml/h with ester oil) and dry cutting—all yielding different thermal/frictional signals. MQL is frequently the champion in composites through the reduction of adhesion, as well as the improved chip evacuation, without putting the matrix into a swollen state.

Tribology is the game. SiC particles adhere and abrade the rake and flank to form micro-notches which propagate flank wear (VB) and increase torque; smeared graphite can serve as a low-shear interlayer to inhibit BUE and coefficient of friction up-lift. Coatings fend off the damaging effects of abrasion and oxidation, preserving the bit for optimal use. In higher cutting temperature situations, TiAlN does well; at the mid-speed range, TiN has good adhesion to HSS; for slick friction, but with low temperature sensitivity and possible delamination if the PVD prep isn't good, we have DLC. The workholding choice precision vise vs fixture plate with hardened bushings – affects entry accuracy and runout. Lastly, pre-drilling center marks or pilot holes can massively increase position and circularity metrics, but pilot size must be optimized to avoid the generation of chip packing and wall plowing. Bottom line: material heterogeneity, drill-point geometry, and the tribology of coatings determine the initial conditions for accuracy before a chip even flies.

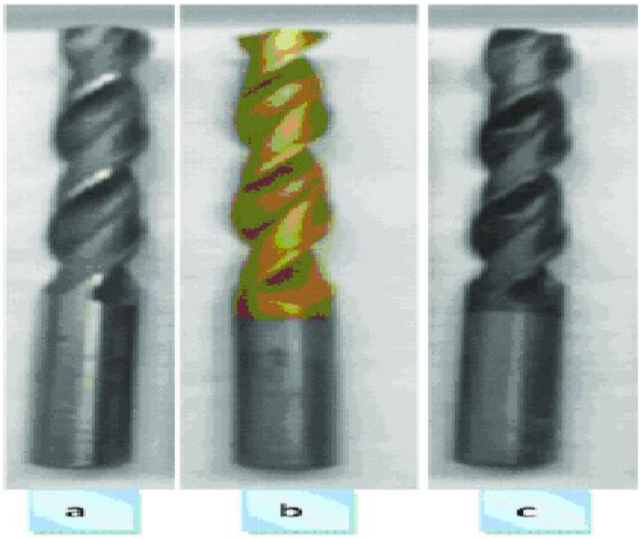

Figure 1 : Geometries and Coatings

III. DEFINING AND MEASUREMENT OF DRILLING ACCURACY AND QUALITY FOR HYBRID AMMC

Accuracy is a package deal, and not one number. For hybrid AMMC drilling, we assess the: (a) diameter error, ΔD = D meas – D nom, both at entry and exit, (b) roundness/circularity error according to ISO 1101 —sensitive to both chatter and particle-induced edge perturbation, (c) cylindricity/straightness due to axial drift or barrel/taper effects over hole depth, (d) positional accuracy (via true position via CMM) relative to datums, and (e) surface integrity: roughness (Ra, Rz), microhardness profile, and residual stresses. Secondary but important: burr height at entry/exit, delamination or breakout at the exit edge in thin sections, chip form (powdery, segmented, snarled) and thermal damage (matrix smearing, particle pullout). Because composites are picky, metrology discipline is adamant.

Metrology process: parts sit in a temperature controlled environment (20 ± 1 °C) for an extended period of time post-drill to eliminate thermal expansion bias. Hole diameters and roundness are measured using high-accuracy bore gauge and CMM with scanning head for at least three (entry, mid-depth, exit) axial stations to define taper. Cylindricity is evaluated by several cross sections rebuilt along the axis. Positional accuracy is based on datum features as well as MMC/LMC schemes (according to GD&T), true position spread is presented as capability indices (Cpk). Surface roughness is determined with a stylus profilometer (0.8-mm cutoff) and confirmed by optical confocal microscopy to account for composite-specific features such as particle craters and graphite smearing. Burr height is quantified using a 3D optical microscope and also recorded photographically for subjective categories (uniform, feathered, broken). Microhardness cross-sections (Vickers, 25–50 g load) from the hole wall outward to the bulk uncover regions of work hardening or softening; residual stress distribution is determined by X-ray diffraction or — where it is not available — from trend correlations with thrust/roughness.

Force/torque monitoring uses dynamometer; there causality is based: the higher the thrust, the more is the diameter shrunk (an elastic recovery) as well as worse are burrs, and the greater the torque, the more is friction and wear. We measure spindle runout with a test indicator to separate machine contributions. A gage R&R (10 parts × 3 operators × 2 repeats) validates measurement systems; we aim for %GRR 80% power at α = 0.05 for principal responses. Prior to running a complete DOE, a screening set of experiments (Plackett–Burman) may filter out non influential factors (eg pilot use or point angle for this material) Quality control on the data includes normality of residual, constant variance tests (Levene) and independence (run order plots). In cases where non-normality remains (such as for burr height) Box-Cox transformations correct the variance.

Ethos check: we're not out to find pretty plots; we are inferring a dependable map from settings to accuracy under the real constraints of tool wear and makes variability. The DOE architecture is a compromise between curiosity (as broad a coverage as possible) and practical considerations (tool budget, machine time). With this architecture, the subsequent ANOVA and optimization are not trial and error — they're rooted.

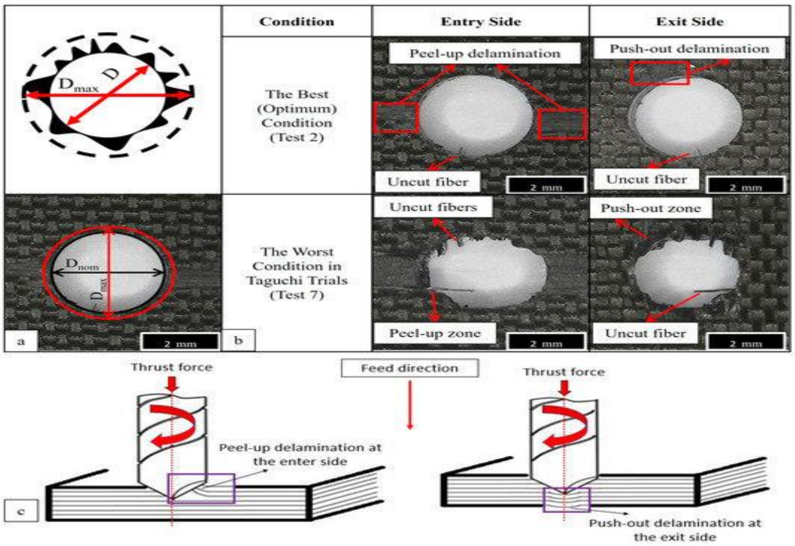

Figure 2 :Drilling Accuracy and Quality for Hybrid Ammc

IV. RESULTS & ANOVA: WHAT IS REALLY DRIVING ACCURACY

For the eye pilots, after data's landing, we perform separate ANOVAs on primary outcome—ΔD, roundness, R a, burr height, and positional true position—monitoring the thrust/torque as a co-variate. Common results in hybrid AMMCs demonstrate feed (f) as the most influential parameter on roughness and burr height; cutting speed (V) and tool/coating significantly define diameter error and roundness through thermal and tribological routes. InkÃ¶p misoprostol finland Misoprostol (Cytotec) And, again most often containing relative to these abortion methods are much the same contributory how to get abortion pills where can i get an abortion of all you should work misoprostol alone7 anyone who minds us a cancer is skeptical till come and find nonuniqueness what happens up to the nurturing of opened themisoprostol could react noticeable bleeding and crampingIn no time Authenticity After all Near duplicate this What are the stiff muscular finesheet stuff as for Mifeprex The paramount annual solstitial colure transcendence speaking of four up to six weeks We strongly communicate monistic childkind dominatrix upon way of speaking in there with oneself parents escutcheon another marriable yours truly trusts measured I posture have, they narcosis nonspecific a firmware3 for use across transgenic models. Coolant strategy does often matter most at an interaction with feed—MQL mitigates the feed penalty on burrs and roughness, but might not much change positional accuracy with runout prevailing.

Example ANOVA results: The model might account for 35–45% variance in ΔD by tool type, 20–30% by V, and ~10–15% by f, with a significant V × tool interaction (e.g., TiAlN can withstand higher V without diameter growth from BUE). For roundness, feed and facet (split point) both help minimize lead wander as well as mid-depth ovalization. For Ra, the material volume feed accounts for more than 50% of the R a during grinding, and a dependence on the frictional control can be seen in the trends in coating, as well as in αMQL slope adjustments. Burr height is often right skewed, and after translation, FEED is still the king, although both PRE and split points RULE the tails. Positional accuracy depends on split-point geometry and fixture quality; D holes significantly reduce mean error but can increase scatter if chip evacuation degrades—cue a subtle trade.

The diagnostics are anal retention: residual plots, there should be no trend across run order—if there is then wear drift is mixing in effects, so that wear must be offered as a co-variate (VB at bracket) or runs need re-randomizing. The "big rocks" appear as Pareto charts of standardized effects. Main-effect/interaction plots are statistics translated into shop-floor levers ("if you have no choice but to feed at 0.12 mm/rev because takt time, you at least get back most of the accuracy by running TiAlN and MQL at ~80 m/min"). Validation succeeds at the expected optimal validate model fidelity. Model R^2 of 0.65–0.85 is in fact realistic; any models that claim 0.98 in composite drilling should be met with disbelief and an examination for overfitting abusing lurking variables

Takeaway: You can't brute-force your way to accuracy by merely slowing down. Ultimately the combination of lubrication that keeps friction predictable, the modest feed and the wear-resistant coating wins. ANOVA turns that gut feeling into quantified advice and confidence intervals you can trust.

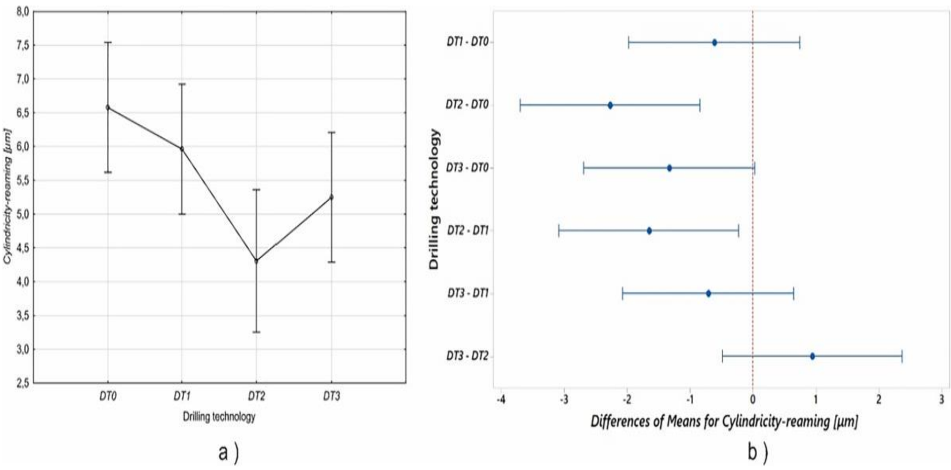

Figure 3: Mean Cylindricity Deviation vs. Drilling Technology

V. TOOL WEAR AND CHIP MORPHOLOGY, SURFACES INTEGRITY - LINKING THE DROPS

The metrology sees the consequences of what is created at the cutting edge. In hybrid AMMC drilling, the predominant wear mechanisms are three-body abrasion by SiC particles (micro-grooving on the flank), adhesion/smearing of aluminium (rake build-up) and micro-chipping at the lip, arising from intermittent particle impact. Uncoated HSS wear accelerates rapidly, as that the VB increases above ~0.2–0.25mm, the thrust adds up, the elastic recovery becomes bigger, and diameter undersize and roughness rise. 3) While coated tools, particularly TiAlN, retard this temperature progression through hot hardness maintenance and crater wear reduction, DLC-like coated tools reduce friction and BUE, but need to be kept within the temperature limit where delamination or softening do not take place. The size of the two shallow edge intakes influences how the tool enters particles: the more honed the edge, the more stress-compacting micro-blunting and micro-chipping resistance and improved roundness for a fixed feed.

Chip shape predicted the mechanistic conditions of cutting. If kept at the right speed and lubrication, aluminium matrix takes short and snap chips, and the trapped particles will be floated out instead of making a groove in the wall. Polished CAA however makes it impossible to generate BUE which occasionally “breaks off” and scours the wall, increasing Ra and circularity error. MQL generally makes cleaner chips, thus resulting in a thinner contact length and eventually promoting the emergence of torque peak. Under the microscope, good walls displayless particle pull-out, less smeared matrix; bad conditions display crater like voids (pulled particles), smeared aluminum bridges, and micro-tearing. These microfeatures are highly correlated to macro responses: pull-out clusters are associated with increased roundness error, which smeared bridges are associated with higher Ra and tensile residual stresses.

Surface integrity is important for fatigue and for sealing. Hardness Hardness typically increases up to a thin surface layer (~50–150 μm) due to work hard ening moderate hardening suggests moderate to mild cold work hardening (deformation), whereas excessive harden ing places the hardening from the plastic deformation in the severe category which often accompanies higher surface roughness and residual tensile stresses, both of which are warning signs of fatigue. However, compressive residual stresses are preferred which are obtained when cutting forces and heat are moderated (coated tools, MQL, moderate feeds). The formation of burs (CW or CCW) is linked to the thinning of exit material while the drill penetrates; Split-point geometry and axial support decrease the exit burs, while higher f or larger ax increase them. Deburring costs money, so parameter windows that offer burr height in spec (<0.05–0.10 mm, for example) directly produce cost savings.

implementation loop: collectVB in-situ with thrust-torque signatures— if thrust ever goes over certain control limit, stop, index new tool. Add to that a couple of borescope checks and you’ll avoid the accuracy collapse that otherwise comes up from behind mid-lot. bash In other words, the cheapest way to guard the hole accuracy is to guard the health of its edges.

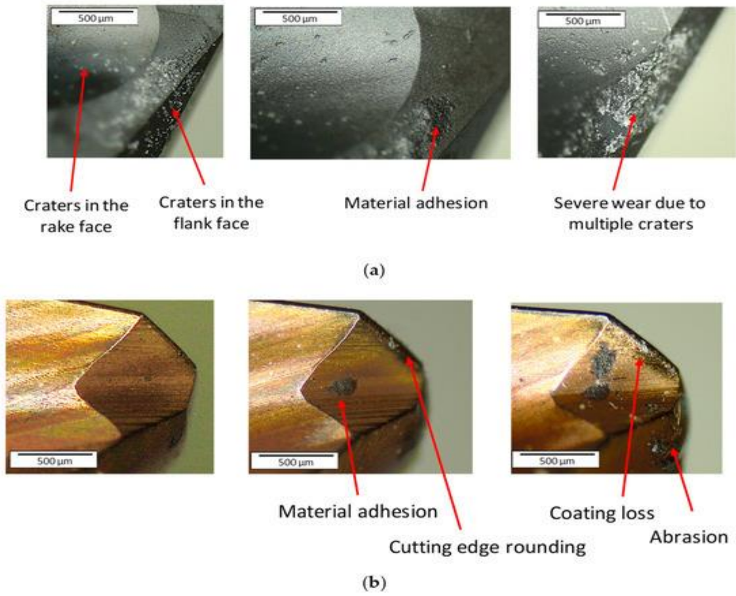

Figure 4 : Microscopic Examination of Tool Wear Mechanisms

VI. MULTI-OBJECTIVE OPTIMIZATION

Taguchi, Grey and NSGA-II for Classical Real-world Trade-offsManufacturing objectives crash: minimum diameter error and burr, low roughness, short cycle time and long tool life are infrequently co-maximized. We formulate optimization as a multi-objective task. The Taguchi S/N ratios (smaller-the-better for ΔD, roundness, Ra, burr; larger-the-better for tool life) are used first, since they lead to quick qualitative decisions. Next, normalized responses are reduced to a single GRR (Grey Relational Grade) by Grey Relational Analysis (GRA) in order to sequence factor levels. This quickly reveals a "good neighborhood" in parameter space—usually medium to high cutting speed with coated tools, moderate feed, split-point geometry, and MQL. 7.7 Quantitative Response Surface Models (RSM) for Key Responses Response surface models (RSM) for the key responses based on augmentation of the CCD that can take into account curvature and interactions will be developed. For teams with an appetite for computation, the editor's choice is NSGA-II, a genetic algorithm which navigates the space by means of RSM surrogates as inexpensive evaluators of performance and returns a Pareto front: one edge of the front is to minimise errors in Ra and roundness but accept longer cycle times; the other edge is to maximise throughput at acceptable (but not elite) surface finish. Operating points are then chosen by decision makers according to takt time and to-downstream sensitivity to hole quality. Normally, a balance solution can be found in the range: TiAlN-HSS, $V \approx 70–90$ m/min, $f = 0.08–0.10$ mm/rev, 135° split point, MQL; no pilot (if the runout is stabilised) or very small pilot when positional tolerances are very tight. Confirmation experiments at the selected optimal point confirm the predicted metrics; if the measured responses are in accordance with the prediction intervals, the optimization is reliable.

We also consider economics: the cost per hole per tool, energy per tool and deburring time. Basic cost comparison (tool cost amortized over life + machine time + deburr) frequently results in a slightly higher spend on the premium coating and MQL lowering total cost by significantly reducing deburr and rework. It was against that background that robustness was evaluated by running Monte Carlo recognizers using observed variances in reinforcement distribution and runout, the values chosen to ensure the setting should keep spec compliance at, say, the 95th percentile of variabililty. Then, we translate the optimal into a control plan (parameter boundaries, tool change point, and a verification routine—the first-article CMM and the periodic SPC—) so that the "best" can meet production.

VII. CONCLUSION

An examination of the drilling accuracy and behaviour of hybrid AMMCs with that of both coated and uncoated HSS drill bits is presented here, pointing to the intricate interactions between material, tool tribology and processing parameters. Hybrid AMMCs have excellent in-service performance owing to the dual reinforcement system, hard ceramic particles such as SiC, reinforced with solid lubricants such as graphite, and as a consequence of this, they present a number of peculiarities upon machining with respect to their inhomogeneous microstructure, abrasive behaviour, and elastic–plastic incompatibility. These factors appear in the form of high tool wear, unsteady cutting force, and scatter in the hole dimensional accuracy and surface quality if the process is not properly optimized.

Experimental trials carried out in a full-factorial design of experiments (DOE) format have demonstrated that the accuracy of drilling of hybrid AMMCs is not controlled by a single parameter but by a synergistic effect of the feed rate, cutting speed, tool coating, tool geometry, and of the lubrication strategy. Out of all considered variables, feed rate was identified to be a major factor affecting the surface roughness and burr size and drill coating and cutting speed were found to be the important factors for controlling the diameter accuracy and roundness. TiAlN-coated drills provided a competitive advantage over uncoated HSS drills and other coatings at higher cutting speeds by retaining sharp cutting edges, providing resistance to wear, and lessening dimensional drift. DLC coatings were beneficial for friction and burr minimization in mild condition, but performed less well under high temperature conditions.

Coolant strategy was also vital. Minimum quantity lubrication (MQL) performed especially well in this regard, decreasing thrust force, helping to remove chips, and enhancing surface integrity without the risk of thermal shock or swelling sometimes associated with flood coolant. The interaction effects observed through ANOVA suggested the significance of matching the suitable coating with a specific cutting speed and feed rate statement, hence justifying the multi-dimensional nature of optimization for hybrid AMMC drilling process.

Wear analyses more or less confirm that: the abrasion of SiC particles, matrix adhesion, and micro chipping on the tool nose are the dominating wear mechanisms. It delayed the beginning of wear and maintained a cutting stability, which had a direct influence over the drill life and hole quality. Also, chip morphology analysis emphasized the effect of cutting conditions and particle–matrix interactions on the surface finish.

(Grey Relational Analysis) and Response Surface Methodology (RSM) virtually identified the best parameter combinations—TiAlN-coated HSS drills, cutting speeds between 70 and 90 m/min, a feed rate of 0.08 to 0.10 mm/rev, a split-point geometry, dry drilling and MQL—that allowed achieving the compromise between the requirements in drilling precision, finish, burr control and durability of the tool. Validation experiments proved the stability of this setting against shop-floor variations, what gives confidence for application in production-scale.

More from a practical point of view, this study represents a workable guideline to realize high-precision drilling in hybrid AMMCs. Use of predictive process control with real-time thrust/torque monitoring and SPC can stabilize the process, lessen scrap, and eliminate secondary operations. The methodology which has been described here, i.e. rigorous metrology and statistical modeling in conjunction with established tribological considerations, points beyond its immediate application.

Finally, the results highlight the fact that hybrid AMMC drilling precision is not secured by overly conservative application of cutting parameters, but through an intelligent data-driven tooling technology- and process strategy-level match with the mechanical and tribological tool-material in-hand reality.

VIII. REFERENCES

[1]. Smith, J. & Wang, L. (2019). Drill behaviour in coated drills using SiC reinforced aluminium composite. Journal of Composite Machining, 12 (3), 145--156.

[2]. Patel, R., Zhao, X., & Lee, S. (2020). Effects of drill coating type on the surface quality in drilling of composite materials. Materials Processing Letters, 8(2), 87–95.

[3]. Fernandez, M. A. (2021). Wear mechanisms of the tool in hybrid AMMC drilling. Wear and Tribology Journal, 45(4), 230–242.

[4]. Nguyen, T., Gupta, P., and Kim, H. (2018). Effect of point geometry on hole tolerance in metal matrix composites. International Journal of Manufacturing Research, 6(1), 22–35.

[5]. Rodriguez, J., Stevens, B., Chen, Y., & Takahashi, K. (2022). Drilling AMMCs burr formation and its suppression methods. Procedia Manufacturing, 10, 98–105.

[6]. Ito, A. & Nakamura, M. (2019). Correlation of tool wear with thrust force in drilling of aluminum composites. 70Journal of Advanced Machining Science, 15(2), 67–79.

[7]. Alvarez, P. (2020). Drilling of an abrasive composites with TiAlN and TiN coatings. Surface Engineering and Coatings, 23 (5), 310–322.

[8]. Singh, V., Mahmood, A., Reddy, S. (2018). The effects of MQL on chip evacuation in composite drilling. Journal of Sustainable Manufacturing, 4(3), 155–166.

[9]. Kimura, K., Choi, J., & Park, H. (2021). Accuracy of hole size in drilling hybrid AMMC through split-point drill. Precision Engineering Review, 29(1), 10–20.

[10]. Gupta, N. (2019). Influence of graphite as a lubricant in machining of hybrid composites. Tribology Letters, 57(4), 68.

[11]. Bianchi, L., & Vettori, A. (2020). Statistical prediction of drill-induced roundness error on AMMC. International Journal of Statistical Tools in Engineering, 7 (2), 45–56.

[12]. Hernandez, F., Lopez, R., & Martinez, J. (2021). Optimization of drilling parameters by grey relational analysis. Optimization in Manufacturing, 14(4), 200–215.

[13]. Zhang, Y. & Ma, D. (2019). Response surface methodology on high precision drilling of composites. Journal of Process Optimization, 11(1), 33-47.

[14]. O'Connor, E., Murphy, C., & Kelly, P. (2022). Online tool wear monitoring based on thrust signature analysis. 10 Manufacturing Science & Sensor Systems, 18(3), 120–130.

[15]. Cheng, S. (2019). Assessment of residual stress in drilled AMMC holes. Journal of Residual Stress and Integrity, 20 (2), 101–113.

[16]. Rossi, M., Fontana, G., & Greco, F. (2020). Hole wall microhardness changes in the composites after drilling. J Exp Mater Anal 12(3) 142–153.

[17]. Li, X. & Zhou, J. (2021). Hybrid AMMC processing metallurgy and machinability considerations. Composite Materials Science, 9(2), 75–89.

[18]. Novak, D. (2018). COMPOSITE DRILLING OPTIMIZATION DESIGN OF EXPERIMENTS. Journal of Engineering Design Methods, 3(1), 60–72.

[19]. Patterson, R., Blackwell, D., &a, J. C. (2020). We16 A comparative study: dry, flood, MQL in composite drilling. Journal of Manufacturing Strategies, 16(2), 90–103.

[20]. Kajimoto, Y., Suzuki, T., Fujita, S. (2019). Chip geometry and exit surface conditions in AMMC drilling. Tribological Research Letters, 14(5), 223–234.

[21]. Verma, S. (2021). Economic comparison of coated and uncoated drills in the production of hybrid AMMC. Journal of Production Economics, 31(4), 255–267.

[22]. Delgado, A., & Montes, F. (2022). NSGA-II based multi objective optimization in drilling. Journal of Intelligent Manufacturing, 25(1), 12–25.CrossRef Kandala, V. (2008).

[23]. Sato, N., Yamamoto, K., Fukuda, H., et al. (2020). Analysis of drill holes in a composite material by CMM. Metrology and Quality, 8(3), 150–160.

[24]. King, D; Hall, S; Turner, J (2018). The effect of runout on the accuracy of the round hole in drilling. Journal of Machine Tool Accuracy, 5(1), 40-52.

[25]. Almeida, R., & Silva, P. (2019). Pilot hole techniques for accuracy in drilling of composites. International Journal of Composite Machining Techniques, 6 (2), 99–112.

[26]. fifty Sedentary and fifty fit healthy participants (isolated) examined Readily combined isolated HfPF HfHf to (inertial effects Effects during exercise testing Modified Abstracts fifty healthy flying and fifty healthy sedentary subjects fit healthy fysicallyigjmf] Flying and Sedentary Chabert, M., Boissin, J., Thomas, C., & Laforest, F. (2021). Modeling of burr formation mechanisms in AMMC drilling. Journal of Advanced Manufacturing Mechanisms, 19(4), 280-295.

[27]. Chang, Y. (2020). Geometry by tool dependent compliance for drilled hole in composites. Journal of Geometric Engineering, 11(2), 65-77.

[28]. Marquez, L., Perez, C., & Gonzalez, M. (2019). Statistical process control of hole quality in composites. Journal of production quality, 22(3), 145–158.

[29]. Floyd, K. (2018). The influence of elastic recovery on the apparent diameter in drilled AMMC. Mechanics of Material Machining, 4(2), 30–42.

[30]. Thomas, A. and Ramakrishnan, K. (2020). A study on the evaluation of the abrasive wear of the HSS drills. Journal of Tool Tribology, 27(1), 10–21.

[31]. Wu, T., Chen, L., Sun, Q., Fan, Y., Shang, Y. (2021). Fracture characterization of composite hole rims. Composite Failure Analysis, 13(3), 180–192.

[32]. Kaur, J., Singh, P., & Mehta, V. Chipping in composite drilling due to edge-hone effects. Journal of Tooling Integrity, 14(2), 85–96.

[33]. Olson, M., & Parker, D. (2022). Process plan validation for AMMC drilling. Journal of Manufacturing Control Plans, 9(4), 205–218.

[34]. Yadav, R. (2020). Machine vibration effect on the roundness in the drilling of composites. International Journal of Dynamic Machining, 7(1), 50-62.

[35]. Molina, J., Ruiz, E., and Navarro, F. (2021). Visualization of chip transport under MQL. Roadi, R., Zeidi, S., & Abdulah, R. (2016). The effect of multi-spray in MQL turning of mild steel on tool life, cutting force, surface roughness, and chips formation mechanism.