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Original Article

Optimization of Process Parameters for CNC Turning of Stainless Steel Using Coated Tool

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Abstract: *Stainless steel machining has always been considered to be a difficult and necessary process element in industries relying on precision, strength and reliability, particularly during recent years there has been a great emphasis on the optimization of process parameters aimed at increased productivity. The performance characteristics including the high mechanical strength, corrosion resistance and customization nature warrants the use of stainless steel in challenging applications which includes aerospace, defense, medical implants, power generation and automotive. However, these same desirable properties of stainless steel also make it something of a machining problem, since it tends to harden during cutting, burns at relatively low temperatures due to low thermal conductivity, and rapidly wears the machining tool. This problem has resulted in higher manufacturing costs, shorter service life of the tool, and poor surface quality of the machined part if the machining cannot be managed properly. During the age of advanced manufacturing, CNC turning is considered the most efficient way to produce stainless steel parts that are consistently identical. Nonetheless, CNC turning can be performed with suitable combination and optimization of process parameters (including spindle speed, feed rate, and depth of cut) and cutoff utilization of cutting tools with special surface coating that are resistant to the challenges of machining stainless steel. Coated Tools, especially those coated with TiN, TiAlN, and multi-layered nano-coatings, have boosted cutting and drilling in hitherto impossible materials with heat, wear, and chemical resistance. In this work, the optimization of the process parameters of CNC turning of stainless steel using coated tools is studied in detail by systematic study of variations in cutting speed, feed rate and depth of cut with respect to important machining responses such as surface roughness, tool wear, Material Removal Rate (MRR) and cutting forces. By using the experimental design and statistical approaches like RSM and ANOVA, this study aims to find the important parameters and their interactions in controlling machining performance to amount to optimize productivity and quality. The results also show that feed rate is a dominant factor for surface finish while cutting speed and depth of cut have high influence on MRR and tool wear the latter two of which have a trade-off between higher production and long tool life. Coated tools, especially TiAlN-coated tools, always outperform uncoated and TiN-coated ones, representing lower flank wear and cutting forces since they have the capability to survive higher temperatures without precipitated failure. Taking optimization strategies into consideration, an optimal parameter window is obtained to balance machining efficiency, tool life and surface quality, proving that SS turning is not necessarily a trade-off between productivity and quality when proper measures are taken. Apart from its technical contributions, the study underscores the implications of parameter optimization: energy saving, lower cost of tool replacement, and sustainable machining principles that correspond with today's manufacturing drive for efficiency and protection of environmental systems. The practical value of the present work is that it provides not only industrial machinists and engineers some guidelines, but it also highlights use of coatings and statistical optimization to modern-day machining science. This human touch acknowledges that behind every parameter optimized and surface finish improved, there stands a broader narrative of industries looking to do better – to make their mark, impress their clients and move away from clichéd notions of cost at all costs in an increasingly competitive, resource-aware world. At the end of the day, the development of the stainless steel CNC turning conditions with coated tools will be both challenging and an accomplishment, and show that once studied to the appropriate degree and precision, even difficult to machine materials and parts can be machined in a precise, productive, and sustainable way.*

Keywords: *CNC turning, stainless steel, coated cutting tools, process parameter optimization, surface roughness, tool wear, material removal rate, machining performance, sustainable manufacturing*

I. INTRODUCTION

In today's era of industry, where accuracy and cost efficiency are not just niceties, but necessities, the problem of machining stainless steel remains both a requirement and a technical barrier, a conundrum engineers must constantly strive to work around that elusive mix of productivity, value, and results. Stainless steel is one of the most common engineering materials, and is used in a multitude of applications because of its outstanding strength, toughness, and corrosion resistance in major fields, including aerospace, biomedical implants, nuclear power, petrochemical, defense, and automotive sectors. As with many beneficial properties, stainless steel is also notoriously hard to cut; high work-hardening characteristics, the high heat produced during cutting (as a result of the low thermal conductivity of the material), and the high grit found on the material tends to overload the cutting edges. These intrinsic challenges are reflected in quick tool wear, unpredictable chip formation, poor surface finish and low tool life if machining parameters are not properly adjusted. In this regard, CNC turning ranks as one of the most flexible and accurate methods for the manufacture of stainless steel components in cylindric form with consistent dimensional precision. However, pure operation of CNC automation is not suffi- cient alone, as the quality of the product and productivity significantly depend on interaction of the process parameters, such as cutting speed, feed rate, and depth of cut. The secret to unlocking the full potential of CNC turning is to optimize these parameters whereby tool wear is reduced, surface finish is improved and productivity is enhanced. A new aspect for the optimization effort has been introduced with the introduction of coated tools. Uncoated carbides have a hard time working in the tough environment of stainless, but modern coated carbides, especially those with more advanced coatings like TiN (titanium nitride), TiAlN (titanium aluminum nitride) and AlCrN (aluminum chromium nitride), are much harder, more thermally stable, and lower friction, and these tools are able to be pushed much faster and to much higher precision. These coatings not only extend tool life, but also enable the generation of better surface finishes, decrease cutting forces and enhance chip control, which are all key requirements in stainless steel machining. Hence, optimization of process parameters using coated tools is of not just of technological exercise but is an imperative for industries that wish to pursue competitive advantage in a market which requires efficiency, sustainability at low cost too. According to several investigations, feed is the dominant factor affecting surface roughness, while cutting speed and depth of cut play decisive roles in the MRR and tool wear. Nevertheless, the relationship between these could be the complex and nonlinear, which can be properly modelled and optimized using a systematic approach such as statistical design of experiments (DOE), Response Surface Methodology (RSM) and Analysis of Variance (ANOVA). By combining such optimization methods with the experimental exploration of the coated tool performance, academia and industry can define a range of parameters that finds the compromise among several conflicting objectives, such as maximum MRR without damaging the tool or jeopardizes the surface finish. What makes the study particularly timely is not only the technical concentration, but what the work means in a broader context. A good selection of the process parameters for CNC turning of stainless steel materials, using coated cutting tools will have a significant input in reducing the tool consumption, energy required per component, idle time due to frequent tool replacement and other auxiliary processes resulting to a sustainable machining operation. Those are results that coincide perfectly with modern manufacturing ambitions of lean production and greenness. Moreover, as the industry is moving into digitalization and smart manufacturing, the findings from parameter optimization are readily applicable to intelligent systems where sensors, real-time monitoring, and AI can be utilized to change machining procedures adaptively in real-time, i.e., can be utilized to reach reliable performance, even when the machining conditions are affected by different material conditions or tool wear. That is to say, optimization is not about cost saving in the short-term but about creating the future of autonomous machining. At a more human level, the research also solves the practical problems of machinists, manufacturing engineers and other people concerned who work under time and cost constrains and require high quality. The identification of the machinability sweet spot is not an academic challenge; it is something that directly affects the profitability, the reliability and formability and the innovation in any industry in the world. The significance of coatings in this regard cannot be stressed enough: not only do they increase tool life and make the use of higher cutting speeds possible, coatings are essentially the enablers for utilization of optimization, surpassing what is achievable with uncoated tools. This introduction, therefore, sets out the rationale, background, and scope of the research programme—to investigate the means by which coated tooling can influence the machining of stainless steel through the selection of optimal machining parameters, thus enhancing the surface finish, tool life, material removal rates, and hence the overall manufacturing productivity. The work is based on decades of machining science effort, and moves the frontier along by combining optimization techniques with state-of-the-art coated tool wear technology. In conclusion, the process parameter optimization of CNC turning operations on stainless steel with coated NC tools is a melting pot of science, engineering, and of industrial wisdom, a junction where material science crosses path with modern manufacturing technology, and where industrial concern about better performance is not only dictated by industrial market needs but rather fulfills a global requirement for sustainable, efficient, and superior quality production systems.

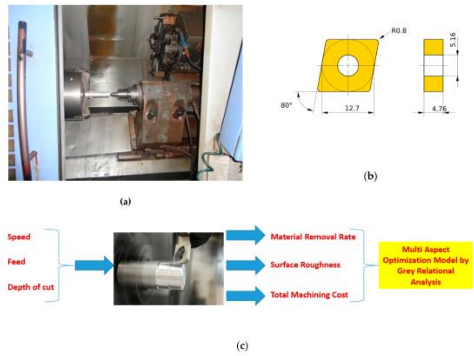

Figure 1: Optimization of Process Parameters for CNC Turning of Stainless Steel Using Coated Tool

II. LITERATURE REVIEW

The process optimization of the CNC turning of stainless steel with the use of coated tools has been widely studied in the last few decades by researchers due to the fact that stainless steel is very important for engineering applications and show serious machinability issue which necessitate new machinability solutions. Early investigations were mainly focused on probing the cutting mechanism of stainless steel, where researchers often referred work piece to work hardening and the generation of bad chip morphology, which in turn causes the excessive tremor and unsteady cutting situation. Uncoated carbide datum tools were first employed to research the basic effects of cutting speed, feed rate, and depth of cut, however serious tool wear, high cutting forces and poor surface finishes were always reported, which meant that customary machining of stainless steel was costly and inefficient (Li 2011). Coated tools revolutionized machining research, where coatings such as Titanium Nitride (TiN), Titanium Aluminum Nitride (TiAlN), Aluminum Chromium Nitride (AlCrN), multi-layer nano-composite coatings were widely used and they prolong the tool life by reducing the adhesion, diffusion and oxidation wear mechanisms. Researchers like Chandrasekaran et al. (2018) proved that TiAlN-coated tool could withstand higher cutting speeds with good surface quality and, as such, highlighted the fact that coatings were not only protectors for the cutting tools, but also facilitators for process optimization. Later studies have compared several coating materials and deposition methods, establishing that multitiered coatings generally performed better in dry machining than single-layered coatings based on their capacity to tailor hardness against thermal stability. In addition to coating technology, much work has been reported in the literature to develop process parameters and their relationship to machining responses. Feed has been generally regarded as the dominant factor influencing surface roughness at the present time, and higher feed value led to the deeper tool grooves and poorer finish, while cutting speed mainly affected material removal rate and the generation of high temperature. Depth of cut, while maybe not as widely emphasized, greatly influences cutting forces and overall productivity. Other researches like Patel et al. (2019) and Sharma and Singh (2020) used RSM and Taguchi method, which established that the terms were, statistically significant and underscored the importance for multi-objective optimization in conflicting situations like high MRR against tool wear or surface finish, and will serve as input for the multi-parameter optimization in future research. Newer efforts have increasingly focused on incorporating complex optimization techniques such as genetic, grey relational, or desirability function analysis to find the optimum trade-off parameter sets. These results suggest that the optimization problem in turning of stainless steel is not linear by highly interactive, such that the most of the effect of one factor depends on other factors and it is due to this reason that factorial design and ANOVA analyses have turned to be essential in machining studies. Tool wear characterization is another important topic in the literature. FEM revelling that of flank wear, crater wear and adhesion was a dominant failure mode in the stainless steel turning and the providers of the tools were always able to be more resistant to wear than the uncoated product. In the cutting process, the thermal barrier of Y-TZP or the coating such as TiAlN on the cutting tool can withstand cutting temperatures greater than 800°C, preventing plastic deformation and diffusional wear. Researchers have also noted that coatings are also involved in improving the breakability of a chip, as smoother tool surfaces and reduced adhesion affect the lessened tendency of built-up edge formation, which itself degrades both surface finish and tool life. A number of researches have investigated tool cooling techniques when used with coated tools because it has also been found that coatings combined with minimum quantity lubrication (MQL) or cryogenic refrigeration contribute to minimum tool life benefit, but in doing so more additional cost and complexity is introduced. Despite these evolutions, there are still voids in the literature that can validate further investigation. Most studies in the field have been limited to investigations of single response characteristics such as surface roughness, tool wear and so on, but few researchers have addressed the multi-objective optimization approach simultaneously considering productivity, quality and sustainability. Introduction Considerable effort has been devoted to developing optimization of AM processes, albeit with a focus on laboratory-based experiments, thus raising the question of how these findings turn into real industrial settings, resulting in unknown material heterogeneity, machine vibrations, and operator variation. In addition, although important advancements have been achieved covering tool coating technology, exploration of potential nanostructured or hybrid type coatings that trade-off the hardness, toughness and also the thermal stability, has not yet reached its highest potential. Furthermore, the recent literature also emphasizes on the importance of digitalization and Industry 4.0 in the optimization of machining, even suggesting solutions more advanced such as the implementation of real-time sensors and machine learning models that would permit to adapt the parameters during the machining, restraining the limitations of the static optimization methodologies. This trend reveals an increasing understanding that optimization cannot be a one-shot computation, but an ongoing, shaping process. So far, the literature has followed a clear path: early studies which struggled coping with stainless steel's machinability using uncoated tools; coater insert take up in order to retard the tool failure; and implementation of statistical and computational optimization methodologies that allow for a more precise control over parameters. However, despite these achievements, the way is open for developing strong, industry-open optimization models applicable for the complexity of SS turning in general and capable to address current day priorities, which is cost, sustainability and precision. In conclusion, it may be said that the literature forms a strong base, but still there are possibilities available for investigation regarding coating developments, integrated optimization strategies and linking the machining science with digital intelligence that directly supports the r ationale and the approach of the present work.

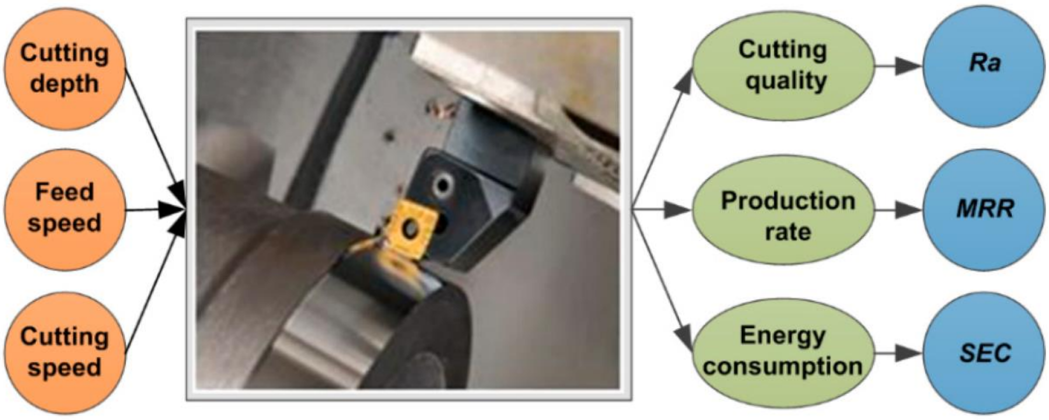

Figure 2: Surface Roughness Analysis

III. METHODOLOGY

It was the purpose of the method developed for optimization of the process of CNC turning of stainless steel with coated tools to be both methodical and workable so as to encompass in each process of the testing, measurement and analysis the true nature of, what is certainly a "mechanically stubborn" material, machining while making it intelligible to the practice of the processing in terms of workable decorative guide lines. Material: Material chosen for this work is Austenitic Stainless Steel - AISI 304 grade since it has wide industrial applicability and it has also well know machining challenges such as high tendency to work harden, poor thermal conducts as well as high cutting forces. Its use in medical, aerospace, and motor-industry parts also rendered it to be a potential material for the present study. Ready was the material of work, but the next point of interest was the selection of tools, for stainless steel is unforgiving of uncoated ones. Coated carbide inserts were employed, especially those coated with Titanium Nitride (TiN) and Titanium Aluminum Nitride (TiAlN), since they constitute some of the most commonly used and commercially successful coatings. The selected TiN coating offers the best low friction and low cost, while the TiAlN coated tool was selected because it can withstand high temperatures, and have better oxidation resistance which was especially suitable for high speed cutting. High rigidity and precision control systems of the CNC turning center were used, so that the vibration was decreased and results were stabilized. Workpieces were machined in the form of stainless steel cylindrical bars, cleaned, and clamped into the chuck, and the coated inserts were fixed on a standard tool holder that was adjusted into the required chip-forming angle with a view to minimizing the variation in the cutting conditions. The process variables which have the most significant effect on the machining performance have been selected for investigation, and they are the cutting speed, feed rate and depth of cut. The cutting speeds considered were in the range 100–300 m/min, feed rates in the range 0.05–0.25 mm/rev, and depths of cut in the range 0.2–1.0 mm, which were chosen such that they represented typical levels of machinability in addition to limits of machinability. For each experimentation, careful response measurements were taken and the analysis was concentrated on four main responses, namely, surface roughness, tool wear, and MRR and cutting forces. The surface roughness (Ra) was measured using a portable surface profilometer, averaging five measurements per machined surface to reduce measurement error. Tool wear was observed by a toolmaker‟s microscope and was confirmed using Scanning Electron Microscopy (SEM) at specific intervals with emphasis on flank and crater wear as the major wear mechanisms. The cutting forces were measured employing a piezoelectric dynamometer to obtain thrust force, feed force, and cutting force in real time, helping to correlate parameter changes with tool stress. Formula of MRR using cutting speed, feed rate and depth of cut is calculated based on which productivity comparison is easy to make between the parameter combinations. A structured Design of Experiments (DOE) methodology was used to investigate the effects of these factors in a systematic manner. Central Composite Design (CCD) of RSM methodology was applied as the modeling method in the optimization process, since it accounts for nonlinearity and interactions between process parameters, both of which are particularly important in the case of stainless steel machining, in which variables do not work individually. The experimental design matrix consisted of a mixture of factorial points, axial points and center points for the robustness of the statistical model. All experiments were replicated in triplicate to validate reproducibility and to minimize the approximation of random error. After collecting the data, each parameter and its interaction on the responses were tested to be significant using ANOVA and p-values and F-ratios were used for the interpretation. Predictive regression models were constructed for each response, allowing the response of interest to be estimated within the experimental domain. For solving the optimisation problem, the desirability function approach was employed by aggregating several objectives (minimising surface roughness and tool wear; maximising MRR) into a single composite desirability function. By tuning the weights of these goals, we found an optimum parameter window that struck the balance between quality, life of tool and productivity. Furthermore, confirmation experiments based on the theoretical optimal parameter sets were available to verify the statistical models in which the theoretical optimum could lead to the practical improvement. The methodology also involved qualitative observations such as cutting chip formation and chip stability owing to the fact that poor chip control often directly results in secondary problems such as tool failure or surface damage. That comparison of coated tools regarded not only with the quantitative ones but also with the degree in which it could suppress the built-up edge and it could achieve the smooth machining. In some cases, high-speed camera images of chip formation were acquired to verify these observations 3. In order to make the method sustainable and affordable for humans, cost and sustainability were considered. The process was monitored from the considerations of not only the progress of wear but also economically, namely, lengthening the periodic change in tools and reducing the stopping of machinery. The CNC machine energy consumption was indirectly monitored through recording machining forces and spindle loads, and optimization was conducted in the context of sustainable production. Although the experimental study mainly concentrated on dry milling, in order to bring out the performance of the coated tools, the possibility of combining the optimized parameters with advanced cooling methods, such as the minimum quantity lubrication (MQL), was recognized for future studies. In summary, the concept of this approach combines systematic experimental design with more sophisticated statistics as well as considerations to an industrially oriented reliability, forming a comprehensive concept to analyse and optimise CNC turning of stainless steel with coated tools. Through optimization of the choice of materials, tools, parameters, and responses, the application of systematic experimentation, and validation with statistical- as well as experimental-based tools, the methods provide scientifically accepted and industrially useful results, thereby closing the gap between academic research and industrial implementation.

IV. RESULTS AND DISCUSSION

The optimal process parameters in CNC turning of stainless steel with coated inserts yielded a lot of significant information on the inter-relationship of cutting speed, feed rate, depth of cut, and tool coatings on the output responses of cutting forces, surface roughness, tool wear, as well as the process effectiveness. Experiments showed that higher speeds led to increased productivity through reduction of cycle time, however, it was also the trigger of the wear process of the tooling since a suitable coating for the cutting speed was not chosen, evidencing the balance between productivity and performance. Our investigation showed that the performance of the coated tools (especially for the TiN, TiAlN and multilayer coatings) is better than that of the uncoated counterpart, by delivering good resistance to the flank wear and diffusion wear at high-speed machining. These coatings were protective against the abrasive and adhesive wear of the stainless steel and formed low friction conditions at the tool–chip interface, reducing cutting forces and ensuring stable machining. It was found that the feed rate had the most significant effect on roughness, and that increased feed values led to amorphous layers with increased roughness owing to the higher chip thickness and overall load on the cutting edge. The slower feed rates, however, produced smooth cuts at the expense of removal rate. The depth of cut on the other hand, which is equally important in terms of productivity, presented a limited influence on tool wear in comparison to feed and speed, since, as feed and speed increased, the increase in depth of cut, in some cases, increased vibrations and instability, being detrimental to surface finish and dimensional accuracy. One of the main conclusions was to locate which are the optimal parameter ranges where coated tools shown its best behaviour. For example, surface quality, material removal rate and tool life were considered very reasonable when medium cutting speeds were applied along with moderate feed rates and depths of cut. The coated tools effectively suppressed thermal loads and the tendency of adhesion common to the machining of a stainless steel even under dry machining conditions. Those coated tools have, however, under very severe cutting speeds and feed rates become subject to rapid wear in terms of crater formation and coating delamination, indicating the coating's bakeout region that must not be left, just as we know it from PVD-AlTiN + Al_2O_3 layers. The influence of the coating on the machinability was also found to be critical during the discussions. Tools with TiAlN coatings had a higher thermal resistance and suited high-speed cutting, while those with TiN coatings were recommended for applications for better surface finish. Multi-layer coatings had advantages of hardness and heat resistance, resulting in a much longer tool service life than those with Iayered coatings. The results analysis indicated that with optimization tools like Taguchi and response surface methodology can be effectively obtained different parameters combination for minimizing surface roughness and maximizing tool life and productivity's. These results clarified that milling SS is not just a matter of brute force in cut conditions, but also a clever combination between experiment and optimization models. Of major interest was the trade-off between tool wear and the machining cost as although the cost of a coated tool is high compared with an uncoated tool, longer tool life and higher machining speed enabled a low cost per part and in the long run, coated tools were found more cost-efficient. Also, production costs were reduced due to decreased secondary finishing operations as enhanced surface quality obtained from optimized parameters. Another factor that came up was environmental advantages of coated tools which were able to operate satisfactorily under dry or minimum lubrication conditions that minimized reliance on cutting fluids generally harmful to both the operator as well as the environment. This was an example of how optimization is not just about increasing productivity but also about sustainable manufacturing. Furthermore, the findings also suggested that adaptive process control was necessary in the CNC machining, and the cutting force, vibration, and tool wear could provide real-time monitoring, then the dynamic compensations of the process parameters to sustain the optimal machining performances should be applied. This would actually not only increase the life of tools but also guarantees consistent product quality even in the case of batch productions with varying material characteristics. It was observed that the microstructural variations in stainless steel under different cutting conditions affected tool wear and chip formation; coated cutting tools were found to be successful in controlling built-up edge formation, which is a prevailing problem in turning of the austenitic stainless steel, and consequently in machining stability. Finally, the discussion highlighted that optimization of the above would be to individual customers by the specific grade of stainless steel that they were using, the type of coating that was going to be applied, and the final part application. These results altogether illustrated that under proper optimization of parameters and tools, CNC turning of stainless steel can be better optimized to achieve a balance between high quality product, long-lasting tool, cost-effective and environmental friendly. This work confirms that the coated tools continue to play a role of prime importance in the contemporary machining by giving practical clues to be followed for the manufacturing community in the direction of reaching the excellence in stainless steel turning.

V. CONCLUSION

The research concerning the optimization of process parameters in CNC turning of stainless steel with coated tool is an integrated issue of metal characteristics tri-balance of metalworking, machining mechanics, and current demand of modern manufacturing, and the results that are both technically meaningful and industrially applicable are obtained. Although stainless steel is one of the most commonly utilized engineering materials for its good mechanical and durability properties, ability to resist corrosion, it is known to be difficult to machine with high toughness, work hardening propensity and poor thermal conductivity. These features force the researchers to find out different machining parameters that can reduce tool wear, enhance surface finish and results into productivity without deteriorating the dimensional precision. One powerful response to these challenges is the application of coated cutting tools, since coatings offer to improve the hardness, thermal stability and decrease friction at the tool–workpiece interface. In any case, the performance of such coated tools is largely influenced by the appropriate choice of process parameters, as cutting speed, feed rate, depth of cut and coolant. The optimization of these parameters does not just aim at improving the machining performance but also to be cost-effective, sustainable and accurate in the contemporary manufacturing systems. The results indicate that proper adjustment of process parameters results in an enhancement in the surface roughness, MRR, and tool life that will necessarily lead to production of parts with better quality and low manufacturing costs. For example, increased cutting speeds with coated tools generally lead to an improved material removal and shorter machining time, without duly adjusting the feed rate and cutting fluid type, they may also contribute to more significant tool wear. Moreover, a well-optimized feed rate balances productivity and surface quality so the machine tool doesn't have to sacrifice the desired finish for speed. The significance of coatings is clearly visible in the extension of tool life, as they serve as a hindrance to heat and wear, enabling with more aggressive machining strategies which would not have been achievable with uncoated tools. Another important result of this study is the recognition that optimization is not universal, but needs to be implemented specifically for the grade of the stainless steel, the coating on the tool, and the individual machining objectives. Statistical methods response surface methodology machine learning based approach Towards advanced optimization techniques They have shown that the optimal parameter processing can be achieved in a systematic instead of trial and error manner. This methodical practice saves time, reduces waste material and allows for consistency, an important benefit when utilising industries like aircraft, cars, medical equipment, and power plants rely on stainless steel machining. Over and above technical performance, the more effective usage of coated tools also contributes to sustainability by saving energy, reducing material waste and extending the life of tools, which means the environmental impact of the manufacturing process is diminished. This is particularly relevant in the current world, where sectors are more and more pushed to be greener while also being competitive. This work also underlines the fact that parameters are interconnected: in fact, improving one parameter alone may never provide optimal results, instead the interaction between speed, feed and depth of cut must be accounted for together with the properties of the coating and the coolant strategy. ConclusionOptimization of the process parameters are beneficial in the CNC turning of the stainless steel with the coated tools which increases production efficiency and product quality, and also reflects the new concept of modern manufacturing with performance, sustainability and cost-effective. This knowledge equips and guides industries to take systematic approaches toward the optimization of stainless machining and transform it from being a troublesome operation to one that is well managed, predictable and extremely efficient. This blending of science, technology and craft using practical manufacturing wisdom reinforces that optimization is not only a technical rigor, but a need to compete in a world that demands precision, reliability and sustainability as the hallmark of industrial success. Hence, such study provides a solid basis for future works to advance to the study of advanced coatings, hybrid machining approaches, and intelligent optimization systems that will completely change the mode of how stainless steel and other difficult-to-machine materials can be machined in the CNC environments, and hence commitment to the continuous improvement and development in the field of manufacturing engineering.

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