Determination of Taguchi Grey Relation Analysis to Influence the Tool Geometry and Cutting Parameters of the Ti-6Al-4V Alloy to Achieve Better Product Quality

S. Ashok Kumar, Ganesh Babu Loganathan, P.R. Shobana Swarna Ratna, G. Balakumaran, S.P. Sundar Singh Sivam

Abstract*: It may be more expensive on some system, as manufacturers frequently obtain and spread over new producing materials that are brighter and stouter—and thus a lot of fuel-effectual—it follows that cutting tool manufacturers should mature tools which will machine the new specimens and Geometry at the best attainable levels of productivity. Feasibly the mutual thread through all producing is the determination for exaggerated productivity and dependableness. As metal cutting operations become increasingly fine-tuned, the relationship between cutlery micro (cutting edge preparation) and macro (rake face topography) pure mathematics is changing into a lot of and a lot of necessary. This study intelligences the outcomes of a Turning experiment showed on the Ti–6Al–4V alloy of L9 orthogonal array on CNC Turning center with Taughi gray relative analysis. Emphases on the optimization of Turning method parameters victimization the technique to get minimum Resultant Cutting Force, Tool Wear, Tool Life, and Energy Consumption. The experimentations were performed on Ti–6Al–4V alloy block of the cutting tool of changed pure mathematics of CNMP120408-SM TN8025 of twelve metric linear unit diameter with cutting purpose one hundred forty degrees, used throughout the experimental work beneath totally different cutting conditions. Grey relative Analysis & ANOVA was castoff to total the primary necessary Cutting speed as constant of 3000Rpm, feed rate, Depth of Cut and Different Tool Geometries conditions that moving the response. The main and interaction effect of the input variables on the expected responses are investigated. The expected values and measured values are fairly Near to the Outcome one.

***Index Terms*: Grey Relation Taguchi method, Geometry Parameters.**

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***Correspondence Author(s)**
S. Ashok Kumar, Department of Mechanical Engineering., Aarupadai Veedu Institute of technology, Vinayaka Mission's Research Foundation, Paiyanoor, Kancheepuram Dist, Chennai- 603 104, Tamil Nadu, India.
Ganesh Babu Loganathan, Assistant Professor, Head of Mechatronics Engineering, Tishk international University, Erbil Kurdistan Region-Iraq.
P.R. Shobana Swarna Ratna, Department of Mechatronics Engineering, SRM Institute of Science and Technology, Kancheepuram District, Kattankulathur- 603203, Tamil Nadu, India.
G. Balakumaran, Department of Mechatronics Engineering, SRM Institute of Science and Technology, Kancheepuram District, Kattankulathur- 603203, Tamil Nadu, India.
S.P. Sundar Singh Sivam, Department of Mechanical Engineering, SRM Institute of Science and Technology, Kancheepuram District, Kattankulathur- 603203, Tamil Nadu, India

I. INTRODUCTION

Geometry of single point turning devices. Both material and geometry of the cutting devices assume vital jobs on their exhibitions in accomplishing viability, proficiency and in general economy of machining. Rake point is given to simplicity of chip stream and in general machining. An instrument's geometry incorporates its shape and measurements on both full scale and miniaturized scale levels. On the full-scale side, the fundamental size and state of a cutting addition decides its quality. Cutting powers following up on a vast supplement will result in lighter burdens than similar powers would make on a littler addition. An extensive, solid supplement empowers utilization of profoundly profitable feeds and profundities of cut. Be that as it may, a substantial addition will be unable to machine littler part includes. Comparable contemplations exist concerning embed shape. A round supplement shape is the most grounded, and a 90-degree corner of a square addition is more grounded than a 35-degree corner of a precious stone supplement. In any case, a round addition can't cut indistinguishable assortment of part profiles from a 35-degree apparatus. There is a tradeoff of solidarity for adaptability of utilization. Another geometric factor includes how the instrument enters the workpiece, characterized by the bleeding edge point, the tendency edge and the rake edge. In the event that the supplement top (rake) face is opposite to the work surface, the instrument's rake point is viewed as negative. Cutting powers are coordinated into the mass or most grounded piece of the apparatus. Then again, when the front line is tilted once more from the workpiece surface, the apparatus' rake edge is viewed as positive. Cutting powers are focused on the device edge, which isn't as solid as the mass. What's more, an addition connected in positive rake must element a wedge or freedom point on the flank face, further diminishing device strength. Negative rake machining is powerful in extreme materials, for example, steels and cast irons, yet in addition produces higher cutting powers, may confine chip stream, and may cause vibration in under unbending machines, installations, or workpieces. Positive rake produces lower cutting powers and more liberated chip stream; however the device is increasingly defenseless to chipping and crack, and chips might be uncontrolled.

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Positive cutting is appropriate for sticky materials and superalloys that require a sharp front line.

The absence of data on cutting device geometry and its impact on the results of machining task can be clarified as pursues. Numerous incredible discoveries on the apparatus geometry were distributed quite a while prior when CNC crushing machines fit for imitating any sort of hardware geometry were not accessible and PCs to ascertain parameters of such geometry were not normal; it was along these lines amazingly hard to repeat appropriate instrument geometries utilizing manual machines. Therefore, once-powerful sections on apparatus geometry in metal cutting and instrument configuration books were decreased to a couple of pages, in which no relationship between's device geometry and execution was typically considered. What is left is a general recognition that the purported positive geometry is by one way or another superior to the negative geometry. All things considered, there is no quantitative interpretation of "better" into the language of specialized information, despite the fact that an incredible number of articles written in numerous expert magazines talk about the subjective focal points of positive geometry. The geometry and classification of cutting instruments, even single-point cutting apparatuses, are shockingly confused subjects [1– 4]. It is troublesome, for instance, to decide the suitable planes in which the different edges of a solitary point cutting instrument ought to be estimated; it is particularly hard to decide the incline of the device face. As pointed out by Researcher Studied [4], there are three fundamental frameworks in which the instrument geometry ought to be considered relying on the targets, to be specific, the device close by, device in-machine (holder) and apparatus being used frameworks. One ought to value the necessity of such thought and the requirement for change frameworks on the off chance that one considers a straightforward cutting addition utilized in an indexable turning, processing or penetrating device. The supplement has its very own geometry, doled out by the addition attracting and demonstrated the inventories of the apparatus makers. Specialist [5] depicts how rake point and cutting parameters influence the remaining worries in turning. Face turning with steady speed in AISI 52100 was utilized. The outcomes demonstrate that it is conceivable to create customized remaining feelings of anxiety by controlling the apparatus geometry and cutting parameters. Analyst [6] explored the impact of materials swelling in ultra-exactness machining of malleable materials. The joined impact of materials swelling and recuperation was found to influence the surface harshness in single-point precious stone turning. The outcomes from the level of unpleasantness anisotropy demonstrate that the surface harshness fluctuates deliberately at various spiral segments of the workpiece. Specialist [7] built up an exact model for surface unpleasantness utilizing two dimension fragmentary factorial plan (25-1) with three recreates considering work piece hardness, feed rate, cutting apparatus point edge ,cutting pace and cutting time as free parameters utilizing nonlinear investigation. Creator Studied [8 6] utilized 23 factorial plan for the advancement of surface harshness demonstrate for turning of gentle steel with covered carbide devices. Analyst Studied [9, 10, 12] have utilized models for anticipating the surface unpleasantness with earthenware wiper embeds. They found that with wiper embeds high feed rate (0.25mm/rev) is conceivable to acquire machined surface <0.8 μm of R . Analyst Studied [9] utilized 23 full factorial structure for AISI 316L steel with three factors named feed, speed and profundity of cut for use of femoral head. Specialist Studied [10-25] have created fake neural systems (ANN) and different relapse approaches utilized for the surface harshness of AISI 1040 steel. Creator Studied. [12] utilized reaction surface strategy for enhancement of hardware geometry parameters like nose sweep, approach point and rake plot for the forecast of surface unpleasantness for AISI 1040 steel. Scientist Described [13-29] utilized RSM for examinations of cutting parameters effect on cutting powers and surfaces in completion hard turning of MDN250 steel and presumed that great surface unpleasantness can be accomplished when cutting pace and profundity of slice are set closer to their abnormal state of the trial range and feed rate is at low dimension of the exploratory range. For improving the related procedures. Amid the present examination, the impact of all the machining parameters, for example, Spindle Speed (SS) as Constant, Feed (f) and Depth of cut (t) has been researched on the responses amid dry machining of Ti alloy. Grey Relational investigation has been used for concurrent improvement of slicing parameters keeping in mind the end goal to get positive execution attributes in machining.in the present examination, test points of interest utilizing the Grey Relational Taguchi system of parameter configuration have been utilized for streamlining numerous execution qualities appreciate Resultant Cutting Force, Tool Life, Tool Wear and Energy Consumption for Turning of Ti Alloy with limit the mechanical toxins. To put it plainly, there's an adequate extent of applying the anticipated technique of Grey Relational Analysis and Taguchi strategy with the various reactions for the change of machining parameters of Ti Alloy utilizing the economical tool, utilized all through the test work for the advantages of enterprises.

II. EXPERIMENTAL METHODS AND MEASUREMENTS

A. Experiments Stages

The Specimen utilized in this examination is TI– 6AL– 4Valloy with the accompanying synthetic arrangement (in wt. %) recorded in table 1. TI– 6AL– 4V compound was Turned by PSG All Gear Lathe. The exploratory outcomes were utilized for demonstrating utilizing dim Relation Analysis, is a pragmatic, utilizing and simple for execution. Energy Consumption was estimated by Energy Meter, Tool Life were estimated by thinking about the impacts of each one of those parameters, the Taylor's apparatus life condition. Instrument Wear was finished by Tool creators Microscope fabricated by Zoller and Resultant Cutting Force was estimated by Kistler make piezo electric dynamometer type 9257B.

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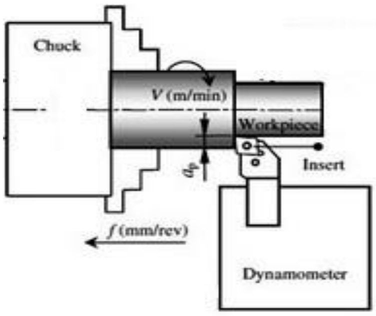

Figure 1: Schematic Diagram for Experimental Setup

B. **Optimization steps of Grey relational analysis:**

Grey-based Taguchi approach for process optimization has been carried out to solve this multi-response optimization problem. Primarily feed, rotational speed in 2 levels of each of the 4 controlled factors.

The steps to be followed in grey relational analysis are as follows:

Step1: Finding out the experimental Data Table.

Step-2: Generation of Grey Relational. That means normalized the values ranging from 0-1 using formula for Lower the better.

$$x_i(k) = \frac{\max x_i(k) - x_i(k)}{\max x_i(k) - \min x_i(k)}$$ Lower the Better.

$$x_i(k) = \frac{x_i(k) - \min x_i(k)}{\max x_i(k) - \min x_i(k)}$$ Higher the Better.

Where Xi (k) = Value after Grey relational generation

Min Yi (k) = minimum of Yi(k) for kth Response

Max Yi (k) = maximum of Yi(k) for kth Response

Step-3: Calculation of Grey relation Co-efficient using formula:

$$x_i(k) = \frac{|x_i(k) - x_0(k)|}{\max x_i(k) - x_0(k)}$$

$$\Delta x_i(k) = |x_0(k) - x_i(k)|$$

= Difference between absolute Values of $|x_0(k) and x_i(k)|$

Step-4: Finding out the Grade for Grey Relational (mean of Grey Coefficients of every factor at ith run. Presently the general execution of various reaction process relies on the ascertained Grey Relational review. This approach changes over a different reaction advancement circumstance with the target work in general Grey Relational Grade.

Step-5: Evaluation of ideal parametric mix which would come about most extreme general Grey Relational Grade. The ideal factor setting for most extreme general dark social review can be performed by Taguchi's strategy.

Step-6: Then plotting the reaction table and reaction diagram we can study the ideal settings of various parameters.

III. EXPERIMENTATION FACTORS AND LEVELS.

In the present-day Situation, Machining of TI–6Al–4V with Minimum Resultant Cutting Force, tool wear, Tool Life and Energy Consumption is a challenge to manufacturing industries. In the contemporary study Feed, Depth of Cut, Clearance angle and Rake Angle are taken as process parameter and is a controllable one.

Table 1: Factors and Levels @ constant 3000 Rpm

Parameters	Unit	Levels		
		1	2	3
Feed	mm/rev	0.02	0.04	0.06
Depth Of Cut	mm	0.5	1	1.5
Clearance angle	0	15	17	20
Rake angle	0	12	17	20

IV. RESULT AND DISCUSSION

The optimization constraint for getting the final reply for the industrial benefits and product excellence by GRA were determined by the above said procedure. The observations were tabulated for discussion.

Table 2: L9 Orthogonal array responses

S. No	Feed mm/rev	Depth Of Cut mm	Clearance angle (^{O})	Rake angle (^{O})	Resultant Cutting Force (N)	Tool Wear (μ)	Tool Life (Min)	Energy Consumption (W)
1	0.02	0.5	15	12	15.604	1.054	84.645	20.572
2	0.02	0.1	17	17	18.961	1.061	77.731	24.701
3	0.02	1.5	20	20	21.841	1.054	72.556	28.809
4	0.04	0.5	15	12	24.968	1.064	70.635	32.554
5	0.04	0.1	17	17	28.083	0.888	64.938	37.046
6	0.04	1.5	20	20	31.210	0.894	61.843	41.122
7	0.06	0.5	15	12	34.272	0.830	59.219	44.825
8	0.06	0.1	17	17	37.452	0.834	57.266	49.253
9	0.06	1.5	20	20	40.567	0.482	54.886	52.923

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Table 3: Grey relational co-efficient and grey grade values

Trail No	NV				GRC				Grey relation	
	RCF	TW	TL	EC	RCF	TW	TL	EC	GRADE	RANK
1	1.000	0.989	1.000	0.000	1.000	0.978	1.000	0.333	0.827714	1
2	0.796	0.996	0.803	0.194	0.710	0.992	0.718	0.383	0.700821	2
3	0.648	0.989	0.644	0.356	0.587	0.978	0.584	0.437	0.646467	3
4	0.508	1.000	0.582	0.486	0.504	1.000	0.545	0.493	0.635455	4
5	0.385	0.771	0.388	0.623	0.448	0.686	0.450	0.570	0.538554	7
6	0.274	0.780	0.276	0.733	0.408	0.695	0.408	0.652	0.540777	6
7	0.177	0.687	0.175	0.824	0.378	0.615	0.377	0.740	0.52744	8
8	0.084	0.693	0.098	0.924	0.353	0.620	0.357	0.868	0.549306	5
9	0.000	0.000	0.000	1.000	0.333	0.333	0.333	1.000	0.5	9

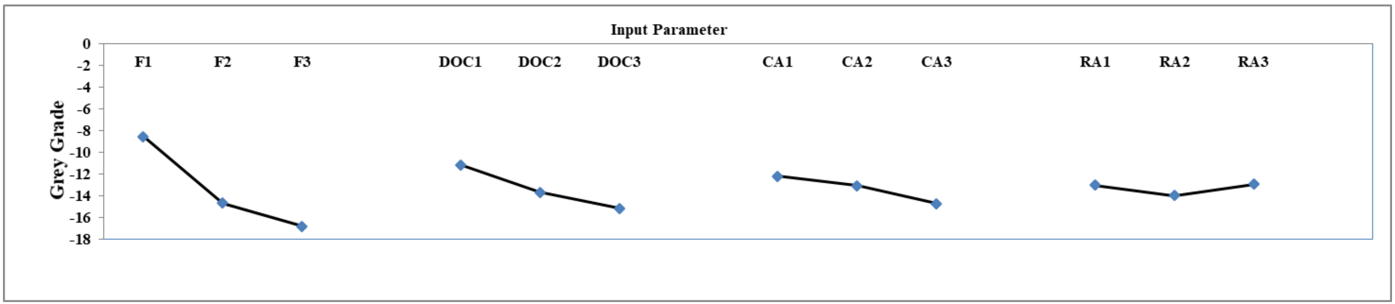

Figure 2: Effects on grade values for Ti–6al–4v

V. Confirmation Experiment.

The confirmation examine is conducted17 at the perfect settings to check the quality characteristics for Turning of Ti–6al– 4v by turning process recommended by the examination. The reaction regards by the assertion attempt preliminary at the Quality settings are F1, DoC1, CA and RA3. The Grey Relational Grade (µcgg) esteem as per esteem is seen to be 0.61. This result is inside the 95% assurance interval of the foreseen perfect condition and moreover Grey Relational Examination of certification attempt is upgraded by 6% from the foreseen mean regard. Along these lines the Grey Relational examination in perspective on Taguchi method for the enhancement of the multi response issues is an extraordinarily supportive gadget for envisioning the results. The purpose for the table 5 is to examine which of the system parameters basically impact the execution characteristics. This examination gives the general responsibility of machining parameters in controlling the response of machining execution criteria for example Grey Grade amid Turning. The criticalness of a variable on the quality trademark can be surveyed by using F-extent. The F-extent is the extent of MS to the blunder. Generally, when F is more noticeable than P-Value, it suggests that the distinction in preliminary factors altogether influences the quality characteristics. The ANOVA table demonstrates that, are enormous (F figured regard is more than the table a motivating force at 95% conviction level. Table 4, demonstrates the ANNOVA for Grey Grade in that Feed (P = 72.64 %) is the hugest variable influencing Depth Of Cut (P = 17.65 %) trailed by Clearance Angle (P=7.91%) and Rake Angle (P= 1.79%), the rate commitment because of mistake gives a gauge of the sufficiency of the analysis.

Table 4: ANOVA on Grey Grade

SOV	SOS	DOF	MS	F	Ftable	%
Feed	0.1598	2	0.0327	163.55	4.2	72.64
Depth Of Cut	0.0409	2	0.0079	39.75	4.2	17.65
Clearance angle	0.0057	2	0.0036	17.82	4.2	7.91
Rake angle	0.0427	2	0.0008	4.04	4.2	1.79
Error	0.002	9	0.000200	___		
Total	0.2491	17				

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VI. CONCLUSION

This inspection was to centered out the optimized mix of Constant Cutting Speed, Feed, Depth Of Cut and Clearance & Rake Angle thus that the minimum Resultant Cutting Force, Tool Wear, Tool Life, and Energy Consumption can be partial exploiting Grey Relation investigation and ANOVA, while Turning of Ti– 6al– 4v, The ends can be abridged as pursues: Grey investigation in the Taguchi strategy for the augmentation of the multi reaction issues is a appreciated device for anticipating the outcomes in the Turning of Ti– 6al– 4v. From this examination, it is uncovered that Minimum Resultant Cutting Force, tool wear, Tool Life and Energy Consumption are conspicuous elements which influence the Turning of Ti– 6al– 4v. Feed (P = 72.64 %) is the most huge variable influencing Depth of Cut (P = 17.65 %) trailed by Clearance Angle (P=7.91%) and Rake Angle (P= 1.79%). The finest performance qualities were become with Ti– 6al– 4v, when Turning the ideal parameters with the F1, DoC1,CA1, and RA3.Confirmation test results demonstrated that the decided ideal mix of Turning parameters fulfill the genuine prerequisites of Turning task of Ti– 6al– 4v.The ANNOVA for Grey Grade in that Feed (P = 72.64 %) is the most huge variable influencing Depth Of Cut (P = 17.65 %) trailed by Clearance Angle (P=7.91%) and Rake Angle (P= 1.79%).

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AUTHORS PROFILE

S. Ashok Kumar, received the M. Tech. Degree in Production Technology from Annamalai University. Since 2010, he has been with Vinayaka mission University as an Asst Professor at the Department of Mechanical Engineering. His research interests include Metal Cutting, Manufacturing Management & Surface Machining and Optimization. He is the author and Co Author of Many published papers on applications of Sheet Metal Formability, Machining Optimization & Manufacturing Management

Ganesh Babu Loganathan, received the M. Tech. Degree in Power Electronics from Anna University. Since 2018, he has been with Tishk international University as an Asst Professor and Department Head at the Of Mechatronics Engineering. His research interests include Management, Power Electronics, Very Large-Scale Integrated Circuits, Surface Machining and Optimization. He is the author and Co Author of Many published papers on applications of Electronics, Integrated Circuits, and Machining Optimization & Manufacturing Management.

P.R. Shobana Swarna Ratna, received the M. Tech. Degree in Computer Integrated Manufacturing from Anna University. Since 2012, he has been with SRM University as an Assistant Professor at the Department Of Mechatronics Engineering. His research interests include Engineering materials and its applications, Manufacturing Technology, Flexible Manufacturing System, Mechanics of solids and fluids, Micro Electro Mechanical systems & Surface Machining and Optimization. He is the author and Co Author of Many published papers on applications Micro Electro Mechanical systems & Surface Machining and Optimization.

G. Balakumaran, received the M. Tech. Degree in Computer Integrated Manufacturing from Anna University. Since 2014, he has been with SRM University as an Assistant Professor at the Department Of Mechatronics Engineering. His research interests include Micro Machining, Unconventional Machining, Condition monitoring. & Surface Machining and Optimization. He is the author and Co Author of Many published papers on applications of Micro Machining, Unconventional Machining, Condition monitoring.

S. P. Sundar Singh Sivam, received the M. Tech. Degree in Computer Integrated Manufacturing from Anna University. Since 2012, he has been with SRM University as an Asst Professor at the Department Of Mechanical Engineering. His research interests include Sheet Metal Forming, Manufacturing Management & Surface Machining and Optimization. He is the author and Co Author of Many published papers on applications of Sheet Metal Formability, Machining Optimization & Manufacturing Management

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