Improvement of Product Quality by Process Parameter Optimization of AISI 1050 by Different Heat Treatment Conditions: Ranking Algorithm and ANOVA

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

Abstract*: AISI 1050 is utilized in the creation of landing Gear, actuators and other aviation parts yet their application is constrained because of erosion protection from the high quality. In any metal cutting task the highlights of Tools, input work materials, machine parameter settings will impact the procedure proficiency and yield quality attributes. A huge enhancement in process productivity might be acquired by the process parameter improvement that distinguishes and decides the areas of basic process control factors prompting wanted yields or reactions with satisfactory varieties guaranteeing a lower cost of assembling. This test thinks about clarifies the issues and machinability issues like failure of tools and precision are found while machining and less yield in machining. In the present investigation of Different Heat treatment, for example, Annealing, Normalizing and Spherodizing was explored in turning of AISI 1050 under the thought of a few turning process Constraints. The anticipated outcomes were observed to be in great concurrence with the test.

***Index Terms*: AISI 1050, Heat treatment, Turning Operation & Process Parameter, Ranking Algorithm**

I. INTRODUCTION

Heat treatment is a procedure of warming and cooling of material. It is conceivable to acquire the alluring mechanical properties for steel or amalgams by warmth treatment. With warmth treatment temperature varies with time is fundamental parameter to change the mechanical properties of the segment. In the event that this variety is appropriate with the goal that stage change is as per part application necessity, in light of the fact that the essential prerequisite of mechanical properties is diverse for various condition. A chilly quality amalgam steel bar is utilized to fabricate wire for virus header. For the most part, the wire produced using the quality pole is spheroidizing tempered, either in a solitary procedure or subsequent to drawing the completed item was accounted for in paper [1]. The wire is HT -strengthened in-development is created by illustration wire loop into wire, trailed by HT, cleaning and covering, and after that a last illustration activity for virus framing. HT of cementite lamellae through toughening enhances the pliability of steel was accounted for in paper [2– 4]. Author gave a spheroidized tempering procedure that created steel wire with almost no decarbonization under totally mechanized control was accounted for in paper [2]. The dominant part of all spheroidizing action is completed to enhance the formability. A spheroidized microstructure is alluring for virus framing since it brings down the stream worry of the material. Steels might be spheroidized to deliver a structure of globular carbides in a ferritic framework were spoken to in paper [5]. Numerous investigations of the systems and energy of HT have been embraced were spoken to in paper [6– 9]. It was presumed that [6] examined the HT Presenting absconds in the cementite by serious plastic twisting is one compelling technique to build the HT speed. An examination in a paper [7] uncovered that the cementites in close eutectic steel can be spheroidized all the more effectively after an extreme illustration. An investigation in a paper [8] examined the upgraded HT inetics regarding carbon disintegration from cementites and imperfections initiated in cementites by serious plastic disfigurement, and uncovered that an expansion in amassed strains in the equivalent channel rakish squeezed steel diminished the HT temperature and time. An investigation in a paper. [9] Developed another strategy for increasingly serious HT of cementite to quicken spheroidization. HT is delivered by non-isothermal holding at high temperatures, by methods for an inside warmth source. In the jolt business, most organizations utilize a subcritical procedure for spheroidized strengthening, by basically warming the items to beneath the lower basic temperature and keeping up this temperature. A few organizations essentially buy steel wires, and cold diminish them, and HT them before pitching them to jolt producers. A few organizations, which fabricate jolts, HT the wires themselves before virus heading. A cool heading-quality AISI 1022 steel wire is normally used to fabricate self-penetrating screws and tapping screws. The wire must be spheroidizing tempered in the wake of illustration the wire loop (F5.5 mm) to a particular size with segment zone decreases of about 60%.

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The nature of spheroidized tempered wire influences the framing nature of the screws. Different constraints influence the nature of spheroidized strengthening, for example, the spheroidized toughening temperature, delayed time, time and stream rate of nitrogen (defensive environment). The impacts of the HT toughening Constraints influence the quality attributes of wires, for example, the elasticity and hardness. The Taguchi strategy is a quality enhancement procedure that utilizes test structure strategies for effective portrayal of an item or process, joined with a measurable investigation of its changeability with the way that pre-generation tests, appropriately planned and broke down, can essentially add to endeavors towards the exact portrayal and streamlining of modern procedures, the quality enhancement of items, and the decrease of expenses and waste Is introduced in paper [10-21]. In the present examination the Heat Treated examples were explored by Process parameter positioning, calculation by TOPSIS and ANOVA for item quality and modern advantages.

II. MATERIALS AND METHODS

Test of AISI 1050 was bought from a neighborhood showcase. All examples of mellow steel of measurements 50× 40 mm was cut utilizing power hacksaw. The concoction structure of the gentle steel test was resolved as given in Table 1. Tests were exposed to warm treatment of Spheroidizing in agreement to ASM International Standards. Four samples were set up for each Heat treatment type.

A. Material composition

The chemical composition -CC of AISI 1050 steel shown in Table 1.

Table 1: Chemical Composition of AISI 1050

C	Mn	Si	S	p
0.508	0.868	0.228	0.025	0.017

B. Working steps

Tests of AISI 1050 steel were utilized for austenization temperature (925 °C) of the material. By then the specific warmth treatment process like tempering, normalizing, and spheroidizing were made. For Annealing, the example was Annealed by warming the material upto the temperature of 925 °C in a mute heater, holding it until the point that the temperature is uniform all through the example for 2 hrs, and was gradually heater cooled. For Normalizing the metal was warmed in a mute heater at a temperature of 950 °C. The material was kept at this temperature for 80 minutes, and after that cooled to room temperature in still air. For Spheroidizing, the metal was warmed up to bring down the basic temperature (LCL) of 700° C - 750 ° C and held for 3 hours and was heater cooled very slowly. The testing for this investigation depended on Taguchi"s plan of tests and symmetrical exhibit. In light of the writing looked into, in present examination three dimensions are characterized for every one of the distinguished factor as appeared Table 2. In present investigation 5 process Constraints with every one of three dimensions was chosen for CNC turning of AISI 1040 steel. For five variables, 3-dimension tests, Taguchi had determined L9 symmetrical cluster and is appeared Table 3. The trial work was completed at Jyothi Automation Pvt. Ltd. Mechanized Numerical Control (CNC) machine and schematic Diagram in 1. Ra was measured by Talysurf. S was measured by Machine vision. Power consumption was measured by using two wattmeter methods. Both calibrated wattmeter was used and their reading were added after multiplying suitable multiplying factor to get PC in watt. Tool Wear was measured by Tool Presetter. The retort gained from the specimens conducted as per L9 OA was recorded in Table 4.

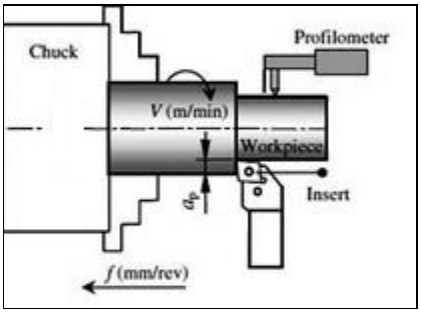

Figure 1: Schematic Layout

Table 2: Process parameter Design

Parameters	Notation	Levels 1	Levels 2	Levels 3
Spindle Speed (Rpm)	A	3000	3500	4000
Feed (mm/rev)	B	0.08	0.1	0.12
Depth of Cut(mm)	C	0.4	0.6	0.8
Heat Treatment	D	Annealing	Normalizing	Spherodizing

C. TOPSIS

The perception of TOPSIS method is that the preferred substitute would have the shortest distance after the ideal and the farthest from the non-ideal. All characteristic in the decision matrix takes either monotonically increasing or decreasing utility.

Step 1: Govern goal and distinguish the correlated assessment criteria.

Step 2: Theory a choice framework in light of all the data available for the criteria. Each line of the choice lattice is designated to one alternative and every section to one standard. Along these lines, a component, x_{ij} of the choice grid demonstrates the execution of i^{th} alternative concerning j^{th} criterion.

Step 3: Acquire the standardized choice framework, r_{ij} utilizing the accompanying condition:

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^2}}$$

Step 4: Hypothesis the WND matrix. This can be signified utilizing the accompanying conditions:

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$$GN_j = \left[\prod_{j=1}^{N} a_{ij}\right]^{1/N}$$

$$w_j = GN_j \Big/ \sum_{j=1}^{N} GN_j$$

Calculate the matrices, $A3$ and $A4$ such that $A3 = A1x\ A2$ and $A4 = A3/A2$,

Where $A_2 = [W_1, W_2 \ldots W_N]^T$

a) Define the maximum Eigen value (λ_{max}) which is average of matrix $A4$.

b) Compute the consistency index as $CI = (\lambda_{max} - N)/(N - 1)$. The smaller the value of CI, the smaller is the deviation from consistency.

c) Estimate the consistency ratio, CR = CI/RI, where RI is the random index value obtained by different orders of the pair-wise comparison matrices.

Usually, a CR of 0.1 or less is considered as acceptable, indicating the unbiased judgments made by the decision makers.

Step 5: Attain the weighted normalized matrix, V_{ij}.

$$V_{ij} = W_{ij} r_{ij}$$

Step 6: Regulate ideal (best) and non-ideal (worst) solutions using the following equations:

$$V^{+} = \left\{\left[\sum_{i}^{Max} V_{ij}/j \in J\right], \left[\sum_{i}^{Min} V_{ij}/j \in J'\right] \Big/ 1,2..N\right\}$$

$$V^{-} = \left\{\left[\sum_{i}^{Min} V_{ij}/j \in J\right], \left[\sum_{i}^{Max} V_{ij}/j \in J'\right] \Big/ 1,2..N\right\}$$

Where J = (j= 1, 2,...,N)/ j is associated with beneficial attributes and J^{I} =

= (j= 1, 2,...,N)/ j is associated with non-beneficial attributes.

Step 7: Attain the separation measures. The separations of each alternative from the ideal and the non-ideal solutions are calculated by the corresponding Euclidean distances, as given in the following equations:

$$S_i^{+} = \left\{\sum_{j=1}^{N}\left(V_{ij} - V_j^{+}\right)^2\right\}^{0.5}, \qquad i = 1,2 \ldots N$$

$$S_i^{-} = \left\{\sum_{j=1}^{N}\left(V_{ij} - V_j^{-}\right)^2\right\}^{0.5}, \qquad i = 1,2 \ldots N$$

Step 8: The qualified closeness of a particular alternative to the ideal solution is computed as follows:

$$P_i = S_i^{-}/(S_i^{+} + S_i^{-})$$

Step 9: A set of alternatives is arranged in the descending order, according to P_i value, indicating the most preferred and the least preferred solutions.

III. Results and Discussions

The contemporary Situation, Machining of Different Heat Treatments of AISI 1050 with Minimum Surface Finish, Roundness, Power Consumption and Tool Wear is a contest to manufacturing industries. In the study SS, F, DOC, and Different Heat Treatment was used for experimental work.

Table 3: Experimental Orthogonal Array

Trail No	A	B	C	D
1	3000	0.08	0.4	Annealing
2	3000	0.08	0.6	Normalizing
3	3000	0.08	0.8	Spherodizing
4	3500	0.1	0.4	Annealing
5	3500	0.1	0.6	Normalizing
6	3500	0.1	0.8	Spherodizing
7	4000	0.12	0.4	Annealing
8	4000	0.12	0.6	Normalizing
9	4000	0.12	0.8	Spherodizing

A. Working steps

Tests of AISI 1050 steel were utilized for austenization temperature (925 °C)

IV. RESULT AND DISCUSSION

Table 4: Experimental L_9 OA

Trail No	Ra(µm)	S (µm)	Pc(Watt)	Tool Wear (µ)
	0.4	0.3	0.2	0.1
1	0.232272	0.376578	0.515	0.045
2	0.240386	0.081782	0.504	0.023
3	0.000878	0.000878	0.492	0.021
4	0.228215	0.271973	1.202	0.041
5	0.240386	0.211112	1.174	0.034
6	0.00719	0.008878	1.145	0.012
7	0.238358	0.387691	2.345	0.039
8	0.246472	0.207308	2.285	0.035
9	0.008878	0.000978	2.225	0.012

Table 5: The minimizing criterions had to be converted.

Trail No	Ra(µm)	S (µm)	Pc(Watt)	Tool Wear (µ)
1	0.0142	0.0111	-0.023	0
2	0.0060	0.3059	-0.012	0.022
3	0.2455	0.3868	0	0.024
4	0.0182	0.1157	-0.71	0.004
5	0.0060	0.1765	-0.682	0.011
6	0.2392	0.3788	-0.653	0.033
7	0.0081	0	-1.853	0.006
8	0	0.1803	-1.793	0.01
9	0.2375	0.3867	-1.733	0.033
Normalized	0.4179	0.7832	3.32386	0.059254

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Table 6: Normalized Data Matrix

Trail No	Ra(µm)	S (µm)	Pc(Watt)	Tool Wear (µ)
1	0.033973813	0.014188288	-0.006919663	0
2	0.014560889	0.390562847	-0.003610259	0.371284882
3	0.587589055	0.493855318	0	0.405038053
4	0.043680275	0.147740509	-0.213606997	0.067506342
5	0.014560889	0.225443504	-0.205183059	0.185642441
6	0.572487456	0.483641487	-0.196458266	0.556927323
7	0.019412924	0	-0.557484176	0.101259513
8	0	0.230300181	-0.539432881	0.168765856
9	0.568448879	0.493727645	-0.521381585	0.556927323

Table 7: Weighted normalized matrix

Trail No	Ra(µm)	S (µm)	Pc(Watt)	Tool Wear (µ)
1	0.013589525	0.004256486	-0.000691966	0
2	0.005824356	0.117168854	-0.000361026	0.074256976
3	0.235035622	0.148156595	0	0.081007611
4	0.01747211	0.044322153	-0.0213607	0.013501268
5	0.005824356	0.067633051	-0.020518306	0.037128488
6	0.228994982	0.145092446	-0.019645827	0.111385465
7	0.007765169	0	-0.055748418	0.020251903
8	0	0.069090054	-0.053943288	0.033753171
9	0.227379552	0.148118293	-0.052138159	0.111385465

Table 8: +ve ideal solution and -ve solution

Trail No	Ra(µm)	S (µm)	Pc(Watt)	Tool Wear (µ)
Ideal	0.235035622	0.148156595	0	0.111385465
worst	0	0	-0.055748418	0

Table 9: Ranking of the Alternative

Trail No	di+	di-	ci	Result - rank
1	0.286623125	0.056868319	0.165559637	8
2	0.234257763	0.149480183	0.389537143	4
3	0.030377854	0.294724006	0.906558966	2
4	0.261061427	0.06028704	0.187606435	7
5	0.254866524	0.085016693	0.250135014	5
6	0.020780684	0.295297543	0.934254616	1
7	0.291574086	0.021689569	0.069237427	9
8	0.265386346	0.076915347	0.224700458	6
9	0.052697291	0.293360265	0.847721022	3

Table 10: From ideal

Trail No	Ra(µm)	S (µm)	Pc(Watt)	Tool Wear (µ)
1	0.221446097	0.143900109	0.000691966	0.111385465
2	0.229211266	0.030987741	0.000361026	0.037128488
3	0	0	0	0.030377854
4	0.217563512	0.103834443	0.0213607	0.097884196
5	0.229211266	0.080523544	0.020518306	0.074256976
6	0.00604064	0.003064149	0.019645827	0
7	0.227270453	0.148156595	0.055748418	0.091133562
8	0.235035622	0.079066541	0.053943288	0.077632294
9	0.00765607	3.83019E-05	0.052138159	0

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Table 11: From the Worst

Trail No	Ra(µm)	S (µm)	Pc(Watt)	Tool Wear (µ)
1	0.013589525	0.004256486	0.055056451	0
2	0.005824356	0.117168854	0.055387392	0.074256976
3	0.235035622	0.148156595	0.055748418	0.081007611
4	0.01747211	0.044322153	0.034387718	0.013501268
5	0.005824356	0.067633051	0.035230112	0.037128488
6	0.228994982	0.145092446	0.036102591	0.111385465
7	0.007765169	0	0	0.020251903
8	0	0.069090054	0.00180513	0.033753171
9	0.227379552	0.148118293	0.003610259	0.111385465

Table 12: ANOVA on TOPSIS

SOV	SOS	DOF	MS	F	F table	%
Spindle Speed	0.0182	2	0.0091	45.41	4.2	1.84
Feed	0.9620	2	0.4810	2405.07	4.2	97.21
Depth Of Cut	0.0066	2	0.0033	16.49	4.2	0.67
Heat Treatment	0.0028	2	0.0014	7.05	4.2	0.28
Error	0.002	9	0.000200			
SSG	0.9896	17				

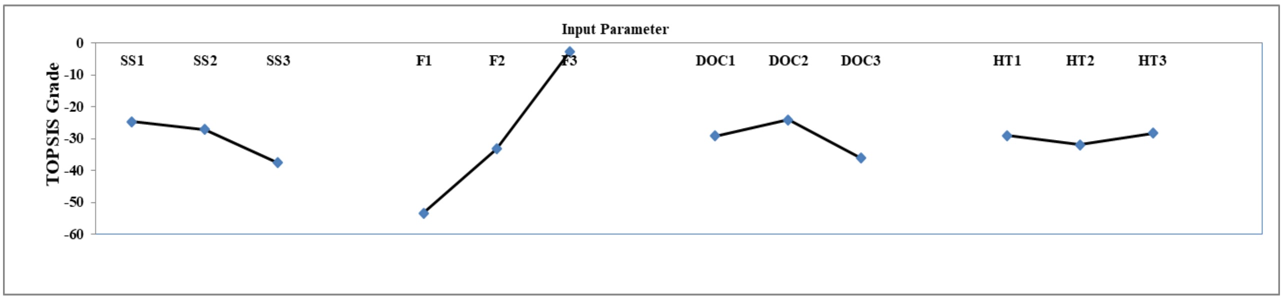

Figure. 7: Factor effects on TOPSIS Grade

In course of information examination, the standardized qualities are resolved as it modifies the qualities estimated on various scales to a notionally regular scale and standardized grid is resolved. The standardized qualities are organized in Table 6.Based on the effect on machining yield, the need weight has been doled out to every reaction. Here, rise to weight has been allocated to every execution trademark and weighted (standardized) basic leadership grid has been appeared Table 7. At that point the positive perfect arrangements and negative perfect arrangements are resolved. The most extreme incentive between the logged qualities are measured as positive perfect arrangement and least esteem alluded as negative perfect arrangement. While for rest of the reactions like surface unpleasantness, Roundness, Power Consumption and Tool Wear bring down qualities are alluring (as they compare to bring down is Better, LB model). Thus, least estimation of the recorded esteem is viewed as positive perfect arrangement and most extreme esteem speaks to the negative perfect arrangement. The positive perfect arrangement and negative perfect arrangement are resolved and classified in Table 8.

From the above table 10, it is clearly visible that Exp 6, is getting the 1st rank is getting the 1st rank for treated. Hence, the corresponding input parameter i.e. SS (Rpm) of 3500, F (mm/rev) of 0.12 and DOC (mm) of 0.8 mm , and Heat Treatment of Spherodizing is found to be the optimum combination for treated

V. CONFIRMATION EXPERIMENT

The trails is led at the model sceneries to check the quality features for the process approved by the analysis. The preliminary at the ideal settings are, SS (Rpm) of 3000, F (mm/rev) of 0.1 and DOC (mm) of 0.8 mm, and heat treatment of Spherodizing is found to be the optimum combination. Hence the TOPSIS is a very useful tool for forecasting the Output responses.

The motivation behind the Anova table 12, for rate commitment of Final individual parameter for TOPSIS Grade the ANOVA table demonstrates that, feed is the overwhelming Factor pursued, feed is the dominating Factor followed by Spindle Speed and other remaining Constraints. From Figure 2, considering maximization of Output Response for getting TOPSIS Grade values we can obtain the optimal parameter conditions SS1 Rpm (3000), F3 mm/rev (0.12), DOC2 mm (0.6), HT3 (Spherodizing).

VI. INFERENCE

The Target of this examination was to find out the optimized combination of SS (Rpm), Feed (mm/rev), DoC (mm), and different Heat Treat Conditions using TOPSIS and ANOVA, while Machining. TOPSIS system for the multi response situations is a very useful tool for ranking the minimum Ra, TW, S, PW in the Machining.

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It does not involve complicated mathematical theory or computation and thus can be employed by the engineers without a strong statistical background. Hence, the corresponding input parameter i.e. SS (Rpm) of 3000, F (mm/rev) of 0.1 and DOC (mm) of 0.8 mm, and heat treatment of Spherodizing is found to be the optimum combination.

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