Effective utilization of Multi Objective Function with the aid of Artificial Bee Colony for Turning on CNC Lathes

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Abstract

The significant intention of this research work is to predict optimal tuning parameters like cutting speed, feed rate, depth of cut and nose radius for minimized surface roughness, maximized material removal rate and minimized tool wear for three different materials namely Inconel718, Hastelloy276 and Monel400 with coated and uncoated carbide turning inserts for CNC lathes. To operate this tedious process in manual consumes enormous time for computing; to conserve this time consumption without compromising its outcome, optimization techniques take part for the betterment. Optimizations techniques involve in this process are Artificial Bee Colony (ABC), Particle Swarm Optimization (PSO) and Cuckoo Search (CS) for the betterment of further improvement in prediction with already proved mathematical model. It is clear that in all material, the optimal tuning parameters attain from the proposed ABC technique, it is quite evident that the proposed ABC technique behave literally and it attain superior result than PSO and CS.

Keyword: Mathematical modelling, Inconel718, Hastelloy276, Monel400, Artificial Bee Colony (ABC), Particle Swarm Optimization (PSO) and Cuckoo Search (CS).

1 Introduction

Nowadays, the optimization has been an essential advance for the manufacturers in mind the end goal to pick up and keep up focused position in the world market. The surface roughness (Ra) of the machined item is essentially utilized as a quality control of a turned item in turning operation.[1] To ensure the machining quality, preservationist cutting parameters are chosen. What's more, the proficiency is decreased to a great extent in light of the multifaceted nature of machining process.[2] Right determination of hardware geometry and cutting parameters that influence surface roughness is vital considers particularly giving tolerance.[3] High-hardness materials incorporate different hardened alloy steels, device steels, unfeeling steels, super compounds, nitrided steels, hard-chrome coated steels, and heat treated powder metallurgical parts.[4] Inconel 718 is a standout amongst the most broadly utilized nickel base superalloys representing around 35% of all production.[5] The motivation behind the metal cutting operation is ordinarily called machining is to deliver a craved shape, size and complete of a segment by evacuating the overabundance metal as chips from a harsh square of material.[6] Cutting speed, feed rate, depth of cut, and edge geometry are turning parameters that altogether influence the execution measures, for example, surface harshness and cutting forces.[7] While these systems can expand MRR and are likely appropriate for some scope of applications.[8] By utilizing this model, the optimized creation forms and very proficient use of various sorts of assets can adequately add to sustainable manufacturing, for example, reduction and recycling of raw material, diminishment of energy preservation, waste, pollution, etc.[9]

INCONEL718 Superalloy

Inconel is a super alloy prepared dominatingly of Nickel and chromium and intended to achieve well in extraordinary situations. Inconel 718, a super alloy in view of iron-nickel solidified by precipitation, is a standout amongst the most generally utilized super alloy that shows satisfactory imperviousness to creep, ductility and exhaustion resistance over 650°C.[10] Inconel 718 superalloy has been connected broadly in high temperature, high load, and consumption safe situations because of its predominant properties. Nevertheless, Inconel 718 is a notable hard-to-cut material. It's little warm conductivity and volume particular heat result in high cutting temperature.[11]

HASTELLOY 276-Superalloy

Nickel based superalloy C-276 is recognized by its high erosion imperviousness to an extensive range of forceful situations experienced in the industry. The nickel matrix of the alloy enables to accommodate high percentages of elements such as chromium, iron, molybdenum etc., while retaining single phase face-centered-cubic structure.[12] The nickel-based alloy C-276 was additionally one of the austenitic stainless steels, which is a high-quality erosion safe and heat resistant alloy with the high substance of Cr and Mo. It broadly utilized as a pressure vessel material at lifted temperatures. [13]

MONEL 400 Superalloy

The Monel 400 alloy is otherwise called superalloy monel. This alloy is accessible in some standard shapes, for example, hexagon, round, tube, pipe, plate, strip, sheet, and wire. Monel 400 (Ni 67%) is prepared of a Nickel-Copper alloy that offers exceptional erosion resistance in seawater. Monel 400 better withstands oxidation assault as a contrast with other copper based alloys and fundamentally averts assault sulfuric acid, hydrofluoric acid, hydrochloric acid, nitric acid, hydrofluoric acid, and alkalis. Monel 400 can be utilized as a part of high destructive environment furthermore these joints execute pleasantly at high-temperature environments.[14]

The machining procedure shapes the premise of the cutting edge designing industry and is included either straightforwardly or in a roundabout way in the manufacture of almost every result of present day human progress. It is a term that covers a huge accumulation of assembling procedures intended to evacuate undesirable material, more often than not as chips, from a work piece to give the desired geometry, size and complete determined to satisfy outline necessities. Optimization is the investigation of getting most great outcomes subject to different asset imperatives. There is a great deal of extension for optimizing different assembling capacities, for example, design, planning, operation (prepare), quality control, upkeep et cetera. Optimization techniques in metal cutting procedures thought to be a basic device for the ceaseless change of yield nature of items and procedures. Displaying of input-output parameter relationship and assurance of optimal cutting conditions for getting strong item or process likewise is vital. The surface complete and exactness of the machined surface has been distinguished as quality characteristics then again, material removal rate (MRR), which demonstrates preparing time of the workpiece, is another critical element that enormously impacts creation rate and cost and consequently regarded as execution file specifically identified with efficiency. In the paper, three objective functions, for example, surface roughness (minimum constraint), material removal rate (maximum constraint) and tool wear (minimum constraint) are fulfilled by the reporter input arrangements specifically Feed rate, Cutting speed, Depth of cut and nose span these input solutions are the optimal solutions. The three sorts of various optimization systems are used for finding the optimal solution, for example, Artificial Bee Colony Optimization (ABC), Particle Swarm Optimization (PSO) and Cuckoo Search (CS) algorithm. In view of these systems, anyone of the strategy is the proposed procedure.

2. Literature review

Jida Huang *et al*.[15] 2015, had suggested the optimum determination of parameters is incredibly essential for the last nature of item in present day mechanical assembling process. Keeping in mind the end goal to accomplish highly product quality, a successful optimization procedure is crucial. In this paper, another hybrid algorithm named teaching-learning-based cuckoo search (TLCS) proposed for parameter optimization issues in structure outlining and machining forms. At that point, the proposed TLCS strategy received into a few surely understood engineering parameter advancement issues. The test comes about demonstrate that TLCS acquires a few arrangements superior to those beforehand reported in the literature, which uncovers that the proposed TLCS was an exceptionally powerful and strong approach for the parameter optimization issues.

Hrelja Marko *et al*.[16] 2014, had expected to assemble advancements are now characterized as on basics of adaptability, autonomous production, and level of automatization. As renovate the manufacturing lines, along these lines we are required to overhaul and incorporate most modern technologies with a specific end goal to keep the business aggressive. Because of the dynamic procedures and increment of the machining parameters, advancing the data that was fundamental for generation got altogether harder. For tackling such issues, need to turn our decision onto the wise strategies, for example, Particle swarm optimization or comparative kind of shrewd optimization. In this paper, show a proposition, how effectively increase optimal cutting parameters – cutting speed, feed rate and cutting depth for specific necessities, for example, cutting power, surface complete – harshness and cutting apparatus life.

Ali R. Yildiz [17] 2013, had proposed a choice of cutting parameters in machining operations was a fundamental undertaking to lessen the cost of the items and increment quality. This paper shows an optimization approach in view of artificial bee colony algorithm for optimal choice of cutting parameters in multi-pass turning operations. The goal is to discover the optimized cutting parameters in the turning operations. A correlation of transformative-based optimization methods to take care of multi-pass turning optimization issues introduced. The after effects of the proposed approach for the contextual investigations contrasted and beforehand-distributed outcomes by utilizing other optimization methods as a part of the literature.

Ali R. Yildiz [18] 2013, had recommended to build up a novel hybrid optimization method (HRABC) in light of artificial bee colony algorithm and Taguchi technique. The proposed approach connected to a basic plan optimization of a vehicle part and a multi-device processing optimization issue. A correlation of state-of-the-art optimization systems for the plan and manufacturing optimization issues introduced. The outcomes have exhibited the prevalence of the HRABC over alternate systems like differential evolution algorithm, harmony search algorithm, particle swarm optimization algorithm, artificial immune algorithm, ant colony algorithm, hybrid robust genetic algorithm, scatter search algorithm, genetic algorithm as far as meeting velocity and productivity by measuring quantity of capacity assessments required.

Bharathi Raja *et al.* [19] 2011, had foreseen for investigating enhanced machining parameters in turning operation the empirical models for machining time and surface roughness are portrayed. CNC turning machine was utilized to lead investigates metal, aluminum, copper, and mild steel. Particle swarm optimization (PSO) utilized to locate the optimal machining parameters for minimizing machining time subjected to wanted surface roughness. Physical imperatives for both analysis and hypothetical approach are cutting speed, feed, depth of cut, and surface roughness. It watched that the machining time and surface roughness in light of PSO are about same as that of the qualities got in light of affirmation analyses; thus, it found that PSO is equipped for selecting fitting machining parameters for turning operation.

3. Proposed methodology

Already developed mathematical model utilized as an objective function to predict tuning parameters such as cutting speed, feed rate, depth of cut and nose radius to attain minimized surface roughness, maximized material removal rate and minimized tool wear. Here, three different materials are used for this experiment investigation those materials are Inconel718, Hastelloy276 and Monel400 with coating and un-coating. The objective of the present work is to optimize the process parameters when turning difficult to machine materials like super alloys with the objective of minimizing Surface Roughness and Tool Wear and then maximizing Material Removal Rate. To study the Surface Roughness, MRR, and Tool Wear produced by Turning of work pieces using coated and uncoated tungsten carbide turning inserts on CNC lathe with various combinations of control factors like cutting speed, feed , depth of cut and nose radius. By changing the type of inserts viz. coated and uncoated carbide, performance study will conducted on various work piece materials. Measuring the surface roughness values using appropriate surface roughness measuring instruments, using digital micrometer to measure work piece diameter before and after each set of experiment to calculate machining accuracy and MRR and then measuring the tool wear after each set of experiments by using confocal Laser microscope. Three different optimization technique involve in this process are ABC, PSO and CS amid, ABC performs better to reveal optimal turning parameters.

Table-1, Hastelloy276 coated

HASTELLOY MACHINED WITH COATED TOOL 1							
	INPUT(CONTROL FACTORS)				OUTPUT(RESPONSES OR Objectives)		
Trial.No.	Cutting Speed(A)	Feed Rate(B)	Depth of Cut(C)	Nose Radius(D)	Surface Roughness(Ra) (to be minimized)	Material removal Rate(MRR) (to be Maximized)	Tool Wear(TW) (to be minimized)
	m/min	mm/rev	mm	mm	µm	mm3/min	µm
1	25	0.08	0.4	0.4	1.003	452.94	145.7
2	25	0.08	0.7	0.8	0.804	540.63	236.62
3	25	0.08	1	1.2	0.975	962.52	142.86
4	25	0.11	0.7	0.4	1.286	918.95	117.14
5	25	0.11	1	0.8	1.262	1128.99	191.4
6	25	0.11	0.4	1.2	1.159	393.99	85.72
7	25	0.14	1	0.4	1.23	673.35	94.28
8	25	0.14	0.4	0.8	0.585	519.33	511.4
9	25	0.14	0.7	1.2	0.73	1349.56	131.4
10	30	0.08	0.7	0.4	0.928	845.4	159.98
11	30	0.08	1	0.8	0.527	611.98	142.86
12	30	0.08	0.4	1.2	0.59	284.33	165.7
13	30	0.11	1	0.4	1.269	1492.26	111.42
14	30	0.11	0.4	0.8	0.382	444.79	282.84
15	30	0.11	0.7	1.2	0.726	784.57	125.7
16	30	0.14	0.4	0.4	1.504	1106.4	154.28
17	30	0.14	0.7	0.8	0.473	940.9	125.7
18	30	0.14	1	1.2	0.452	567.9	217.14
19	35	0.08	1	0.4	0.906	1207.74	185.7
20	35	0.08	0.4	0.8	0.462	1060.19	188.56
21	35	0.08	0.7	1.2	0.65	789.06	189.56
22	35	0.11	0.4	0.4	0.783	693.52	114.28
23	35	0.11	0.7	0.8	0.581	940.23	271.4
24	35	0.11	1	1.2	1.062	781.36	2148.56
25	35	0.14	0.7	0.4	1.944	1500.39	97.14
26	35	0.14	1	0.8	0.837	1610.56	242.84
27	35	0.14	0.4	1.2	0.557	622.05	148.56

Table-2, Hastelloy276 uncoated

HASTELLOY MACHINED WITH UNCOATED TOOL 1							
	INPUT(CONTROL FACTORS)				OUTPUT(RESPONSES OR Objectives)		
Trial.No.	Cutting Speed(A)	Feed Rate(B)	Depth of Cut(C)	Nose Radius(D)	Surface Roughness(Ra) (to be minimized)	Material removal Rate(MRR) (to be Maximized)	Tool Wear(TW) (to be minimized)
	m/min	mm/rev	mm	mm	µm	mm3/min	µm
1	25	0.08	0.4	0.4	0.667	469.45	450
2	25	0.08	0.7	0.8	1.443	581.08	520
3	25	0.08	1	1.2	1.78	822.61	194
4	25	0.11	0.7	0.4	0.932	630.67	154
5	25	0.11	1	0.8	0.459	1116.65	182
6	25	0.11	0.4	1.2	0.513	460.51	496
7	25	0.14	1	0.4	0.746	1352.73	238
8	25	0.14	0.4	0.8	0.458	565.63	422
9	25	0.14	0.7	1.2	0.806	775.02	704
10	30	0.08	0.7	0.4	0.499	685.31	280
11	30	0.08	1	0.8	1.312	1045.14	542
12	30	0.08	0.4	1.2	0.418	1119.33	426
13	30	0.11	1	0.4	1.151	1849.26	162
14	30	0.11	0.4	0.8	0.489	515.63	410
15	30	0.11	0.7	1.2	0.691	958.06	214
16	30	0.14	0.4	0.4	1.535	748.78	176
17	30	0.14	0.7	0.8	0.528	1099.52	264
18	30	0.14	1	1.2	0.643	1098.21	212
19	35	0.08	1	0.4	0.6	1184.2	136
20	35	0.08	0.4	0.8	0.883	403.49	206
21	35	0.08	0.7	1.2	1.312	793.83	312
22	35	0.11	0.4	0.4	0.695	962.33	172
23	35	0.11	0.7	0.8	0.596	1090.99	488
24	35	0.11	1	1.2	0.453	1496.29	414
25	35	0.14	0.7	0.4	1.435	1133.41	438

26	35	0.14	1	0.8	0.927	1847.69	198
27	35	0.14	0.4	1.2	0.427	799.69	216

Table-3, Inconel718 coated

INCONEL MACHINED WITH COATED TOOL 1							
	INPUT(CONTROL FACTORS)				OUTPUT(RESPONSES OR Objectives)		
Trial.No.	Cutting Speed(A)	Feed Rate(B)	Depth of Cut(C)	Nose Radius(D)	Surface Roughness(Ra) (to be minimized)	Material removal Rate(MRR) (to be Maximized)	Tool Wear(TW) (to be minimized)
	m/min	mm/rev	mm	mm	µm	mm3/min	µm
1	25	0.08	0.4	0.4	1.017	151.99	188
2	25	0.08	0.7	0.8	1.145	633.25	590
3	25	0.08	1	1.2	0.707	677.83	354
4	25	0.11	0.7	0.4	1.339	220.47	216
5	25	0.11	1	0.8	0.937	992.4	224
6	25	0.11	0.4	1.2	0.53	406.31	386
7	25	0.14	1	0.4	1.319	1279.79	422
8	25	0.14	0.4	0.8	0.632	1552.95	554
9	25	0.14	0.7	1.2	0.731	738.82	558
10	30	0.08	0.7	0.4	0.788	684.93	442
11	30	0.08	1	0.8	0.526	921.15	200
12	30	0.08	0.4	1.2	0.655	236.16	424
13	30	0.11	1	0.4	0.754	1359.5	228
14	30	0.11	0.4	0.8	0.669	596.52	358
15	30	0.11	0.7	1.2	0.749	1015.98	496
16	30	0.14	0.4	0.4	1.719	2235.94	352
17	30	0.14	0.7	0.8	0.804	1167.13	370
18	30	0.14	1	1.2	0.784	1175.87	302
19	35	0.08	1	0.4	0.792	1614.97	210
20	35	0.08	0.4	0.8	0.561	545.17	320
21	35	0.08	0.7	1.2	0.636	418.31	330
22	35	0.11	0.4	0.4	0.89	752.99	298
23	35	0.11	0.7	0.8	0.567	1084.82	258
24	35	0.11	1	1.2	1.548	1192.53	314
25	35	0.14	0.7	0.4	1.59	1206.75	224
26	35	0.14	1	0.8	0.815	760.46	268
27	35	0.14	0.4	1.2	1.005	584.3	198

Table-4, Inconel718 uncoated

INCONEL MACHINED WITH UNCOATED TOOL 1							
	INPUT(CONTROL FACTORS)				OUTPUT(RESPONSES OR Objectives)		
Trial.No.	Cutting Speed(A)	Feed Rate(B)	Depth of Cut(C)	Nose Radius(D)	Surface Roughness(Ra) (to be minimized)	Material removal Rate(MRR) (to be Maximized)	Tool Wear(TW) (to be minimized)
	m/min	mm/rev	mm	mm	µm	mm3/min	µm
1	25	0.08	0.4	0.4	0.5625	359.41	308
2	25	0.08	0.7	0.8	0.5953	816.73	255
3	25	0.08	1	1.2	0.6653	831.86	182
4	25	0.11	0.7	0.4	0.973	878.11	282
5	25	0.11	1	0.8	0.957	1049.83	221
6	25	0.11	0.4	1.2	0.4511	560.93	329
7	25	0.14	1	0.4	1.044	706.52	252
8	25	0.14	0.4	0.8	0.8559	730.62	371
9	25	0.14	0.7	1.2	0.8827	1262.23	307
10	30	0.08	0.7	0.4	0.7151	692.19	303
11	30	0.08	1	0.8	0.7418	958.44	239
12	30	0.08	0.4	1.2	0.6085	338.51	414
13	30	0.11	1	0.4	1.11	1316.66	253
14	30	0.11	0.4	0.8	0.7939	610.09	342
15	30	0.11	0.7	1.2	0.6939	931.5	440
16	30	0.14	0.4	0.4	1.021	608.06	314
17	30	0.14	0.7	0.8	0.7076	1536.09	315
18	30	0.14	1	1.2	0.8096	1111.96	392
19	35	0.08	1	0.4	0.8827	810.23	290
20	35	0.08	0.4	0.8	0.706	1066.39	460
21	35	0.08	0.7	1.2	0.7821	661.74	413
22	35	0.11	0.4	0.4	0.7198	1102.79	331
23	35	0.11	0.7	0.8	0.865	703.98	400
24	35	0.11	1	1.2	0.5516	1129.39	413
25	35	0.14	0.7	0.4	1.11	1533.04	298

26	35	0.14	1	0.8	0.9294	1805.55	441
27	35	0.14	0.4	1.2	0.6836	1033.34	490

Table-5, Monel400 coated

MONEL400 MACHINED WITH COATED TOOL 1							
	INPUT(CONTROL FACTORS)				OUTPUT(RESPONSES OR Objectives)		
Trial.No.	Cutting Speed(A)	Feed Rate(B)	Depth of Cut(C)	Nose Radius(D)	Surface Roughness(Ra) (to be minimized)	Material removal Rate(MRR) (to be Maximized)	Tool Wear(TW) (to be minimized)
	m/min	mm/rev	mm	mm	µm	mm3/min	µm
1	25	0.08	0.4	0.4	1.4455	336.14	255
2	25	0.08	0.7	0.8	1.2648	586.26	160
3	25	0.08	1	1.2	1.82	793.22	292
4	25	0.11	0.7	0.4	1.707	759.71	146
5	25	0.11	1	0.8	2.325	1152.69	223
6	25	0.11	0.4	1.2	1.87	401.88	360
7	25	0.14	1	0.4	2.544	1450.89	252
8	25	0.14	0.4	0.8	3.083	489.22	146
9	25	0.14	0.7	1.2	2.869	850.92	180
10	30	0.08	0.7	0.4	1.643	387.54	458
11	30	0.08	1	0.8	1.584	1018.21	160
12	30	0.08	0.4	1.2	1.729	718.87	274
13	30	0.11	1	0.4	2.179	1501.6	143
14	30	0.11	0.4	0.8	1.582	538.93	120
15	30	0.11	0.7	1.2	2.2283	172.6	174
16	30	0.14	0.4	0.4	2.741	675.51	237
17	30	0.14	0.7	0.8	2.393	1098.19	243
18	30	0.14	1	1.2	2.176	1504.08	139
19	35	0.08	1	0.4	1.279	897.46	220
20	35	0.08	0.4	0.8	1.403	449.84	172
21	35	0.08	0.7	1.2	3.129	1105.01	183
22	35	0.11	0.4	0.4	2.956	670.17	229
23	35	0.11	0.7	0.8	1.361	1088.81	174
24	35	0.11	1	1.2	2.017	1064.84	123
25	35	0.14	0.7	0.4	2.913	1441.54	434

26	35	0.14	1	0.8	3.317	2000.95	134
27	35	0.14	0.4	1.2	0.488	624.15	268

Table-6, Monel400 uncoated

MONEL400 MACHINED WITH UNCOATED TOOL 1							
	INPUT(CONTROL FACTORS)				OUTPUT(RESPONSES OR Objectives)		
Trial.No.	Cutting Speed(A)	Feed Rate(B)	Depth of Cut(C)	Nose Radius(D)	Surface Roughness(Ra) (to be minimized)	Material removal Rate(MRR) (to be Maximized)	Tool Wear(TW) (to be minimized)
	m/min	mm/rev	mm	mm	µm	mm3/min	µm
1	25	0.08	0.4	0.4	0.762	331.04	594
2	25	0.08	0.7	0.8	1.923	658.97	598
3	25	0.08	1	1.2	1.915	865.53	532
4	25	0.11	0.7	0.4	2.232	822.46	599
5	25	0.11	1	0.8	2.2206	1235.99	469
6	25	0.11	0.4	1.2	2.5	356.83	598
7	25	0.14	1	0.4	2.581	1372.46	599
8	25	0.14	0.4	0.8	3.076	608.08	512
9	25	0.14	0.7	1.2	2.685	186.18	523
10	30	0.08	0.7	0.4	1.176	1083.75	600
11	30	0.08	1	0.8	1.932	1057.43	363
12	30	0.08	0.4	1.2	1.33	305.3	600
13	30	0.11	1	0.4	1.593	1524.55	163
14	30	0.11	0.4	0.8	1.832	628.73	580
15	30	0.11	0.7	1.2	2.043	632.27	495
16	30	0.14	0.4	0.4	3.022	951.62	478
17	30	0.14	0.7	0.8	22.619	1258	438
18	30	0.14	1	1.2	1.802	982.99	217
19	35	0.08	1	0.4	1.344	1198.75	598
20	35	0.08	0.4	0.8	2.193	578.44	595
21	35	0.08	0.7	1.2	1.975	738.83	306
22	35	0.11	0.4	0.4	2.435	889.16	278
23	35	0.11	0.7	0.8	2.491	1171.63	592

24	35	0.11	1	1.2	2.052	1398.19	452
25	35	0.14	0.7	0.4	20.739	1595.25	243
26	35	0.14	1	0.8	2.005	1229.58	593
27	35	0.14	0.4	1.2	1.632	465.13	597

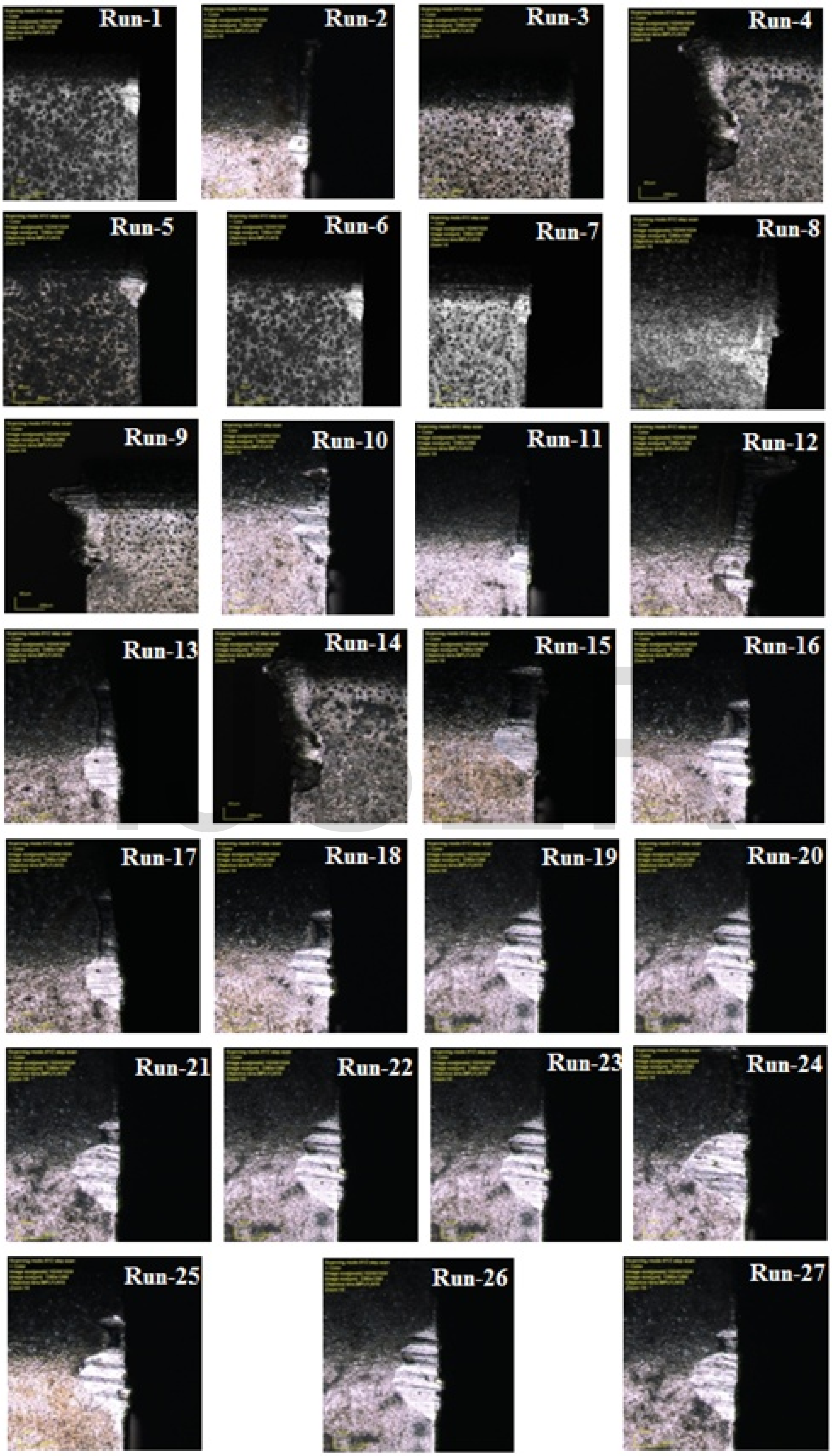

Figure-1, Photographs indicates wear of major flank by abrasion phenomenon

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3.1 Simulation investigation with artificial bee colony

The core intention the proposed simulation work is to optimize the procedure parameters when it is turning hard to machine materials like super alloys with the objective of minimizing surface roughness and tool wear and maximizing Material Removal Rate (MRR). There are three distinctive work materials, which are broadly utilized and hard to machine by utilizing two sorts of inserts uncoated and coated carbides for HASTELLOY 276, INCONEL718 and MONEL 400. For finding the optimal turning parameters, mathematical modelling used for various measured responses such as surface roughness (minimum), tool wear (minimum) and Material Removal Rate (maximum). These multi objective functions satisfied by the correspondent input parameters such as feed rate, cutting speed, depth of cut and nose radius, these input parameters are the optimal turning parameters. For optimization, three different techniques are utilized namely Artificial Bee Colony Optimization (ABC), Particle Swarm Optimization (PSO) and Cuckoo Search (CS) algorithm. Based on these algorithms Artificial Bee Colony Optimization (ABC) performed better compared with other techniques. The flowchart for Artificial Bee Colony Optimization (ABC) appeared underneath figure2.

3.1.1 Initializing input parameters

Initially random solution generated for four input parameters with the range of cutting speed ($25 \leq A \leq 35$), feed rate ($0.8 \leq B \leq 0.14$), depth of cut ($0.4 \leq C \leq 1$), nose radius ($0.4 \leq D \leq 1.2$). Number of solution generated in this process is ten then this ten randomly generated solution applied for fitness evaluation.

$$X_i = \{A, B, C, D\} \quad (1)$$

Where, X_i defines an initial solution, i ε [1, 2, … 10]. Since, i^{th} value considered as the number of solution.

3.1.2 Fitness Function

Randomly generated solutions fed in to objective function for computing its fitness, here below shown equation (2) comprised of three objective functions (F_i) and i belong to surface roughness, material removal rate and tool wear. Whereas α_i and β_i are the term act as weights and it differ for three objective functions. Maximum sum of individually attain objective function fitness value is consider as best fitness in that iteration.

$$F_i = \sum_{j=1}^{NH} \alpha_j \frac{1}{1+\exp\left(\sum_{i=1}^{NI} X_{ij}\beta_{ij}\right)} \quad (2)$$

$$Best\ fitness = Max\ [sum(F_i)] \quad (3)$$

Then, attained best fitness from initially generated random solution utilize for updating solution process those process detailed in below sections.

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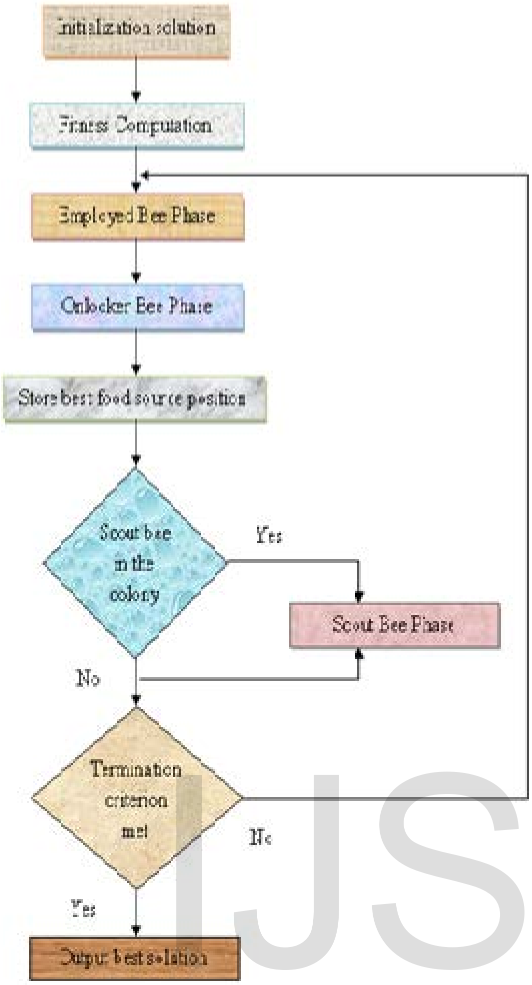

Figure-2, flow chat of Artificial Bee Colony

3.1.3 Employed bee

Employed bee is the process where the new solution is generated under the given equation.

$$Eb_{ij} = X_{ij} + \Phi_{ij}(X_{ij} + X_{kj}) \qquad (4)$$

Equation (4) is utilized to generate the new element in the defined solution *i*, where as in Φ_{ij} , Φ range from [-1, 1] and *ij* indicates the index position and *k* determines randomly *k*∈ {1, 2...size (*i*)} the significance constraint in this process k ≠ *i*. The Fitness computation process held up for evaluating the fitness for the newly generated solution by Equation (4). Then the greedy selection Gr_{ij} process is performed to retrieve the best solution from the currently generated Eb_{ij} and X_{ij} .

3.1.4 Probability calculation

The Probability calculation (pb_i) is calculated for the Gr_{ij} as per the process shown below.

$$pb_i = \frac{F_i}{\sum_{i=1}^{NS} F_i} \qquad (5)$$

The above Equation (5) is the process to find out the probability rate of attaining fitness after the greedy selection process. After completion of the probability calculation process the attained solution is in the order that the fitness has higher probability priority rate.

3.1.5 Onlooker bee

Subsequent to the probability rate calculation, the solution sorted and treated as the initial solution for the onlooker bee section. Based on the aforementioned solution, the new solution (Kb_{ij}) is evaluated by using Equation (4) and the fitness is computed for Kb_{ij} . Again, the greedy selection process performed in order to pick the best solution amid the presently occurring onlooker bee solution $Kb_{ij}(F_i)$ and the probability based greedy solution occurring in the previous step.

3.1.6 Scout bee

The Scout bee happens when the betrayed arrangements happen and it rehashed constantly until as far as possible, which will prompt the reason for arbitrary arrangement as has happened already. In this work, as far as possible is set as two, when the left arrangement surpasses two, then the previously mentioned arbitrary arrangement fulfilling the imperatives happen.

4. Results and discussion

Here, with three different materials Hastelloy276, Inconel718 and Monel400 optimal tuning parameters predicted with three different optimization techniques. Optimization techniques incorporates with our objective function to predict optimal tuning parameters namely cutting speed, feed rate, depth of cut and nose radius for surface roughness, material removal rate and tool wear. Different analyses were take part to investigate the performance of optimization techniques and their investigation in the objective function.

Table-7, optimal tuning parameters attain from artificial bee colony technique

Material	Cutting Speed(A)	Feed Rate(B)	Depth of Cut(C)	Nose Radius(D)	**Surface Roughness(Ra)**	**Material removal Rate(MRR)**	**Tool Wear(TW)**
Hastelloy276 coated	30	0.136287	0.931255	1.2	**0.0589**	**7474.6**	**42.9683**
Hastelloy276 uncoated	27	0.129341	0.658982	0.4	**0.010607**	**7078.066**	**18.9819**
Inconel718 coated	26	0.102275	0.731902	1.2	**0.073741**	**5381.607**	**87.58394**
Inconel718 uncoated	26	0.115807	0.803864	1.2	**0.070895**	**8342.793**	**114.8715**
Monel400 coated	30	0.114282	0.956967	0.4	**0.051367**	**5663.078**	**12.47973**
Monel400 uncoated	33	0.144555	0.870157	0.4	**0.063527**	**3879.907**	**54.6119**

Above table illustrate optimal tuning parameters attain from proposed artificial bee colony optimization technique for three different material. When compare to other optimization techniques and experimental process the proposed artificial bee colony technique reveal optimal tuning parameters to achieve minimized surface roughness and tool wear and maximized material removal rate. The performance of turning parameters in three different materials differs in its measurement, even in the case of same material coated and uncoated having different measurement to achieve its targeted output value. Among afore state all materials Hastelloy276 uncoated having better output.

4.1 Surface roughness obtained from objective function for individual optimization techniques

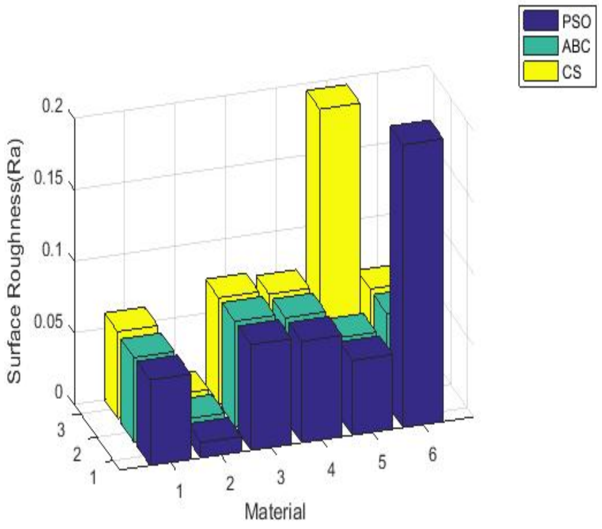

Figure-3, Surface roughness obtained from objective function

The above graph shown the output of surface roughness for six different material namely Hastelloy276 coated (1), Hastelloy276 uncoated (2), Inconel718 coated (3), Inconel718 uncoated (4), Monel400 coated (5), Monel400 uncoated (6). As we know that the surface roughness value should be minimum, from the above graph the Hastelloy276 uncoated having minimum surface roughness value among all compared material. From the above all comparative algorithm, the proposed ABC reveals better minimized surface roughness in all material compared with other algorithm namely PSO and CS. In Monel400 coated CS is far behind the proposed ABC and PSO and in Monel400 uncoated PSO far behind ABC and CS.

4.2 Material removal rate obtained from objective function for individual optimization techniques

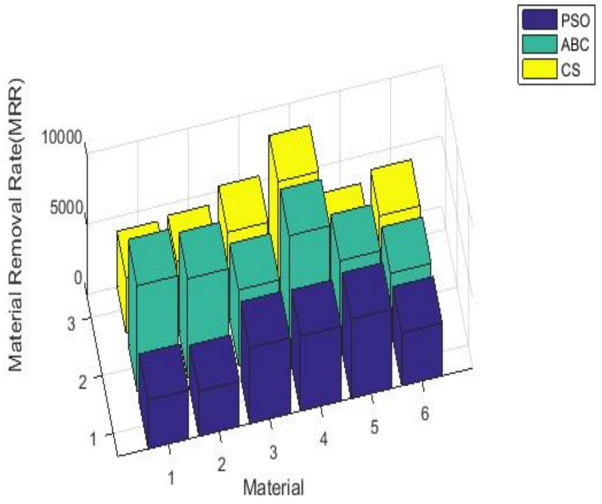

Figure-4, Material removal rate obtained from objective function

The on top the graph exposed output of Material removal rate pro six different material namely Hastelloy276 coated (1), Hastelloy276 uncoated (2), Inconel718 coated (3), Inconel718 uncoated (4), Monel400 coated (5), Monel400 uncoated (6). As we be acquainted that material removal rate ought to maximum, beginning beyond graph the Inconel718 uncoated encompass maximum material removal rate among all compared material. From the above all virtual algorithm, the proposed ABC reveals better-maximized material removal rate in all material compared with other algorithm namely PSO and CS. In Hastelloy276 coated, Hastelloy276 uncoated the proposed ABC is far better than PSO and CS.

4.3 Tool wear obtained from objective function for individual optimization techniques

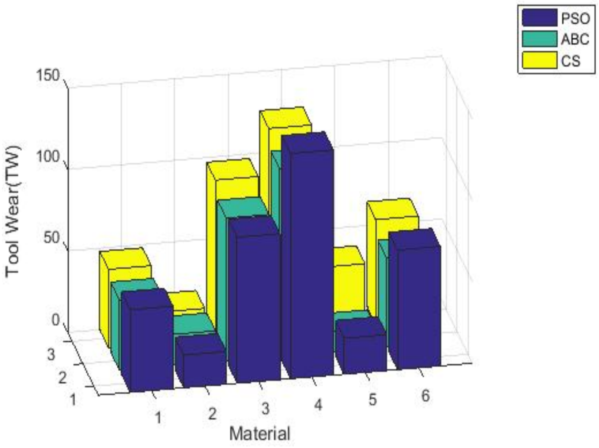

Figure-5, Tool wear obtained from objective function

The beyond graph shown the output of Tool wear designed for six different material namely Hastelloy276 coated (1), Hastelloy276 uncoated (2), Inconel718 coated (3), Inconel718 uncoated (4), Monel400 coated (5), Monel400 uncoated (6). Discern that Tool wear value should be minimum, from the above graph the Hastelloy276 uncoated having minimum tool wear among all compared material. From the above all comparative algorithm, the proposed ABC reveals better-minimized tool wear in all material compared with other algorithm namely PSO and CS. In Hastelloy276 uncoated and Monel400 coated the proposed ABC technique reveals far better minimized tool wear compare with PSO and CS.

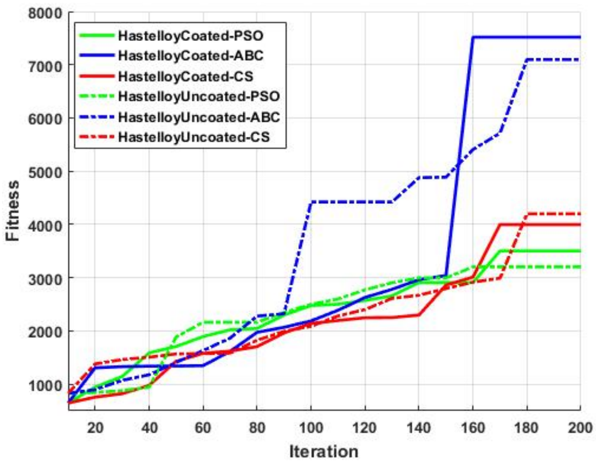

Figure-6, Convergence graph for Hastelloy276

The above graph illustrates the convergence performance of three different optimization technique for Hastelloy276 coated and Hastelloy276 uncoated. This fitness based convergence graph plot from equation (3) for consecutive iterations of PSO, ABC and CS. From the graph, it is quite evident that the proposed ABC technique reveals maximized fitness function than PSO and CS. From origin to some extent, the proposed ABC technique varies up and down in this convergence travel; for Hastelloy276 coated it took lead from 148th iteration and get saturate at 160th iteration, the achieved optimal solution correspondent with elements to compute fitness is 30, 0.136287, 0.931255, 1.130135 and 0.0589, 7474.6, 42.9683. For, Hastelloy276 uncoated it took lead from 90th iteration and get saturate at 160th iteration, the achieved optimal solution correspondent with elements to compute fitness is 27, 0.129341, 0.658982, 0.427214 and 0.010607, 7078.066, 18.9819.

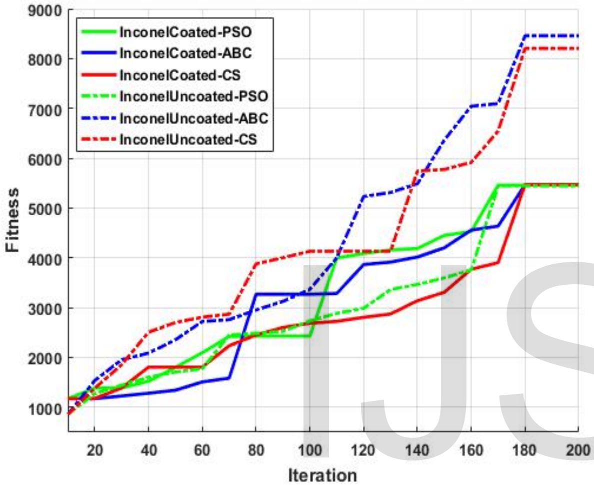

Figure-7, Convergence graph for Inconel718

The exceeding graph exemplifies the convergence concert of three altered optimization technique for Inconel718 coated and Inconel718 uncoated. This fitness based convergence graph plot from equation (3) for consecutive iterations of PSO, ABC and CS. since the graph, it is quite evident that the anticipated ABC performance divulge maximized fitness function than PSO and CS. Origin to some degree, the proposed ABC technique varies up and down in this convergence travel; for Inconel718 coated the proposed ABC curve get saturate at 180th iteration, the achieved optimal solution stringer with rudiments to compute fitness is 26, 0.102275, 0.731902, 1.16121 and 0.073741, 5381.607, 87.58394. For, Inconel718 uncoated it took escort from 143rd iteration and get saturate at 180th iteration, the accomplished optimal solution correspondent with elements to compute fitness is 26, 0.115807, 0.803864, 1.089961 and 0.070895, 8342.793, 114.8715.

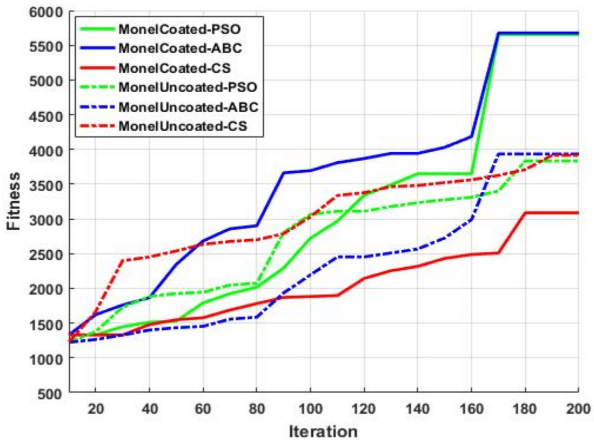

Figure-8, Convergence graph for Monel400

The graph illustrates the convergence concert of three different optimization technique for Monel400 coated, Monel400 uncoated. This fitness based convergence graph plot from equation (3) for consecutive iterations of PSO, ABC and CS. From the graph, it is quite evident that the proposed ABC technique reveals maximized fitness function than PSO and CS. From starting point to some extent, the proposed ABC technique varies up and down in this convergence travel; for Monel400 coated the proposed ABC took the lead from 60th iteration and the curve get saturate at 169th iteration, the achieved optimal solution correspondent with elements to compute fitness is 30, 0.114282, 0.956967, 0.538104 and 0.051367, 5663.078, 12.47973. For, Monel400 uncoated it took lead from 162nd iteration and get saturate at 164th iteration, the achieved optimal solution correspondent with elements to compute fitness is 33, 0.144555, 0.870157, 0.456908 and 0.063527, 3879.907, 54.6119.

5. Conclusion

The significance intention is analysed and solved in this research paper, the final optimal outcome attain from ABC technique comparative superior than other optimization technique namely PSO and CS. Here, three different materials Hastelloy276, Inconel718 and Monel400 are taken in to consideration for predicting optimal turning parameters for CNC lathes. The optimal turning parameters and its corresponding output are cutting speed, feed rate, depth of cut and nose radius for minimized surface roughness, maximized material removal rate and minimized tool wear. It is quite evident from the analysis that the proposed ABC technique behave literally in all case of testing materials and it shows the optimal result compare with PSO and CS. In general, the overall comparative study states that the proposed ABC lead the superiority of 31% for PSO and superiority of 23.5% in CS.

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