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A Review of the Recent Development in Machining Parameter Optimization

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Abstract

The optimization process is applied to the machining operations in order to provide continual improvement in accuracy and quality of produced parts. The effects of machining parameters in milling operations, such as spindle speed, depth of cut and feed rate are investigated in order to minimize the surface roughness as well as the time of machining process. The effective machining parameters, such as depth of cut, feed rate and spindle speed in turning operations are investigated to minimize the surface roughness as well as the time of machining process. Also, machining parameters, such as peak current, gap voltage, duty cycle and pulse on time in Electro Discharge Machining (EDM) operations can be optimized in order to obtain the optimized material removal rate, tool wear, and surface roughness in part production process. To improve material removal rate, surface roughness, and spark gap in part production process using the wire EDM operations, machining parameters, such as spark on time, spark off time, input current are studied and optimized. To calculate optimized machining parameters, different optimization methods, such as Taguchi method, fuzzy logic algorithm, artificial intelligence, genetic algorithm, artificial neural networks, artificial bee colony algorithm, ant colony optimization and harmony search algorithm are used. As a result, time and cost of accurate production can be reduced to increase productivity in part production process using machining operations. In this paper, a review of machining parameter optimization is presented and future research works are also suggested. The main aim of the study is to review the challenges and limitations of the optimization techniques used in optimizing machining parameters. It has been observed that the research field can be moved forward by reviewing and analyzing recent achievements in the published papers.

Keywords: Machining Parameters, Optimization, Efficiency of part production.

1. Introduction

To remain in competitive environment of marketing, time and cost of part production should be analyzed and minimized in terms of efficiency enhancement in part production process. Machining time and surface roughness can be minimized in order to increase efficacy in part production process. Also, cutting tool life as well as tool wear can be maximized in order to decrease the cost of part production using machining operations. The optimized machining parameters can be calculated using different optimization methods to increase efficiency in process of part production. To calculate optimized machining parameters, different optimization methods, such as Taguchi method, fuzzy logic algorithm, artificial intelligence, genetic algorithm, artificial neural networks, artificial bee colony algorithm, ant colony optimization and harmony search algorithm are used. As a result, machining cost and production time of machined components can be decreased and the quality of the final products can be increased in terms of productivity enhancement of part production using optimized machining parameters.

Electrical discharge machining (EDM) is a non-traditional processing technique that involves cutting materials from a component by a series of repetitive electrical discharges over electrodes and the part being manufactured in the existence of a dielectric fluid [1]. The machining parameters optimization of the EDM is reviewed by Nahak and Gupta [1]in order to increase efficiency during the machining operations. To increase efficiency in part production process, Optimization process of machining parameters is reviewed by Mukherjee and Ray [2].A review in optimizing machining parameters is presented by Yusup et al. [3] to analyze and classify the previous research works in order to increase productivity in part production process.

Predicting surface roughness in machining is reviewed by Benardos and Vosniakos[4] to analyze the applications of different optimization methodology in terms of efficiency enhancement of part production. Advanced optimization techniques in machining parameters of electric discharge machining, abrasive jet machining, ultrasonic machining is reviewed by Rao and Kalyankar [5] to increase productivity in part production process using machining operations. Literature review of optimization technique for chatter suppression in machining is presented by RazlanYusoff et al. [6] to decrease the chatter in machining operations using optimized machining parameters, such as spindle design, tool path, cutting process, and variable pitch. To increase productivity in part production process using turning

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operations, optimization process of machining parameters is reviewed by Aggarwal and Singh [7].

A review in recent development of mechanical behavior of materials during machining operations is presented by Soori and Asmael [8] in order to increase accuracy as well as efficiency in machining operations. Applications of the Computer Aided Process Planning (CAPP) in manufacturing systems is reviewed by Soori and Asmael [9] to analyze and expand the computer applications in production engineering. Recent development in friction stir welding process is studied by Soori et al. [10] in order to develop the part manufacturing process using welding operations. To study and minimize the cutting temperature during milling operations, through which it is difficult to cut materials, advanced virtual machining system is presented by Soori and Asmael [11]. To minimize the residual stress and deflection error in five axis milling operations of turbine blades, advanced virtual machining system is proposed by Soori and Asmael [12].

To minimize the deflection error in five axis milling operations of impeller blades, Soori and Asmael [13] developed virtual machining systems. To analyze and modify the applications of the Virtual manufacturing systems in development process of part production, virtual product development is studied by Soori [14]. To develop the decision support systems in the data warehouse management, advances in web-based decision support systems is studied by Dastres and Soori [15]. To develop the applications of the artificial neural networks in different areas, such as risk analysis systems, drone control, welding quality analysis and computer quality analysis, a review in recent development and applications of the systems is presented by Dastres and Soori[16].

Applications of the information communication technology in the environmental protection is presented by Dastres and Soori [17] in order to decrease the effects of technology development to the natural disaster. To increase surface quality during five-axis milling operations of turbine blades, Soori et al. [18] presented advanced virtual machining system. To analyze and modify the machining operations in virtual environments, virtual machining systems and applications are presented by Soori et al. [19-23].

In the present research work, different issues of research related to machining parameter optimization are categorized to provide a useful study for the researchers in the interesting field. As a result, new ideas in machining parameter optimization process and gaps in the existing literature are obtained and future research works are also suggested in order to push forward this interesting research field.

Section 2 presents a review of research works related to machining parameter optimization. In section 3, research works are classified according to the different topics in research to the machining parameter optimization, and future research works in the interesting field are also suggested.

2. Review of research works in machining parameter optimization

The research works in the field of machining parameter optimization is recently developed in different topics of machining operations to increase quality as well as efficiency in the part production. Several approaches are recently developed in the optimization process of machining parameters. The different topics of research works are classified in this section in order to review their achievements in the research field.

2.1. Taguchi method

The optimization technique of Taguchi method is developed by Professor Genichi Taguchi of Telegraph Company of Japan in order to increase productivity in production process of robust products. According to Taguchi method, total loss generated by a product to the society after shipping is the quality of the manufactured product. In order to increase the product quality in minimizing the effects of noise factors in part production process, the experimental design as an optimization technique is investigated by Taguchi. Review on optimization of cutting parameters in machining using Taguchi method is presented by Chandel and Giri [24] to increase surface quality of produced parts using machining operations. To increase surface quality of produced parts using the abrasive flow machining technology, study of machining parameter optimization based on Taguchi method is investigated by Li et al. [25]. The optimized machining parameters in end milling operations of Inconel 718 super alloy is obtained by Maiyar et al. [26] in order to increase surface quality of produced parts using machining operations.

To improve material removal rate, surface roughness, and spark gap in part production process using wire cut electrical discharge machining operations, the Taguchi grey relational analysis is investigated by Rajyalakshmiand Ramaiah [27]. To obtain the optimized tool wear, surface roughness and cutting forces in machining operations, optimization of machining parameters, such as spindle speed, feed rate and depth of cut during micro-milling of Ti6Al4V titanium alloy and Inconel 718 materials using Taguchi method is presented by Kuram and Ozcelik [28].Optimized machining parameters, such as peak current, gap voltage, duty cycle and pulse on time in Electro Discharge Machining (EDM) of AISI D3 steel materials using Taguchi method is investigated by Nipanikar [29] to increase efficiency of part production process. WEDM Parameter Optimization for Silicon/Magneisum Composite Using Taguchi Based method is studied byKavimaniet al.[30] to calculate the maximum material removal rate with minimal surface roughness in part production process. The optimization cycle of machining parameters, such as spark on time, spark off time, input current and wire feed rate in wire EDM on aluminum and mild steel using Taguchi method to reduce surface roughness in component production processes is investigated by Tilekar et al. [31]. To increase productivity in part production processes, the effect of CNC milling machining parameters on surface finish using Taguchi method is investigated by Joshi and Kothiyal [32].

The application of the Taguchi method in the optimization phase of machining parameters, such as speed, cut depth and feed rate, in order to reduce the surface roughness in part production process in the milling operation of glass fiber reinforced plastic is studied by Ghalme et al. [33].

2.2. Fuzzy logic algorithm

The optimization method of fuzzy logic is an alternative search mechanisms optimization technique to find optimal solutions for complex optimization problems. There are different steps for the optimization algorithm of the fuzzy logic. In the first step, in order to evaluate the selection criteria, the matrix of the membership degree of the existing bids is constructed. Then, in order to calculate the optimized member of the population by obtaining maximum of the global membership degree as an inference operator, the vector of the global membership degree of the bids to the selection criteria is created. Finally, the optimized member is selected and validated according the selection criteria of the optimization method. To increase material removal rate in part production processes using EDM of AISI 316 LN stainless steel, optimization of process parameters such as pulse current, pulse on-time, and pulse off-time using fuzzy-based multi-objective PSO is investigated by Majumder [34]. To increase efficiency in part manufacturing process, application of the Fuzzy logic algorithm in obtaining the optimized machining parameters is reviewed by Adnan et al. [35].

Optimization process of machining parameters, such as the depth of cut, cutting speed, feed rate, and tool nose runoff for CNC machining operations using fuzzy and game theory methods is investigated by Chuang et al. [36] to increase cutting tool life in machining operations by obtaining the optimized condition of the tool wear and cutting noise. To increase efficiency in part production process, the optimization algorithm of fuzzy theory in optimization process of electrical discharge machining process is applied by Lin and Lin [37]. To calculate optimized machining parameters, such as cutting speed, feed rate, depth of cut, nose radius and cutting environment in terms efficiency enhancement of part production process, application of the fuzzy theory method in optimization process in high speed CNC turning of AISI P-20 tool steel is investigated by Gupta et al. [38]. To increase efficiency in die casting process of magnesium alloy, application of the fuzzy logic algorithm in optimization process of machining parameter, such as the pressure of injection, the plunger velocity and the filling time is investigated by Chiang et al. [39].

The effective parameters of turning of Al-SIC-Gr for hybrid metal matrix composites using the using grey-fuzzy algorithm is investigated by Suresh et al. [40] to obtain the optimal level of machining parameters in turning operations. Optimization process of multiple characteristics of EDM parameters based on desirability approach and fuzzy logic in machining process of super alloy Inconel 718 is presented by Sengottuvel et al. [41] to maximize the material removal rate, tool wear and minimize surface roughness in EDM production process. Optimization of electro discharge machining process parameters with fuzzy logic for stainless steel 304 is studied by Ubaid et al. [42] to obtain the optimized pulse off time and current parameters in EDM machining operations. Optimization of material removal rate in Wire EDM using fuzzy logic and artificial neural network is investigated by Ashok et al. [43] to calculate the optimized Pulse-on, Pulse- off, current and servo voltage parameters in terms of efficiency enhancement of part production. Multi-objective optimization of wire electro discharge machining process parameters using grey-fuzzy approach is investigated by Das et al. [44] to improve productivity in part production process using machining operations.

2.3. Artificial intelligence

The artificial intelligence optimization algorithm is population based optimization technique in which the best member of the population is selected within the specified range. The behaviour of natural entities for each member of population is a solution for the optimization problem. As a result, the optimized member of the considered population is obtained using the artificial intelligence method. To calculate optimized machining parameters in terms of efficiency enhancement of part manufacturing process, applications of the artificial intelligence to calculate optimized machining parameters is reviewed by Park and Kim [45].

To increase productivity in part production process using turning operations, applications of the artificial intelligence in optimization process of part production is investigated by Aggour et al. [46]. Automatic prediction of required surface roughness by monitoring wear on face mill teeth using artificial intelligence is presented by Pimenov et al. [47] to monitor the main drive power in terms of productivity enhancement of part production process. Parameters forecasting and optimizing of laser welding operations using the artificial intelligence techniques is investigated by Nikolić et al. [48] to increase efficiency in part production process using laser welding operations. Application of the artificial intelligence in parameter optimization process of a multi-pass milling process is investigated by Rao and Pawar [49] to minimize production time in terms of productivity enhancement of part production. Artificial intelligence applications for fault diagnosis of rotating machinery is reviewed by Liu et al. [50] to increase accuracy and efficiency in part production process using rotating machinery systems. To obtain the desired surface quality in machined parts using optimized feed rate and spindle speed, supervision controller for real-time surface quality assurance in CNC machining using artificial intelligence is developed by Moreira et al. [51]. To minimize the surface roughness of produced parts in turning operations of medical stainless steel, modeling and optimization of surface roughness parameters using artificial intelligence methods is investigated by Kovač et al. [52]. An optimization algorithm is developed by Wang et al. [53]to provide better efficiency and lower power consumption for a milling process. Flowchart of the developed optimization method in the study is shown in the figure 1[53].

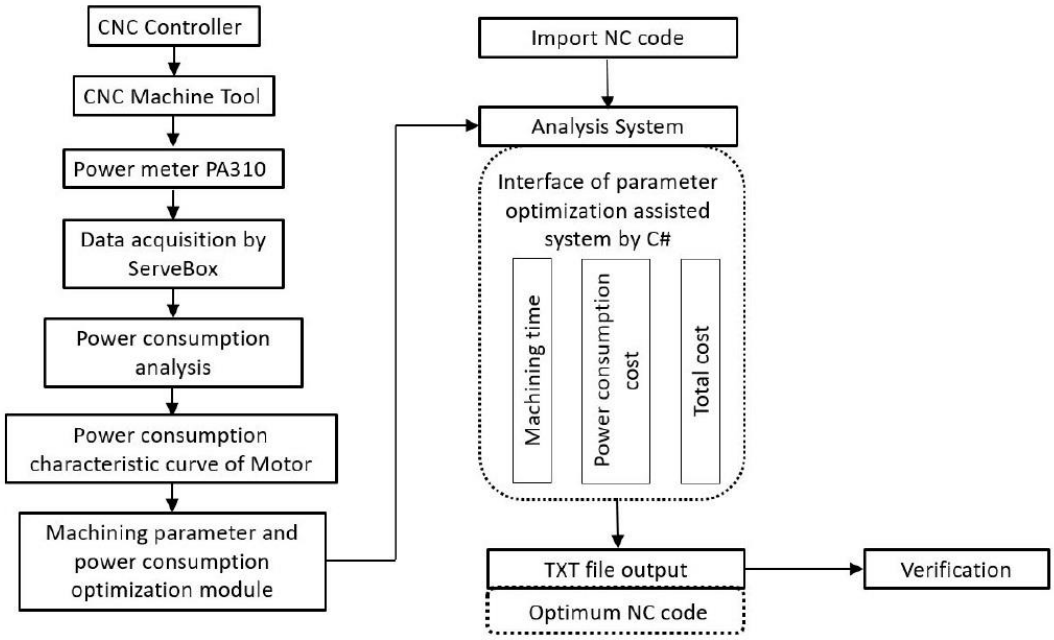

Figure 1. Optimization flowchart machining and power consumption [53]

2.4. Genetic algorithm

To obtain the optimized member in a population, the genetic optimization algorithm is presented which can solve the linear and nonlinear problems. To implement the optimization method, a set of chromosomes or strings with an infinite length is considered for each bit which is called a gene. A population is a selected number of chromosomes, and a generation is the population at a given time. Reproduction, crossover, and mutation are main operators of the algorithms. The Reproduction is the first operator of the algorithm which copies individual strings into a separate string according to their fitness values. The crossover is the second genetic operator which exchanges some part of two or more chromosomes to reproduce new offspring with the hope of collecting all good features of previous ones. Finally, to keep diversity in the population in order to get a quicker convergence, mutation is applied after crossover to provide a small randomness into the new chromosome.

To increase accuracy in part production process using optimized fitness value in machine tools, application of the genetic algorithm in obtaining the optimized parameters of support vector machine is investigated by Zhu et al. [54]. In order to increase performances of machining operations using the optimized machining parameters, Chandrasekaran et al. [55] presented a review in application of the neural networks, fuzzy sets and genetic algorithms in machining parameter optimization process.

The optimization process of cutting parameters, such as cutting speed, feed rate, cutting depth, and the number of passes for multi-pass milling operations using genetic algorithms to improve efficiency in part production processes is studied by An et al. [56]. Machining parameter optimization of the milling process based on genetic algorithms to increase efficiency and decrease the cost of component production processes is presented by Yang et al. [57].

Zhang et al. [58]investigated the application of the genetic algorithm to obtain optimized machining parameters, such as processing time and electrode wear in micro-EDM machining operations, to improve efficiency in component production processes. Selvam et al. [59]presented optimization of machining parameters for face friction operation in a vertical CNC milling machine using genetic algorithm to minimize surface roughness in mild steel milling operations using three zinc-coated carbide devices. Ahmad et al. [60] presented optimization of cutting parameters for end milling operation by soap-based genetic algorithm to improve productivity in part production processes.

Sardiñas et al. [61]presented multi-objective optimization of cutting parameters, such as cut size, feed rate, and spindle speed in turning processes using the genetic algorithm in order to improve profitability in part production processes. Genetic algorithm-based optimization of the cutting parameters in turning processes to reduce machining time in component production processes is presented by D’addona and Teti [62]. The optimization process of drilling parameters, such as cutting speed, feed rate, and cutting environment in AISI 1045 drilling using surface response technique and genetic algorithm to reduce surface roughness in part production process is investigated by Kilickap et al. [63]. Optimized machining parameters, such as feed rate and spindle speed using the genetic algorithm to decrease the tool deflection error in the milling operations is presented by Soori et al.[23]. Flowchart and strategy of machining parameters optimization by genetic algorithm is shown in Fig. 2[23].

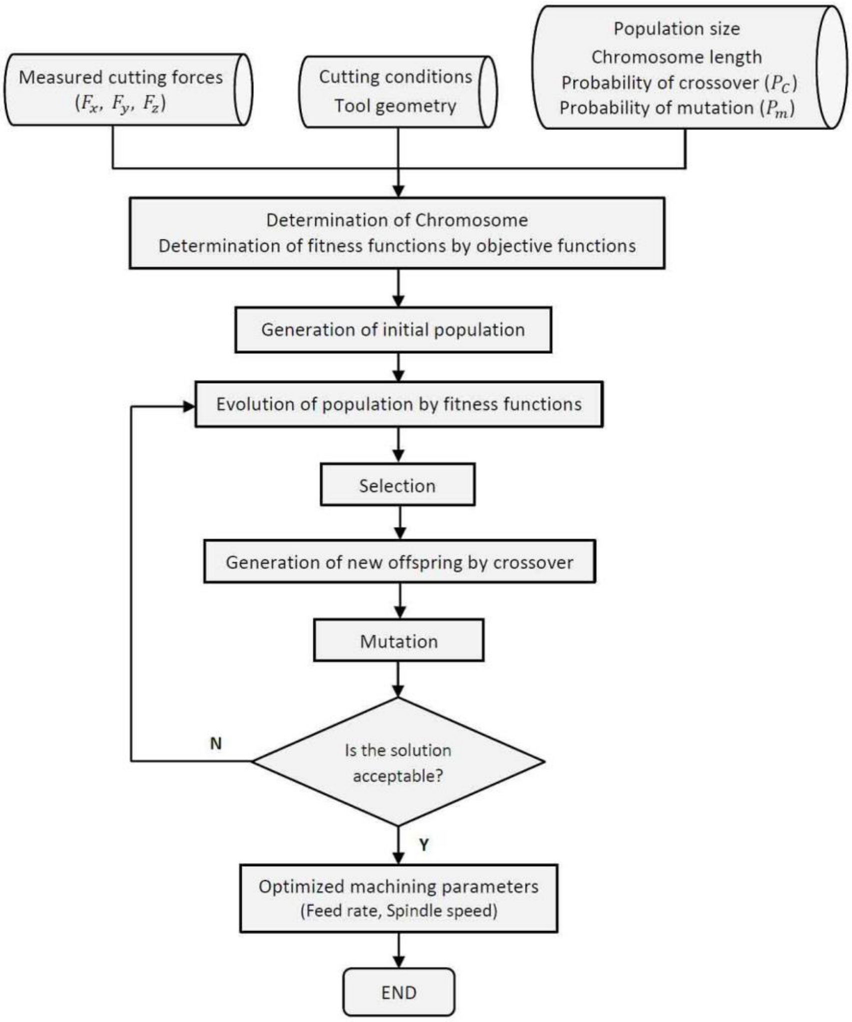

Figure 2. Flowchart and strategy of machining parameters optimization by genetic algorithm[23].

2.5. Artificial Neural networks

The Artificial neural network (ANN) optimization method is nonlinear mapping systems in the field of artificial intelligence to calculate the optimized parameters by using a non-linear regression. To calculate the optimized parameters, the new objective function should be polynomial. As a result, the optimum setting of different parameters till date remains a troublesome assignment can be calculated as optimized parameter of the problem.

The production of an artificial neural network for surface roughness and system prediction to reduce surface roughness of generated parts is investigated by Iriaye et al. [64].

To improve efficiency in the component development process, the application of the artificial neural networks and the genetic algorithm to obtain the selection of cutting inserts and the optimization of cutting parameters for turning operations is proposed by Pardo [65]. Optimization of surface roughness parameter in milling operations using fuzzy logic and artificial neural network methods is investigated by Vignesh et al. [66] to increase surface quality of produced parts using milling operations. In order to increase profit rate, and the quality of the final products in part production process, parameter optimization of milling operation using teaching-learning-based optimization and artificial neural network is studied by Warghat and Deshmukh [67].To minimize the surface roughness of produced parts in the end milling machining operations, application of the artificial neural network in prediction of the surface roughness is presented by Zain et al. [68]. To enhance the productivity in part manufacturing process, optimization of neural network using taguchi-grey relational analysis with signal-to-noise ratio approach for 2.5D end milling process is presented by Kumar et al. [69].Optimum machining parameters in face milling operations of X20Cr13 stainless steel by using neural network and harmony search algorithm is investigated by Razfar et al. [70] to minimize the surface roughness in part production process.

2.6. Artificial bee colony algorithm

The Artificial Bee Colony algorithm is a stochastic algorithm based on population that simulates the foraging behavior of honey bee colonies to determine the optimal parameter in the problems. Inside the algorithm three classes of bees are known as working bees, onlookers, and scouts. The algorithm only contains one artificial bee used for each supply of food. Working bees go to their food source and back to hive and dance in this area. The onlookers observe the dances of working bees and choose food sources according to dances to pick the best type of food. As a result, the best source of food is chosen as optimized member of the population.

To obtain optimized metal removal rate and surface roughness in component production processes, the parametric optimization method of electrochemical machining, electrochemical discharge machining and electrochemical micromachining processes using artificial bee colony algorithm is presented by Samanta and Chakraborty [71]. To enhance efficiency in part production processes, a modified artificial bee colony algorithm for real-parameter optimization process in machining operations is investigated by Akay and Karaboga [72].

Optimization of cutting parameters in multi-pass turning using artificial bee colony is investigated by Yildiz [73] to increase productivity in part production process using turning operations. Application of the artificial bee colony algorithm in parameter optimization of support vector machine is studied by Ming and Yue-qiao [74] to increase accuracy in part production process using optimized fitness value in machine tools. To minimize the surface roughness of produced parts, optimal machining control parameters using artificial bee colony is investigated by Yusup et al. [75]. Das et al. [76]investigated the application of artificial bee colony algorithm in the component development process to optimize the material removal rate and surface roughness in EDM of EN31 tool steel.

To enhance the productivity in part manufacturing process using laser beam machining operations, optimized process parameters of the production method using artificial bee colony algorithm is studied by Mukherjee et al. [77]. Multi-objective optimization of process parameters for the electrochemical machining of SIC composite using a hybrid fuzzy-artificial bee colony algorithm to optimize material removal speeds, to reduce surface roughness and to over-cut in component output using electrochemical machining is presented by Solaiyappan et al. [78]. Das et al. [79] presented a research work on electrochemical machining of EN31 steel for optimizing the rate of material removal and surface roughness using artificial bee colony algorithm.

2.7. Simulated annealing

To calculate the optimized parameter in the problem, the simulation of annealing process of heated solids is considered. In the annealing process, the temperatures of heated solids are increased to convert it to the liquid phase. Then, it will slowly cool through lowering the temperature of the heat bath. The minimum energy state with the greatest probability at the lowest temperature of the part in an annealing process will be selected as the optimized parameter of the problem. To present applications of the simulation methodologies in machining parameter optimizations, integration of process simulation in machining parameter optimization is investigated by Stori et al. [80]. A technique for optimizing Non-linear programming is used in the analysis to select process parameters based on closed-form analytical constraint equations. The application of the genetic algorithm and simulated annealing in order to optimize machining parameters, such as cutting distance, cutting speed and feed rate for turning cylindrical stock operations to improve the surface quality of the component output is presented by Thompson and Fidler[81]. To optimize the machining parameters during CNC turning operations of AL alloys, advanced optimization methodology based on simulated annealing technique is presented by Aghdeab et al. [82].

Machining condition optimization by genetic algorithms and simulated annealing to improve performance in component development processes using machining operations is presented by Khan et al. [83]. The optimization of electric discharge machining using simulated annealing to simultaneously increase the rate of material removal as well as minimize surface roughness is investigated by Yang et al. [84]. Optimization of multi-pass milling using parallel genetic algorithm and parallel genetic simulation annealing to improve efficiency in machining operations using optimized machining parameters is presented by Wang et al. [85].

To achieve the global optimization of product development and manufacturing in part production using machining operations, a simulated annealing-based optimization approach for integrated process planning and scheduling is investigated by Li and McMahon [86]. To estimate optimal process parameters of the abrasive waterjet machining operations, applications of the genetic algorithm and simulated annealing is investigated by Zain et al. [87].The optimization cycle of turning process parameters for cylindrical parts using the simulated annealing approach to increase performance in product manufacturing utilizing turning operations is investigated by Kolahan and Abachizadeh [88]. Multi-objective optimization of high-speed milling operations with simultaneous genetic computational annealing to increase performance in machining operations utilizing tailored machining parameters is presented by Wang et al. [89]. To minimize the surface roughness in end milling Ti-6Al-4V, applications of the simulated annealing method in obtaining the optimized machining parameters, such as radial rake angle is investigated by Zian et al. [90]. The developed flowchart in the study for optimization process of machining parameters is shown in the figure 3[90].

2.8. Ant colony optimization

The ant colony optimization algorithm is inspired by the foraging actions of the ants in discovering short paths between their nests and sources of food. Growing ant in this algorithm represents a complete solution to find the shortest route between their nest and food sources. After all the ants create solutions, local search is then applied to determine the optimal response to the question. The flowchart of the ant colony optimization is presented by Karaboga and Akay [91]as is shown in the figure 4.

Optimization of multi-pass turning operations using ant colony system is investigated by Vijayakumar et al. [92] to minimize the surface roughness of produced parts. Optimization of operations sequence in computer aided process planning of part production using an ant colony algorithm is studied by Krishna and Rao[93] to increase efficiency in part manufacturing using optimized production parameters. To decrease the cost for machining operations, application of ant colony optimization algorithm in process planning optimization is investigated by Liu et al. [94]. Optimized process design for a hybrid punch and laser cutting system using ant colony optimization to achieve the best cutting tool paths in terms of quality enhancement of the component manufacturing cycle is presented by Wang and Xie [95]. Parameter optimization of support vector machine by improved ant colony optimization is presented by Rongali and Yalavarthi [96] to optimize the parameters of machining operations in terms of productivity enhancement of part production. Multi objective optimization in drilling operations of carbon fiber reinforced composites using ant colony algorithm is presented by Sankar and Umamaheswarrao [97] to increase material removal rate in terms of efficiency enhancement of part manufacturing process. To minimize machining time in improving the efficiency of component production processes, tool path length optimization of contour parallel milling operations based on modified ant colony is investigated by Abdullah et al. [98]. To minimize cutting tool failure in terms of increased productivity of the component production process, delamination factor and optimization of cutting force in the finishing of carbon fiber reinforced polymer composites using back propagation neural network-ant colony optimization is presented by Soepangkat et al. [99].The use of the ant colony optimization for machining parameters in final milling operations to eliminate surface roughness in component development processes is studied by Kadirgama et al. [100]. Optimization of cutting parameters in multipass turning operation using ant colony algorithm method is studied by Pansare et al. [101] to enhance efficiency in part production process.

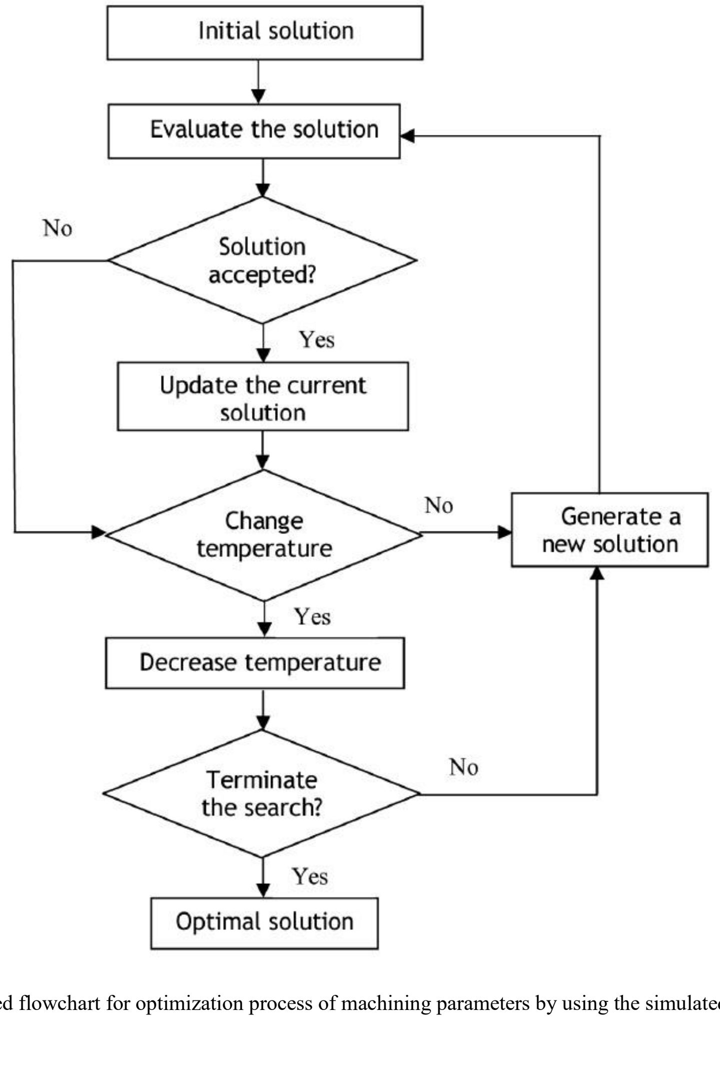

Figure 3. The developed flowchart for optimization process of machining parameters by using the simulated annealing method [90].

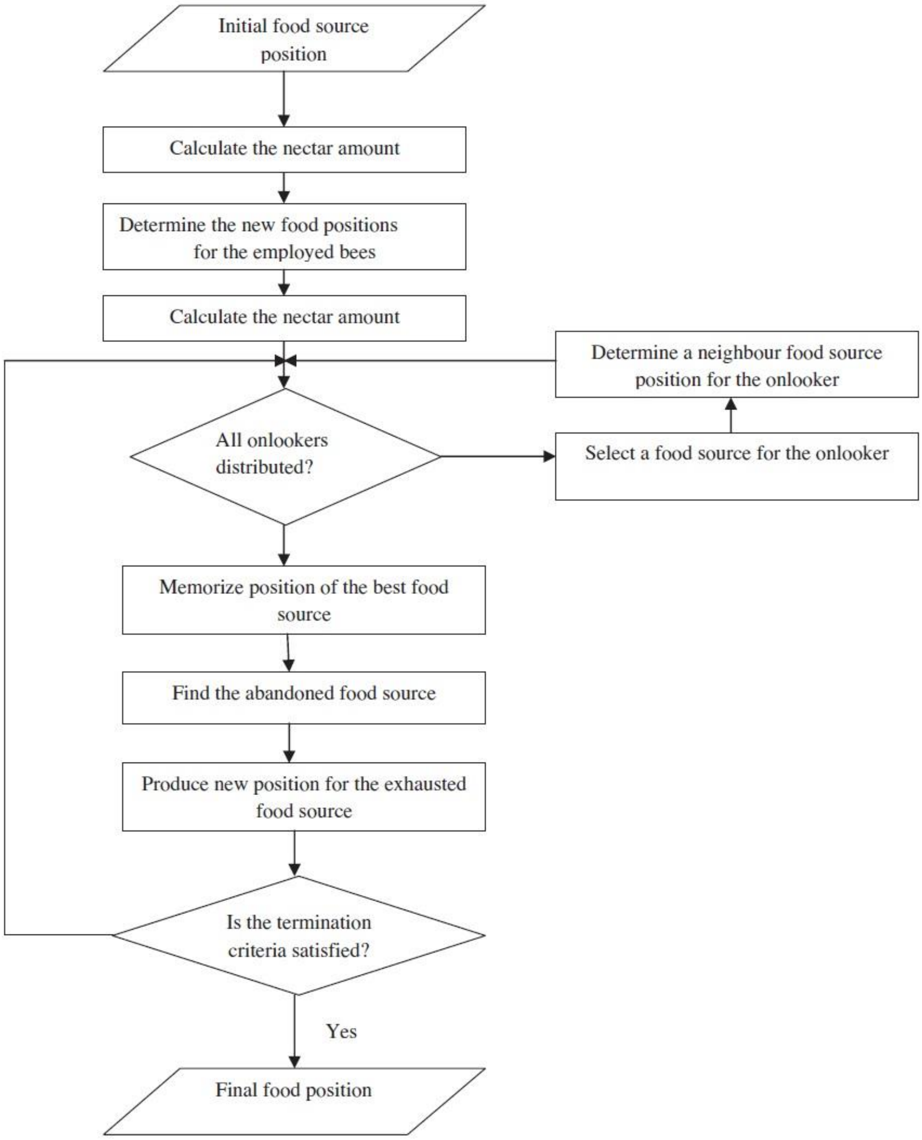

Figure 4. The flowchart of the ant colony optimization [91].

2.9. Particle swarm optimization

The optimization of the population-based particle swarm is developed using the technique of artificial intelligence to calculate the optimal parameter. In this algorithm, a population of simple agents is created, interacting locally with each other and with their environment to get the optimized member as a point or surface in an n-dimensional space. Particles then move through solution space, and are evaluated in compliance with those success requirements at each time period. The orientation of each particle is determined by its best-known local location, and it is also directed towards the best-known search-space locations. As a consequence, the swarm may be estimated as the optimal community participant for the right solutions. Application of the particle swarm optimization method in obtaining the optimized machining parameters such as time for machining, the material removal rate, and the feed rate is investigated by Vergara-Villegas [102] in order to increase efficiency in part production process. To obtain the maximum material removal rate and good surface roughness in electrochemical machining operations, application of the particle swarm optimization method in the part production process is investigated by Chenthil and Ravindran [103]. In order to obtain the minimum quantity lubrication environment in machining operations of the Titanium Alloy, application of the surface methodology and particle swarm optimization is investigated by Gupta et al. [104].To increase efficiency in machining operations of hard to cut materials such as Inconel 718 super alloy, application of the particle swarm optimization method in optimization process of electrical discharge machining parameters, such as material removal rate, electrode wear ratio, surface roughness and radial overcut are studied by Mohanty et al. [105].The optimization process of machining parameters, such as spindle speed, feed rate, and cut depth in machining operations of AA6061 materials using surface reaction methodology and particle swarm optimization to reduce surface roughness and power consumption in terms of productivity enhancement of component output is investigated by Lmalghan et al.

[106]. Implementation of particle swarm optimization and surface reaction technique for machining parameters optimization of aluminum matrix composites in milling process is presented by Malghan et al. [107]. Surface roughness modeling and optimization in keyway milling using ANN, genetic algorithm, and particle swarm optimization to minimize surface roughness in part production processes is investigated by Ghosh et al. [108]. The use of the genetic algorithm and particle swarm optimization in order to obtain standardized parameters of laser beam micro machining operations such as current (A), pulse frequency (Hz), and scanning speed (mm / sec) to improve surface quality in generated pieces is investigated by Kalita et al. [109].In order to reduce surface roughness in the component manufacturing process utilizing milling operations, an efficient cellular particle swarm optimization for parameter optimization of a multi-pass milling method is investigated by Gao et al. [110].Optimization of characteristic parameters in milling by using particle swarm optimization is presented by Župerl et al. [111] to minimize the surface roughness by using optimized cutting speed and feed rates in machining operations. The developed optimization algorithm to obtain the optimized cutting conditions in the study is shown in the figure 5[111].

2.10. Scatter search technique

The Scatter search optimization technique is a method based on combining decision rules and constraints in order to obtain the best solution based on the original elements. As a result, joining solutions based on generalized path are calculated and evaluated in order to select the best solution as optimized solution of the population. To increase efficiency in part production process, optimization of machining parameters, such as depth of cut, feed and cutting speed using scatter search algorithm is investigated by Siva and Balachithra [112]. To obtain the maximum machine power, required surface finish and maximum cutting speed in milling operations, optimization of machining parameters using the scatter search approach method is presented by Krishna and Rao [113]. To improve production efficiency and output levels in component manufacturing processes, multi-objective optimization of surface grinding operations for machining operations, such as wheel speed, job piece size, dressing depth and dressing lead using scatter check approach is investigated by Krishna and Rao [114]. An optimum parallel set of design and manufacturing tolerances for specific stack-up conditions using scatter search approach to reduce the overall cost of manufacturing in component production cycle is presented by Krishna and Rao [115]. Determination of optimal machining conditions using scatter search is studied by Chen and Chen [116] to improve the machining economics, machining quality and machining safety in part manufacturing process using machining operations. Application of the scatter search optimization for multi node machining operations with fixture layout is presented by Prabu [117] to minimize geometric error and deformation in workpiece during machining operations. Flowchart representing scatter search in fixture layout optimization is shown in the figure 6[117].

2.11. Response surface methodology

In the response surface optimization methodology, sequence of designed experiments is used in order to obtain an optimal solution for the problems. In this method, statistical approaches can be employed to maximize the speed of optimization calculation in order to find the optimal answer within less computational works. Parameter optimization in forming operations of the AA5052 Aluminum using response surface methodology is presented by Mugendiran et al. [118] to optimize the surface roughness as well as wall thickness condition in part production process. The optimization mechanism of the abrasive water jet machining parameters, such as pumping system, stand-off distance and nozzle speed in green composite parts using reaction surface technique to reduce surface roughness and cycle time in component production processes is studied by Bhowmik and Ray [119]. Prediction and optimization of machining parameters for minimizing power consumption and surface roughness in machining operations using response surface methodology is investigated by Kant and Sangwan [120]. The developed optimization algorithm in the study is shown in the figure 7[120].To obtain the optimized machining parameters during electrochemical machining operations, application of the response surface methodology is presented by Kalaimathi et al. [121]. The response surface method is applied by Vinayagamoorthya et al. [122] to obtain the optimized thrust force and torque during drilling operations of composite structures.

To reduce surface roughness in developed parts using turning operations, the optimization of machining parameters for turning operations based on surface reaction methodology is studied by Makadia and Nanavati [123]. Process parameter optimization for fused deposition modeling using surface response technique combined with fuzzy inference framework to increase accuracy and efficiency in the production process of the component is investigated by Peng et al. [124]. To minimize the surface roughness in machining operations of glass fiber reinforced plastics with a polycrystalline diamond tool, application of Taguchi and response surface methodologies is investigated by Palanikumar [125]. Parametric optimization of powder mixed electrical discharge machining by response surface methodology to maximize the rate of material removal and minimize surface roughness in part production processes is presented by Kansal et al. [126]. The optimization of device geometry parameters for turning AISI 1040 steel operations based on the reaction surface technique to reduce surface roughness in component development processes is studied by Neşeli et al. [127]. Multi-process parameter optimization in face milling of Ti6Al4V alloy using response surface methodology is investigated by Saini et al. [128] to obtain the optimized surface roughness, tool wear and tool vibration conditions in part production process. To minimize surface roughness in part production process using electric discharge machining operations, optimization of the machining parameters, such as pulse current, pulse on-time and pulse off-time for Al/ZrO_2 composite workpiece through response surface methodology is presented by Alagarsamy et al. [129]. To investigate effects of machining parameters, such as machining voltage and machining on time, on the recast material layer and micro-hardness of the machined sample, optimization of Micro-electro Discharge Drilling Parameters of Ti6Al4V Using Response Surface Methodology and Genetic Algorithm is presented by Kumar and Hussain [130]. Optimization of machining parameters, such as cutting speed, feed rate and approach angle and cutting fluids based on response surface methodology in turning operations of titanium alloy is investigated by Kumar Gupta et al. [131] to minimize quantity lubrication and surface roughness in turning operations. The developed methodology in the study is shown in the figure 8[131].

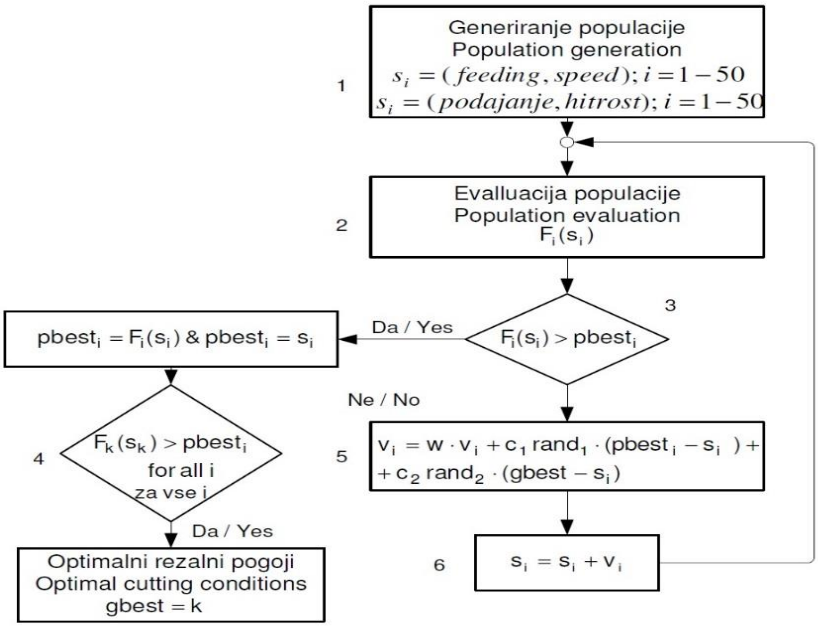

Figure 5. The developed optimization algorithm using particle swarm optimization to obtain the optimized cutting conditions [111].

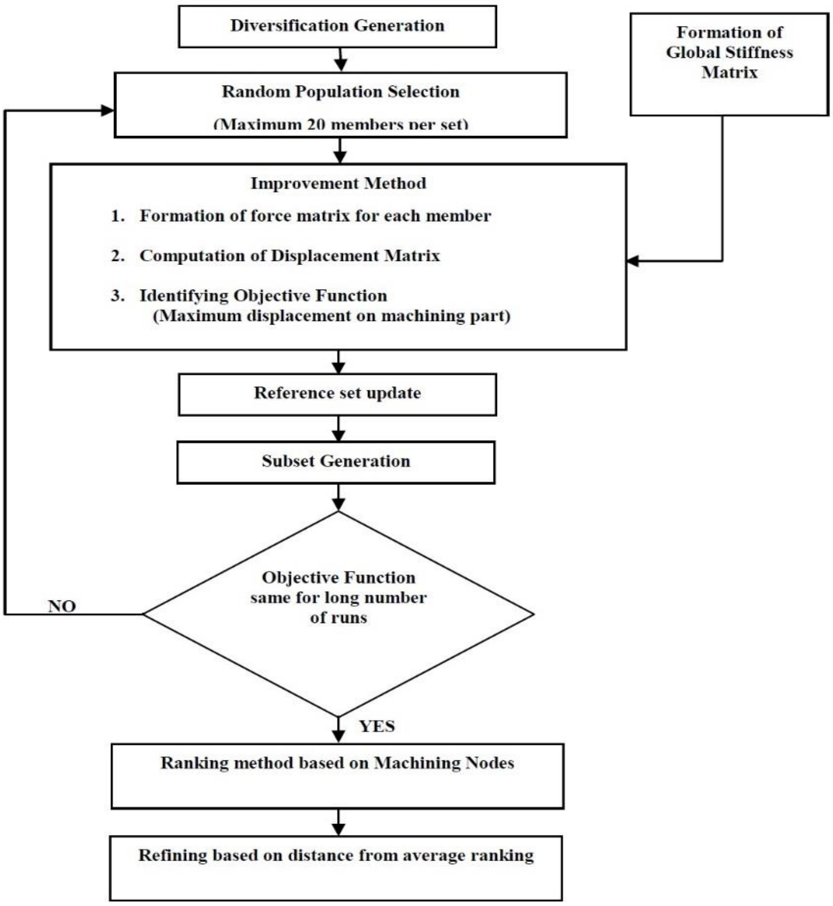

Figure 6. Flowchart representing scatter search in fixture layout optimization [117].

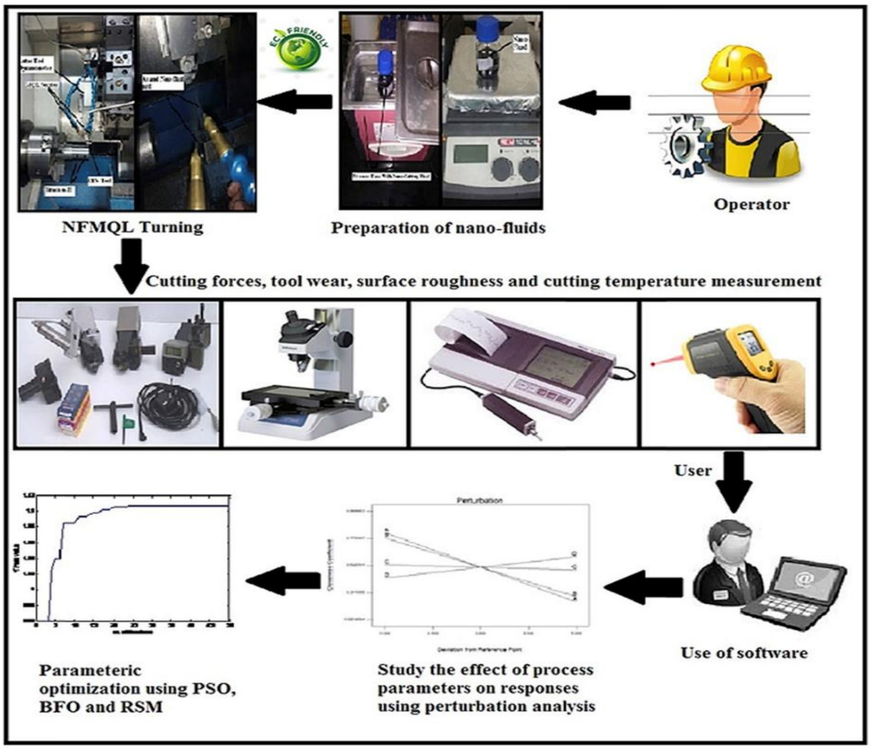

Figure 7. The developed optimization methodology to minimize quantity lubrication and surface roughness in turning operations [131].

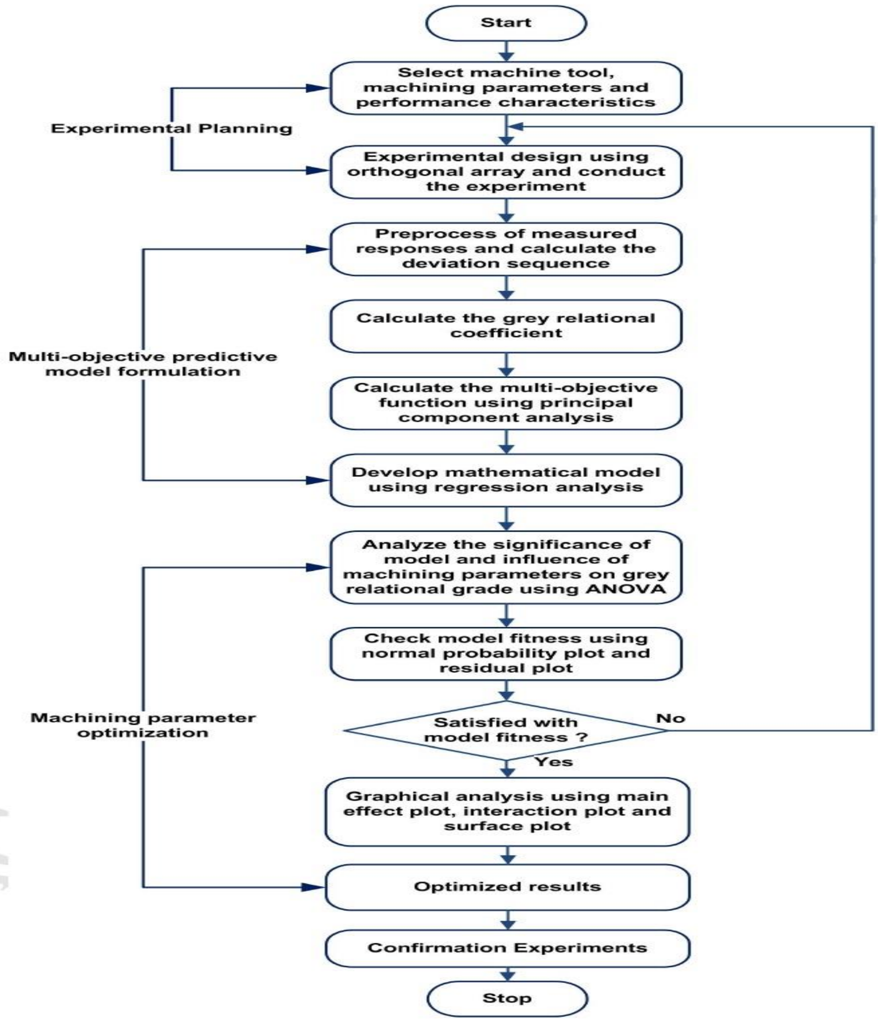

Figure 8. The developed optimization algorithm to minimize power consumption and surface roughness in machining operations [120].

2.12. Harmony search algorithm

In the harmony search optimization algorithm, the behavior of the musicians in finding a pleasing harmony is simulated in order to obtain the optimized member of population. The process of search for the perfect harmony is base of the optimization method in calculating the optimal solutions in engineering problems. Optimization process of electric discharge machining parameters such as pulse on time, peak current, servo voltage and servo speed using harmony search algorithm is investigated by Deris et al. [132] to minimize surface roughness in part production process. To obtain the optimum cutting parameters such as number of passes, depth of cut in each pass, cutting speed and feed rate for multi-pass face-milling operations, application of the harmony search algorithm in minimizing the total cost of produced parts is presented by Zarei et al. [133]. Optimization of drilling process parameters using harmony search algorithm to improve productivity in component production processes is presented by Chatterjee et al. [134]. The application of a Fuzzy Embedded Harmony Search Algorithm to obtain optimized machining parameters such as drill speed, feed and drill diameter in drilling operations of CFRP (polyester) composites to obtain optimized thrust power, torque, surface roughness and delamination factor conditions in component production processes is presented by Abhishek et al. [135]. Optimization approach to determine the optimal process parameters such as part thickness, taper angle, pulse duration, discharge current, wire speed and wire tension in wire electrical discharge machining process during taper cutting operation using the harmony search algorithm is investigated by Nayak et al. [136] to optimize the angular error, surface roughness, and cutting speed conditions in part production process. In order to minimize surface roughness in the component development cycle using milling operations, parametric optimization of face friction using harmony search algorithm is proposed by Nagarchi and Patel [137]. Application of the harmony search optimization in obtaining the EDM machining process parameters, such as pulse on time, peak current, servo voltage and servo speed in die sinking operations of SS316L stainless steel is studied by Deris et al. [138] to increase dimensional accuracy of produced parts using EDM machining operations. Optimization process of machining parameters such as spindle speed, feed rate and depth of cut in turning operations of AISI D2 Steel using the Grey Relation Analysis integrated with Harmony Search method is investigated by Kumari et al. [139] to maximize the material removal rate and minimize the surface roughness in part production process.

Recent development of the machining parameter optimization is shown in the table 1.

Table 1. 1Recent development of machining parameter optimization

Topic of research work	Papers	Finding/ Discoveries
Taguchi method	[26]	The machining parameters are designed to improve the surface strength of the manufactured parts in Inconel 718 super alloy's end milling operations.
	[28]	Parameters of machining such as spindle rpm, feed rate and cut depth during micro-milling of Ti6Al4V titanium alloy and materials from Inconel 718 are optimized.
	[32]	The effect of CNC milling machining parameters on surface finish using Taguchi method is investigated to increase productivity in component production process.
Fuzzy logic algorithm	[36]	The process of optimizing machining parameters such as the cutting depth, cutting speed, feed rate, and tool nose runoff for CNC machining operations are studied using fuzzy and game theory techniques.
	[40]	The optimization of machining parameters is explored when transforming Al-SIC-Gr hybrid metal matrix composites using grey-fuzzy algorithm.
	[44]	Multi-objective optimization of process parameters for wire electro discharge machining using grey-fuzzy methodology is investigated to improve component output efficiency.
Artificial intelligence	[46]	Applications of the artificial intelligence in the optimization process of part production are investigated to increase productivity in part production process using turning operations.
	[49]	Application of artificial intelligence in the parameter optimization method of a multi-pass milling method is studied in order to reduce the machining time.
	[51]	To improve surface quality in machined components, supervisory controller is developed using artificial intelligence for real-time surface quality assurance in CNC machining.
Genetic algorithm	[56]	To maximize performance, the optimization process of cutting parameters such as cutting speed, feed rate, cutting depth and number of passes is studied using genetic algorithms for multi-pass milling operations.
	[59]	Optimization of machining parameters for face friction operation in a vertical CNC milling machine is introduced using genetic algorithm to minimize surface roughness.
	[62]	Genetic algorithm-based optimization of cutting parameters in turning processes is introduced to reduce machining time.
Artificial Neural networks	[65]	The implementation of artificial neural networks and genetic algorithm to obtain the cutting-insert selection and cutting-parameter optimization is investigated in order to improve the output in turning operation.
	[67]	Parameter optimization of milling operation is researched using teaching-learning-based optimization and artificial neural network.
	[69]	Optimum machining parameters in X20Cr13 stainless steel face milling operations are investigated through the use of neural network and harmony search algorithm.
Artificial bee colony algorithm	[71]	To optimize material removal efficiency, parametric optimization processes of electrochemical machining, electrochemical discharge machining and electrochemical micromachining processes using artificial bee colony algorithm are provided.
	[75]	Optimal machining control parameters using artificial bee colony are investigated to reduce the surface roughness of the generated parts.
	[78]	Multi-objective optimization of process parameters for SIC composite electrochemical machining is introduced using hybrid fuzzy-artificial bee colony algorithm.
Simulated annealing	[80]	Integration of process simulation into machining parameter optimization is explored in order to present implementations of the simulation methodologies of machining parameter optimization.
	[83]	Made state optimization by genetic algorithms and virtual annealing is proposed to increase performance in component manufacturing processes using machining operations.
	[87]	Versions of genetic algorithm and computational annealing are explored to approximate optimum process parameters of the abrasive water jet machining operations.
Ant colony optimization	[93]	Optimization of operations sequence using an ant colony algorithm is studied in computer-aided process planning of component output.
	[96]	Optimization of support vector machine parameters is provided by improved optimization of ant colonyto maximize the machining performances.
	[100]	To minimize the surface roughness of the manufactured parts, the modification of the optimization of the ant colony is studied for machining parameters in end milling operations.
Particle swarm optimization	[102]	For maximize performance, the use of the particle swarm optimization approach is investigated in obtaining the optimized parameters of machining such as machining time, material removal rate and feed rate.
	[105]	To improve efficiency in the electrical discharge machining, the use of the particle swarm optimization approach in the optimization process of parameters such as material removal rate, electrode wear ratio, surface roughness, and radial overcut is studied.
	[108]	Modeling and optimization of surface roughness in keyway milling using ANN, genetic algorithm, and particle swarm optimization is studied to minimize surface roughness of generated sections.
Scatter search technique	[113]	To achieve full machine tool power, necessary surface finish and full cutting speed in milling operations, optimization of the machining parameters is provided using the scatter quest technique.
	[115]	To minimize the machining costs, optimum design range and manufacturing tolerances are provided simultaneously with specific stack-up conditions using scatter search process.
	[117]	To reduce the geometric error, implementation of scatter search optimization with a fixture architecture is introduced for multi-node machining operations.
Response surface methodology	[119]	To minimize surface roughness, the process of optimizing abrasive water jet machining parameters such as pumping mechanism, stand-off width, and nozzle speed in sections of green composites is studied using reaction surface methodology.
	[126]	Parametric optimization of powder blended electrical discharge machining by reaction surface technique is provided to optimize the rate of material removal.
	[128]	Multi-process parameter optimization in face friction of Ti6Al4V alloy using reaction surface methodology is investigated to reduce the surface roughness.
Harmony search algorithm	[132]	The method of optimizing electric discharge machining parameters such as pulse on time, peak speed, servo voltage and servo velocity is investigated using harmony search algorithm to minimize surface roughness.
	[135]	The implementation of a Fuzzy embedded harmony search algorithm to obtain optimized machining parameters such as drill rpm, feed and drill diameter in CFRP (polyester) composite drilling operations is introduced.
	[138]	In order to improve dimensional precision, the application of harmony search optimization is studied in obtaining the parameters of the EDM machining cycle such as pulse on time, peak current, servo voltage and servo speed in the SS316L stainless steel die sinking operations.

3. Conclusion and future research works

In the present research work, a review in recent development of machining parameter optimization is presented. In order to provide a review in optimization procedures of machining parameters, applications of the different optimization methods, such as Taguchi method, fuzzy logic algorithm, artificial intelligence, genetic algorithm, artificial neural networks and artificial bee colony algorithm, simulated annealing, ant colony optimization, particle swarm optimization, scatter search technique, response surface methodology and harmony search algorithm in optimization process of machining parameters is investigated. The results of machining parameters such as spindle speed, cut distance, and feed rate are studied to reduce the surface roughness as well as machining time in milling operations. The efficient machining parameters such as cut width, feed rate, and spindle speed are investigated to reduce the surface roughness as well as time of machining cycle in turning operations. In the Electro Discharge Machining (EDM) operations, the machining parameters such as peak speed, gap voltage, service cycle and pulse on time are optimized to achieve the optimal material removal efficiency, tool wear and surface roughness in component development method. Using the wire EDM operations, machining parameters such as spark on time, spark off time, input current are analyzed and optimized to increase material removal efficiency, surface roughness and spark gap in component production cycle. To maximize the material removal rate, minimize the surface roughness and over-cut in part production process using electrochemical machining operations, effective machining parameters such as current, voltage, electrolyte concentration and feed rate are analyzed and optimized. In the abrasive water jet machining operations, machining parameters such as jet transverse speed, stand-off distance and abrasive flow are optimized in order to minimize the surface roughness and maximize the material removal rate in part production process. The effective machining parameters such as laser power, cutting speed, pressure of the gas and pulse width in the laser beam machining operations are optimized in order to minimize the surface roughness and maximize the material removal rate in part production process.

Machining operations of hard to cut materials such as super alloys and Inconel materials and composite materials can be analyzed and optimized to increase efficiency in part production process. Application of optimization process in increasing the cutting tool life can be developed by considering the different materials of cutting tools, cutting tool wear and generated heat in the cutting zone. The automated tool changing systems in machine tool centers can be analyzed in order to be optimized. Also, parameters of cutting tool geometries as shape and different angles can be analyzed and optimized in order to decrease cutting forces in terms of cutting tool life enhancement in machining operations. Moreover, cutting inserts and tool holders can be optimized in order to improve efficiency in part production process using machining operations. Energy consumption of machine tools can be analyzed in order to be decreased using optimization methods in order to decrease cost of part production. Quantity lubrication parameters during machining operations can be considered to be optimized in order to be minimized. Form tolerance and orientation tolerance in EDM machining operations can be considered in order to obtain the optimized machining parameters.Parameters of micro-and nano-machining operations can be analyzed in order to be optimized in terms of productivity enhancement of part manufacturing.

Waste materials in part production process using machining operations can be decreased by applying the optimized machining parameters to the process of part production. Applications of virtual machining systems in optimization process of machining operations can be developed in order to increase the effects of optimization techniques in terms of productivityenhancement of part production. Application of the Computer Aided Process Planning (CAPP) in the optimization process of machining operations can be investigated in order to increase added values in process of part production. Application of mathematical modeling in increasing the surface roughness of produced part can be developed by using optimized machining parameters in order to increase quality as well as efficiency in part manufacturing process. The process of workpiece clamping and machining fixtures can be analyzed and optimized in order to increase accuracy in process of part production using machining operations. Moreover, machining fixture layout for tolerance requirements can be optimized in machining operations in order to increase accuracy in part production process.

The optimization process can be applied to the grinding as well as polishing operations in terms of productivity enhancement of part production using optimized machining parameters.Applications of mathematical modellin as well as computational methods in optimization process of machining operations can be developed in order to enhance the efficiencyof machining operations. Machining parameters in multi-passes of roughing as well as finishing operations can be optimized in order to decrease the machining time as well as productivity of part production using machining operations. Applications of optimization methods in the intelligent machining systems can be investigated in order to provide intelligent machining parameter selection and intelligent process management during machining operations. Machining parameters optimization of ultrasonic assisted turning and milling operations can be investigated in order to minimize the residual stress as well as vibration during chip formation process. Surface quality during milling operations of matrix composite structures can be analyzed in order to be enhanced by using the optimized machining parameters. Application of online monitoring systems in machining parameters optimization can be studied in order to decrease the cutting tool failure and energy consumption during machining operations. Optimization process of sustainable manufacturing process can be studied to reduce negative environmental consequences while preserving energy and natural resources in part production process using machining operations.

The residual stress due to machining operations in produced parts can be decreased using optimized machining parameters in order to increase performances of machined parts in the hard-working conditions. Multi-pass machining operations can be analyzed and optimized in order to decrease time and cost of part production.

Effective machining parameters in chatter and vibration can be analyzed in order to increase accuracy in machined parts by using the optimized machining parameters. The machining operations in the fourth generation of developed industries as industry 4.0 can be analyzed and optimized in order to modify the process of part production.

These are suggestions for the future research works in the research filed of machining parameters optimization to increase efficiency in part manufacturing process using machining operations. So, high quality products regarding to the minimization of machining time and cost of part production can be presented in terms part production development using optimized machining operations.

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