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WELCOME FROM THE RECTOR OF UNIVERSITAS INDONESIA

I am honoured to have the opportunity to officially welcome you to the 12th International Conference on QiR (Quality in Research) 2011. As we are all aware that the impact of globalization has resulted in a very competitive business environment; a condition that makes the fulfillment of the needs of customer/clients' ever–sophisticated project, product, or service most challenging. Without any doubt, a sustainable design and technology is the key factors in assisting our industries to enhance their contributions to the future development of humanity. Therefore, it is our hope that this conference will be able to provide an international forum for exchanging knowledge and research expertise as well as creating a prospective collaboration and networking on various fields of sustainable engineering and architecture.

In order to achieve business objectives and benefits, engineering products or projects require various resources, skills, and technology. Accordingly, we need an application of knowledge, tools, and techniques necessary to develop sustainable products or projects, which are environmentally friendly, produced through efficient processes, and adapted to local conditions. And this may be achieved by eco-technology. Eco-technology is a technology that will give consumers what they want; lower cost, convenience, save money and deliver what people everywhere needs: less waste, less pollution, and green environment. Eco-technology practices can facilitate to conserve and restore the environment through the integration of engineering and ecological principles. However, eco-technology requires multidisciplinary synthesis of knowledge and skills; and the development and application of this technology in the sector of industry and services is therefore a crucial requirement for sustainable development process. For this reason, we urgently need new technologies and practical applications to be further developed based on the current knowledge.

Accordingly, I hope this conference can be a kick-off for the strengthened action and partnerships on creating a platform for us; national and international thinkers, academics, government officials, business executives and practitioners, to present and discuss the pivotal role of engineers in creating sustainable development.

I would like to thank the Faculty of Engineering of Universitas Indonesia for organizing this meaningful and timely event, and supporting organizations for their participation and contributions. I am sure that you will all find this conference stimulating and rewarding and with this, I wish you all a fruitful conference.

Prof. Dr. der. Soz. Gumilar Rusliwa Somantri
Rector
Universitas Indonesia

WELCOME FROM THE DEAN OF FACULTY OF ENGINEERING UNIVERSITAS INDONESIA

On behalf of the Faculty of Engineering, University of Indonesia, it is my greatest pleasure to extend our warmest welcome to all of you to the 12th International Conference on QiR (Quality in Research) 2011. As we know that this conference is conducted to cover a wide range of sustainable design and technology issues, I hope this two days-conference will be spent in interesting discussions and exchange of ideas. I also hope that this conference will be able to provide a state-of-the-art information and knowledge in this challenging world of sustainable design and technology. The growing success of our institutions and expertise should urge us to develop our competitive capabilities, especially when we face certain challenges which should be overcome with hard work, cooperation, and working together hand in hand. We will work together to develop a common path and develop collaboration opportunities for future action and research on multi-disciplinary engineering areas for quality of life and humanity.

I am delighted that you have accepted our invitation to this conference in such a large numbers as indicated and that we will have many international speakers and papers from various countries to be presented and discussed in these two days. We will explore various issues on sustainable development and we must widen the scope of sustainability from a product-, system-, or an individual building-scale to the whole community-scale. At the same time, we have to widen the focus from ecological aspects to social and economic aspects. This means that environmental solutions should always be considered from the aspects of human health and well-being, safety, and economic point of view. This conference provides an excellent forum for engineering professionals, business executives, industry practitioners, and academicians to exchange ideas and to share their experience, knowledge and expertise to each other.

I would like to thank our sponsors, supported bodies, and various contributors for their generous support of this conference. I would also like to thank our distinguished speakers for agreeing to share their insights with us. To our friends from overseas and other provinces of Indonesia, I would also like to extend a warm welcome to you and wish you an enjoyable stay in Bali. Last but not least, I would invite you to join me in thanking the committed staff that made this conference happen and to make it success.

I wish us much success in the deliberations, discussions, and exchange of ideas which we will have within this conference and I wish you a very pleasant and enjoyable stay here in Bali.

Prof. Dr. Ir. Bambang Sugiarto, M.Eng
Dean Faculty of Engineering
Universitas Indonesia

WELCOME FROM THE QiR 2011 ORGANIZING COMMITTEE

On behalf of the Organizing Committee, it is my greatest pleasure to extend our warmest welcome to all of you to the 12th International Conference on QiR (Quality in Research) 2011. The selected theme for this year's conference is "Integrated Design in Urban Eco-Technology for Quality of Life and Humanity". With this theme, the conference focuses on the scientific analysis and design of the key factors explaining the success applications of integrated design in urban eco-technology, their market perspectives, and their contributions to the existing and future development of humanity. In line with this theme, it is our utmost pleasure to hold the QiR 2011 in conjunction with the 2nd International Conference on Saving Energy in Refrigeration and Air Conditioning (ICSERA 2011).

With its continuous presence for 12 years, QiR has become an icon for Faculty of Engineering Universitas Indonesia in serving the objectives to provide engineering excellence for both national and international in all aspects of engineering, design, and architecture. For the first time, the QiR 2011 is held in a famous beautiful island of Indonesi - Bali. The QiR 2011 is supported by Universitas Udayana, in the spirit of strengthening of cooperation and mutual growth to be world class institution. I am delighted to inform you that we have such a large number of participants today, as indicated, that we will have 21 invited speaker presentation and more than 520 papers from more than 20 countries to be presented and discussed during these two days-conference. We are fortunate to have a lot of good quality papers belong to:
32 papers on ICSERA
39 papers on Chemical Engineering
115 papers on Electrical Engineering
37 papers on Mechanical and Naval Architecture Engineering
101 papers on Materials Engineering
54 papers on Architecture & Planning
75 papers on Industrial Engineering
72 papers on Civil Engineering

I would like to thank all contributors, speakers and participants for your generous support to this conference. It is my pleasant duty to thank all the members of Organizing Committee and the International Board of Reviewers for their advices and help. We are grateful to all Sponsors, Supporters, Exhibitors, Partner Universities and Professional Associations, for their spontaneous response and encouragement through committing funds and extending help in kind. I would like to sincerely thank the Rector of Universitas Indonesia and the Dean of Faculty of Engineering, for fully supporting the Committee and providing all supports to make this conference happen and to make it a success.

I wish you a very pleasant stay here in Bali; and finally, let me wish all of you a meaningful and fruitful conference. Thank you and we hope to see you again at the QiR 2013.

Prof. Dr. Ir. Bondan T. Sofyan, M.Si.
Chairman of QiR 2011 Organizing Committee

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SYMPOSIUM F

Optimization of Cutting Conditions when End Milling Aeronautic Materials (Ti-6Al-4V) using Genetic Algorithm and Response Surface Methodology

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ABSTRACT

The present work was initiated to explore the optimum tool performance in machining of Ti-6Al-4V using Super-Nitride (SN_{TR}) coated WC-Co end mills under wet conditions. Ti-alloys, particularly α + β alloys such as Ti-6Al-4V, have been the focus of considerable research recently because of their high specific strength to weight ratio, which is even maintained at elevated temperatures, excellent fracture toughness, extensive ductility and corrosion resistance. These properties make Ti-alloys the most attractive metallic materials for metal working, aeronautic industry, chemical industry, marine environments, and biomaterials applications. The Response Surface Methodology (RSM) and Genetic Algorithm (GA) were used in finding the optimum machining conditions. It was proven that overall performance using GA delivers better results than RSM, when the experimental trials were conducted according to design of experiments (DOE).

Keywords

Optimum Tool Performance, Super-Nitride, Titanium Alloys, Response Surface Methodology, Genetic Algorithm

1. INTRODUCTION

As mentioned above, ti-alloys, particularly α + β alloys such as Ti-6Al-4V, have been the focus of considerable research recently, because of their excellent fracture toughness, extensive ductility, corrosion resistance and high specific strength to weight ratio (E/ρ), which is even maintained at elevated temperatures (250 °C – 600 °C). These properties make Ti-alloys the most attractive metallic materials for metal working, aeronautic industry, chemical industry, marine environments, and biomaterials applications [1]-[2]. On the other hand previous studies have shown that titanium alloys are considered as the difficult to machine materials because of its low thermal conductivity, its high heat capacity and high chemical reactivity, regardless of the type materials used[3]-[5]. To overcome such situation, the optimum cutting conditions play a significant role in machining of difficult to cut materials. One of the optimum cutting conditions that result in the best tool performance using RSM was reported by[6]. Another investigation were carried out by [7] and [8] using genetic algorithms for machining processes. They reported that genetic algorithm can be utilized for investigating the optimum machining conditions. None of previous studies were focused for optimizing of cutting conditions on aerospace materials using this algorithm. This challenge was taken into consideration in this study, to fill the lack of information in this field. Therefore, further investigation of utilization of a genetic algorithm, was employed for optimizing of machining conditions on titanium alloys.

2. EXPERIMENTAL SET-UP

The tests were carried out with a constant a_a (axial depth of cut) 5mm and a_e (radial depth of cut) 2mm under flood conditions with a 6% concentration of water base coolant using MAHO 700S CNC machining center for side milling operation. The grade K-30 solid carbide end mill cutters, with PVD Super Nitride coated which were prepared with different radial rake angle according to Design of Experiment (DOE), were used for experimentation

The reference workpiece material was a rectangular bar (110 x 110 x 270 mm) of Ti-6Al-4V. Tool life criteria used were $VB_{max} \geq 0.25$ mm, chipping $VB_{ave} \geq 0.20$ mm and catastrophic failure.

Tool wear was measured using a Nikon tool makers' microscope with 30x magnification. The measurements of tool wear according to ISO 8688-2 were carried out for each cutting edge at initial cut and continuously after a particular length of cut (depend on wear progressive of each tool) until the end of tool life was achieved.

The independent variables such as cutting speed, feed, and radial rake angle coded with the following equation by taking into consideration the capacity and limiting cutting conditions of milling machine.

$$x = \frac{\ln x_n - \ln x_{n0}}{\ln x_{n1} - \ln x_{n0}} \quad (1)$$

Where x is the coded variable of any factor corresponding to its naturalx_n, x_{n1} is the natural value at the +1 level andx_{n0}, is the natural value of the factor corresponding to the base or zero level[9]. The level of independent variables and coding identification are illustrated in Table 1.

Table 1: Levels of independent variables for end milling Ti6Al4V

Independent Variable	**Level in coded form**				
	-α	-1	0	1	+α
V ($m.mm^{-1}$) x_1	124.53	130	144.22	160	167.03
f_z ($mm.tooth^{-1}$) x_2	0.025	0.03	0.046	0.07	0.083
γ_o (°) x_3	6.2	7.0	9.5	13.0	14.8

3.RESEARCH METHODOLOGY

The mathematical models which were built using RSM will be utilized to find the optimum cutting condition using GA. The results delivered by using GA, were compared to the results using RSM[10]. The models can be described as 3F1 and 2nd CCD mathematical model.

The 3F1 mathematical model can be illustrated as:

$$y = 1.3454 - 0.64798x_1 - 1.293x_2 + 0.053199x_3 - 0.23732x_1x_2 \quad (2)$$

with the following ranges of cutting speed V_c, feed per tooth $f_z$and radial rake angle γ_o: 130≤ V_c≤ 160m.min^{-1}; $0.03 \leq f_z \leq 0.07$mm tooth^{-1} ; and $7 \leq \gamma_o \leq 13$ (º).
while the 2nd CCD mathematical model illustrated as follow:

$$y = 1.7688 - 0.64452x_1 - 1.2860x_2 + 0.052572x_3 + 0.050453x_1^2 - 030624x_2^2 - 0.076721x_3^2 - 0.23732x_1x_2 \quad (3)$$

with the following ranges of cutting speed V_c, feed per tooth f_z and radial rake angle γ_o:124.53≤ $V_c \geq$ 167.03m.min^{-1}; 0.025≤ f_z ≥0.083mm tooth^{-1} ; and $6.2 \leq \gamma_o \geq 14.8$ (º).

GA form a class of adaptive heuristics base on principles derived from the dynamic of natural population genetic. The searching process simulates the natural evaluation of biological creatures and turns out to be an intelligent exploitation of a random search.

The problem to be solved using GA is coded to binary numbers known as chromosomes. Each chromosome contains the information of a set of possible process parameters. The population of chromosomes is formed randomly. The fitness of each chromosome is then evaluated using an objective function after the chromosome has been decoded. Selected individuals are then reproduced; the selecting occurs usually in pairs through the application of genetic operator. This operator is applied to pairs of individuals with a given probability, and result in a new offspring. The offspring from reproduction are then further perturbed by mutation. These new individuals then make up the next generation. These processes of selection, reproduction and evaluation are repeated until some termination criteria are satisfied. The representing of GA is illustrated in Figure 1.

In order to optimize the present problem using GA, the following parameters such as population size, maximum number of generation, total string length, crossover probability, mutation probability, and elitism probability have to be selected to obtain optimal solution with less computational efforts.

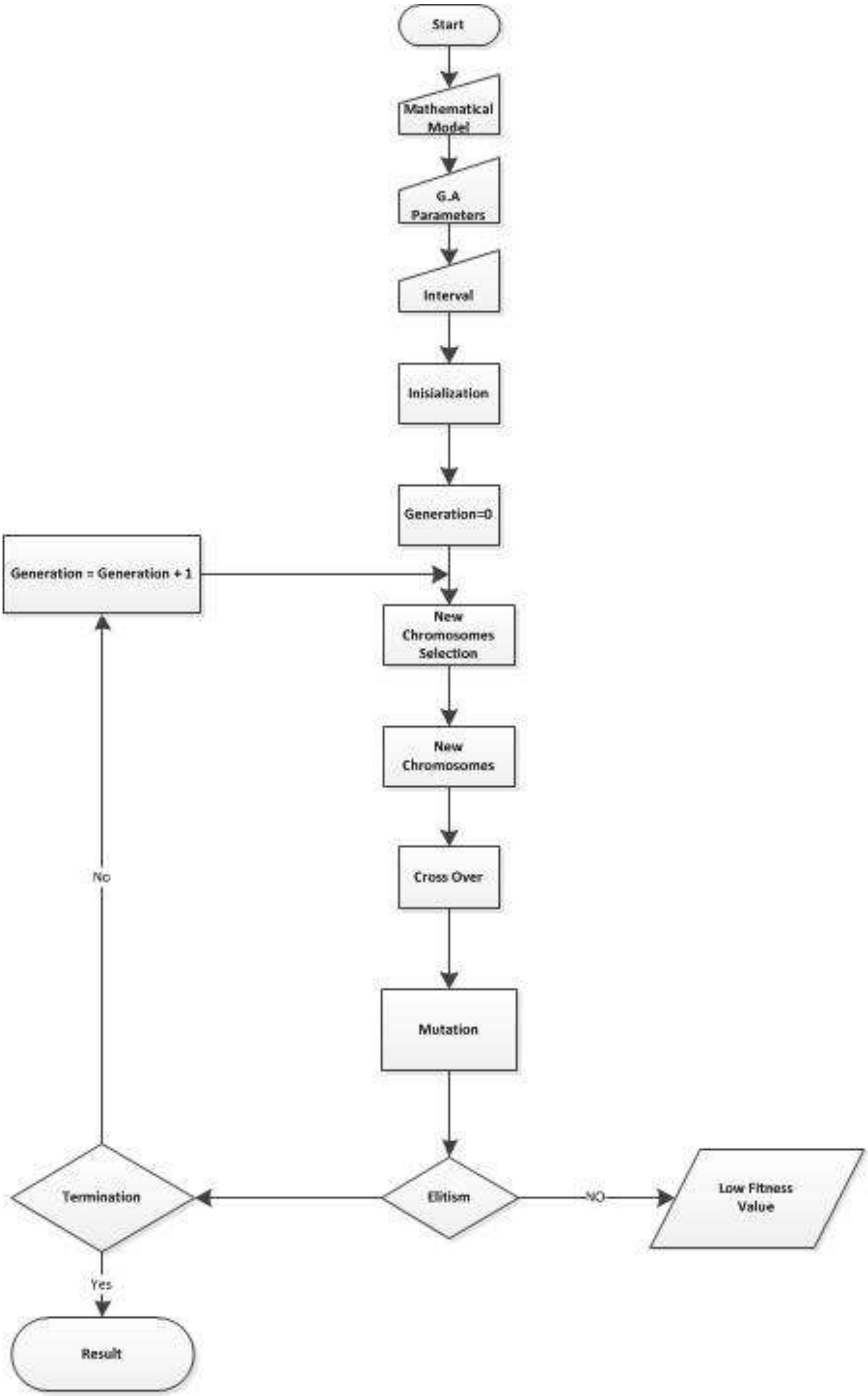

Figure 1: Flow chart of GA methodology approach.

4. RESULTS AND DISCUSSION

Tool life experimental results for SN_{TR} coated carbide tools are illustrated in Table 2These results are used to validate the comparison between the optimization using RSM and GA.

Table 2: Tool life result for SN_{TR} coated carbide tools

Std Or der	Type	Cutting speed V [m/min]	Feed rate fz [mm/th]	Radial Rake angle γ[°]	Tool Life [min]
1	Factorial	-1	-1	-1	20.09
2	Factorial	1	-1	-1	8.85
3	Factorial	-1	1	-1	2.41
4	Factorial	1	1	-1	0.41
5	Factorial	-1	-1	1	22.2
6	Factorial	1	-1	1	9.68
7	Factorial	-1	1	1	2.72
8	Factorial	1	1	1	0.46
9	Center	0	0	0	5.77
10	Center	0	0	0	6.04
11	Center	0	0	0	5.69
12	Center	0	0	0	5.94
13	Axial	-1.4142	0	0	16.12
14	Axial	-1.4142	0	0	15.95
15	Axial	1.4142	0	0	2.56
16	Axial	1.4142	0	0	2.70
17	Axial	0	-1.4142	0	16.44
18	Axial	0	-1.4142	0	16.03
19	Axial	0	1.4142	0	0.44
20	Axial	0	1.4142	0	0.43
21	Axial	0	0	-1.4142	4.94
22	Axial	0	0	-1.4142	4.43
23	Axial	0	0	1.4142	5.55
24	Axial	0	0	1.4142	5.29

Table 3: The optimization results using RSM and GA

Std Order	Experimental Results (min)	Response Surface Methodology (min)	Genetic Algorithm (min)
1	20.09	20.02	20.09
2	8.85	8.78	8.88
3	2.41	2.43	2.28
4	0.41	0.41	0.53
5	22.2	22.27	22.12
6	9.68	9.76	9.94
7	2.72	2.70	2.73
8	0.46	0.46	0.50
9	5.77	3.84	3.82
10	6.04	3.84	3.82
11	5.69	3.84	3.82
12	5.94	3.84	3.82
13	16.12	16.14	15.64
14	15.95	16.14	15.64
15	2.56	2.61	2.58
16	2.7	2.61	2.58
17	16.44	19.59	15.38
18	16.03	19.59	15.38
19	0.44	0.52	0.43
20	0.43	0.52	0.43
21	4.94	4.67	4.55
22	4.43	4.67	4.55
23	5.55	5.42	5.27
24	5.29	5.42	5.27

Table 4: Comparison between RSM and GA validated using the experimental results.

Std Order	Experimental Results (min)	RSM (min)	GA (min)	Error of RSM	Error of GA
1	20.09	20.02	20.09	0.0043	0.0000
2	8.85	8.78	8.88	0.0054	0.0011
3	2.41	2.43	2.28	0.0003	0.0159
4	0.41	0.41	0.53	0.0000	0.0140
5	22.2	22.27	22.12	0.0053	0.0060
6	9.68	9.76	9.94	0.0066	0.0662
7	2.72	2.70	2.73	0.0004	0.0001
8	0.46	0.46	0.50	0.0000	0.0014
9	5.77	3.84	3.82	4.0815	4.1811
10	6.04	3.84	3.82	4.0815	4.1811
11	5.69	3.84	3.82	4.0815	4.1811
12	5.94	3.84	3.82	4.0815	4.1811
13	16.12	16.14	15.64	0.0106	0.1564
14	15.95	16.14	15.64	0.0106	0.1564
15	2.56	2.61	2.58	0.0005	0.0021
16	2.7	2.61	2.58	0.0005	0.0021
17	16.44	19.59	15.38	11.2526	0.7328
18	16.03	19.59	15.38	11.2526	0.7328
19	0.44	0.52	0.43	0.0065	0.0001
20	0.43	0.52	0.43	0.0065	0.0001
21	4.94	4.67	4.55	0.0002	0.0188
22	4.43	4.67	4.55	0.0002	0.0188
23	5.55	5.42	5.27	0.0000	0.0230
24	5.29	5.42	5.27	0.0000	0.0230
MSE (Mean Square Error)				1.620391906	0.778974202
RMSE (Root Mean Square Error)				1.272946152	0.882595152

The optimization results using RSM and GA are shown in Table 3. The Mean Square Error (MSE) of both methods are figured out in Table 4. From this table, it can be concluded that the optimization using GA delivered better results than that using RSM. It can be recognized from the value of MSE of each approach.

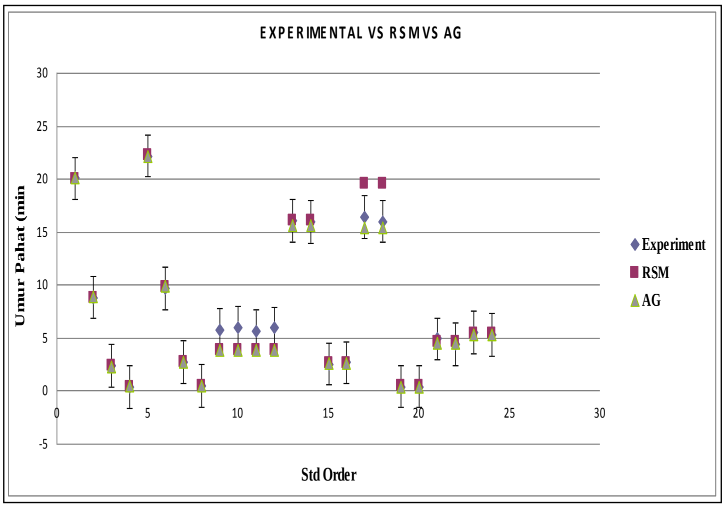

Figure 2: Error Distribution of both optimization methods validated by experimental results.

To provide easier observation of errors, the occured errors was represented and visualized in Figure 2. Finally, it can be concluded from the optimization results that GA has the ability and is suitable for achieving the best possible tool life when end milling Ti-64 in combination of cutting speed, feed rate, and radial rake angle.

5. CONCLUSIONS

1) The better overall performance in finding the optimum cutting conditions was delivered by GA compared to RSM. This can be recognized from its accuracy using the validation tests.

2) The best results of GA was produced using following parameters:
   - Population size : 80
   - Number of generation : 5
   - Total string length : 34
   - Crossover probability (Pc) : 0.8
   - Mutation probability (Pm) : 0.03
   - Elitism probability : 0.5
3) Even GA delivers better results than RSM, the difference between them was not significant.
4) It was found that GA can only give better results when the optimum parameters were taken in the iterations.

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