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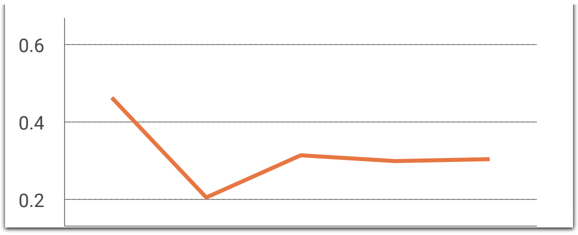

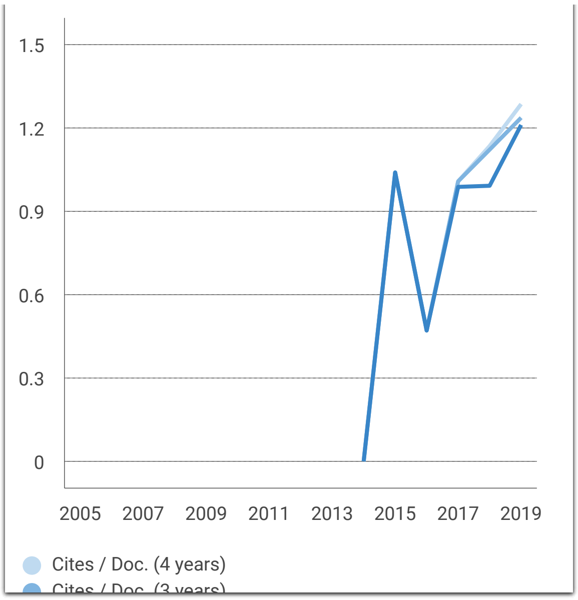

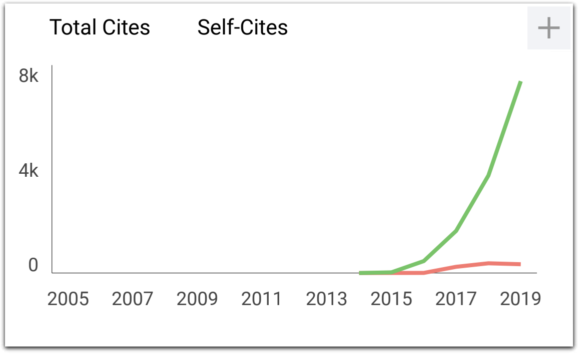

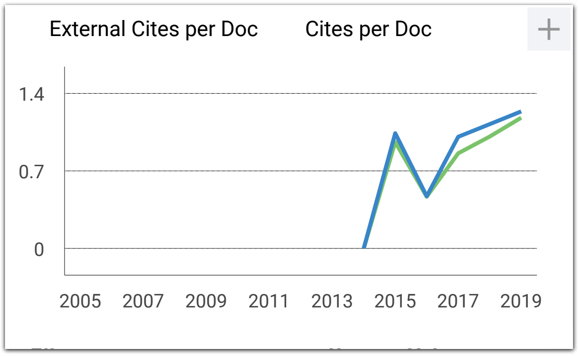

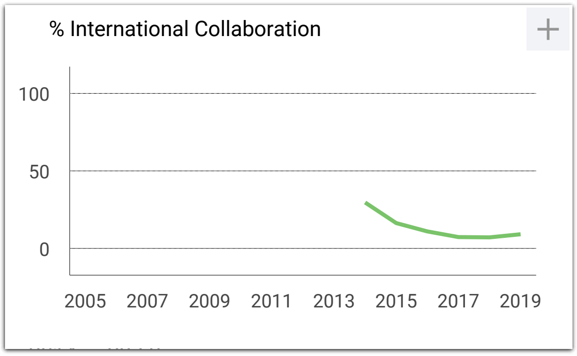

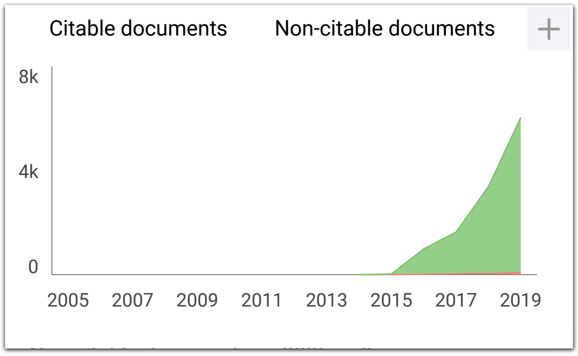

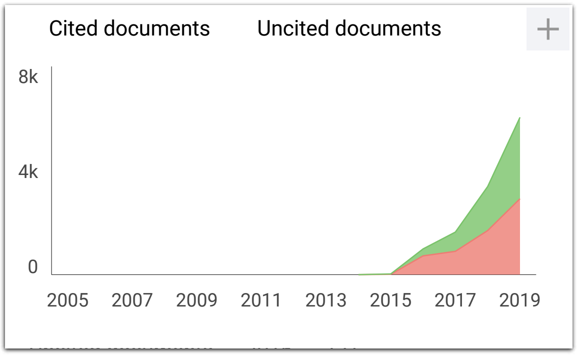

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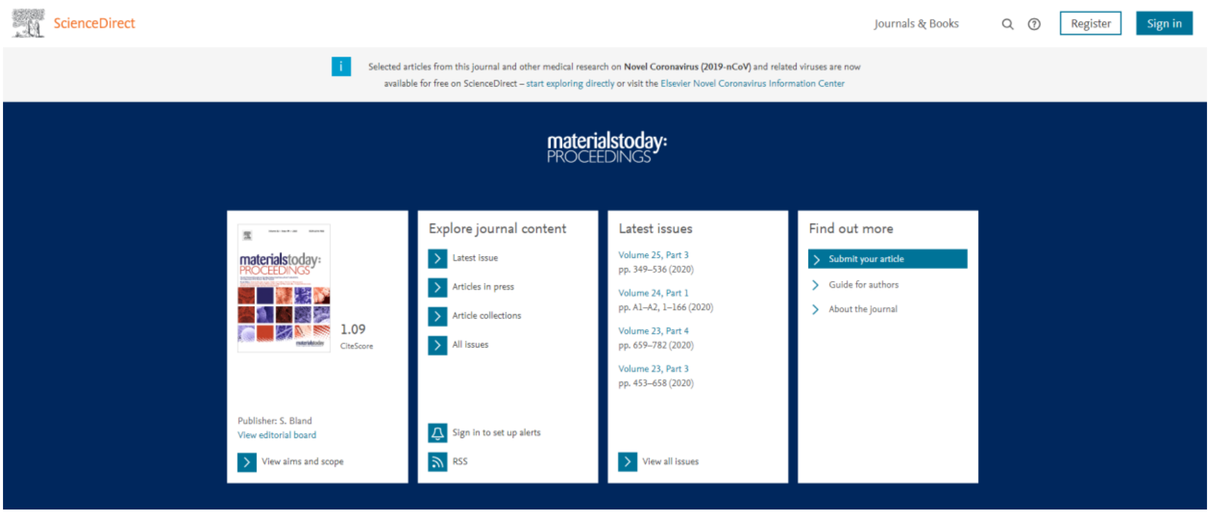

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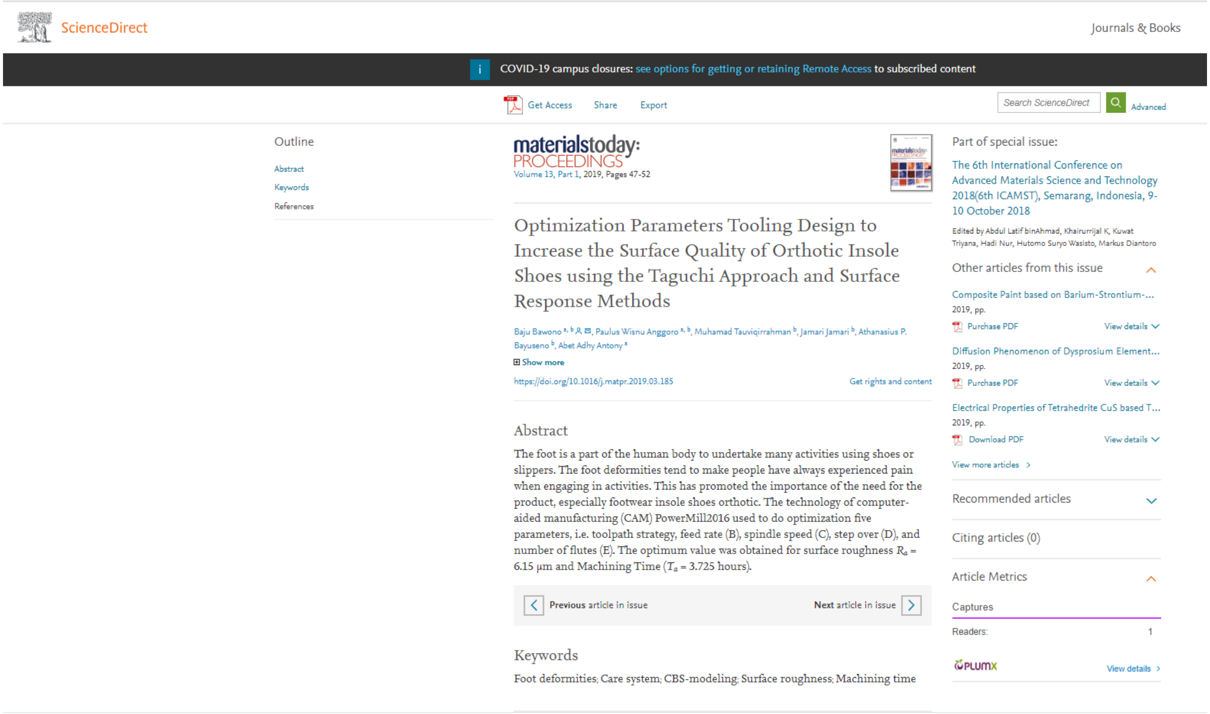

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Baju Bawono [a, b], Paulus Wisnu Anggoro [a, b], Muhamad Tauviqirrahman [b], Jamari Jamari [b], Athanasius P. Bayuseno [b], Abet Adhy Antony [a]

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Abstract

The foot is a part of the human body to undertake many activities using shoes or slippers. The foot deformities tend to make people have always experienced pain when engaging in activities. This has promoted the importance of the need for the product, especially footwear insole shoes orthotic. The technology of computer-aided manufacturing (CAM) PowerMill2016 used to do optimization five parameters, i.e. toolpath strategy, feed rate (B), spindle speed (C), step over (D), and number of flutes (E). The optimum value was obtained for surface roughness R_a = 6.15 μm and Machining Time (T_a = 3.725 hours).

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Keywords

Foot deformities; Care system; CBS-modeling; Surface roughness; Machining time

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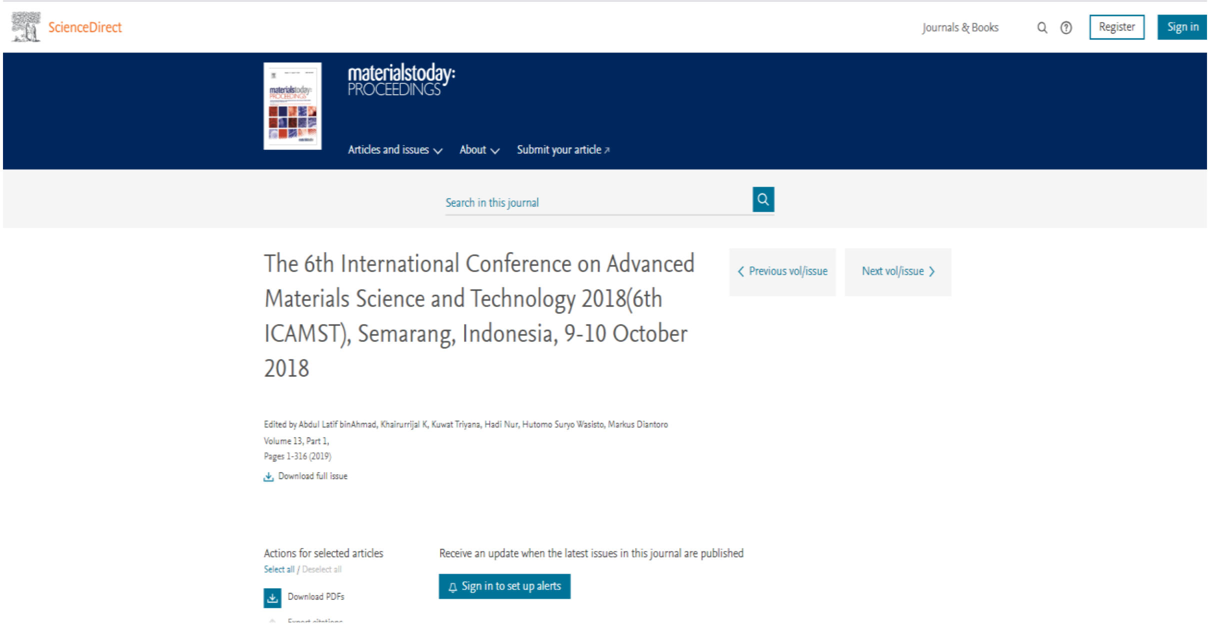

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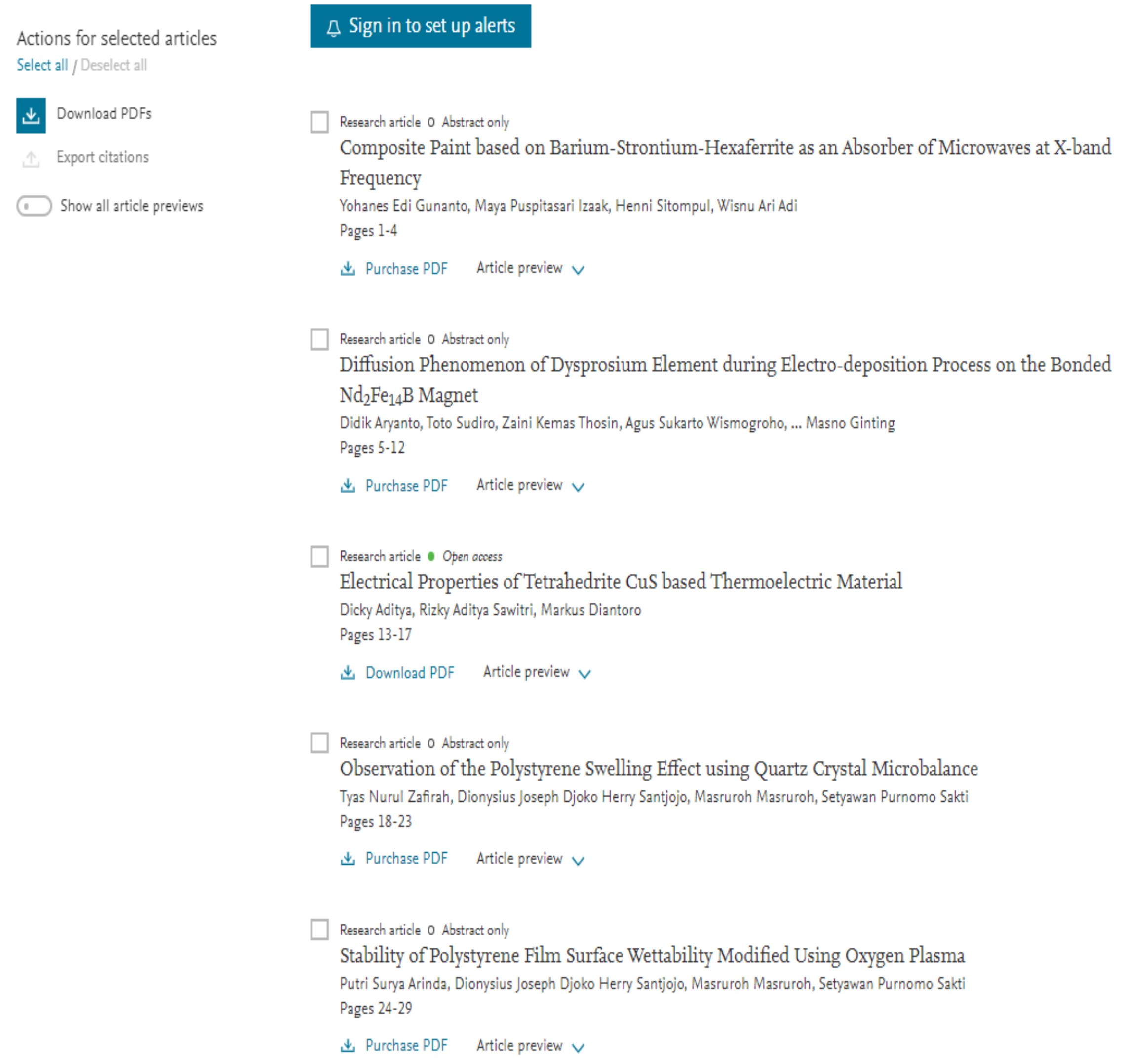

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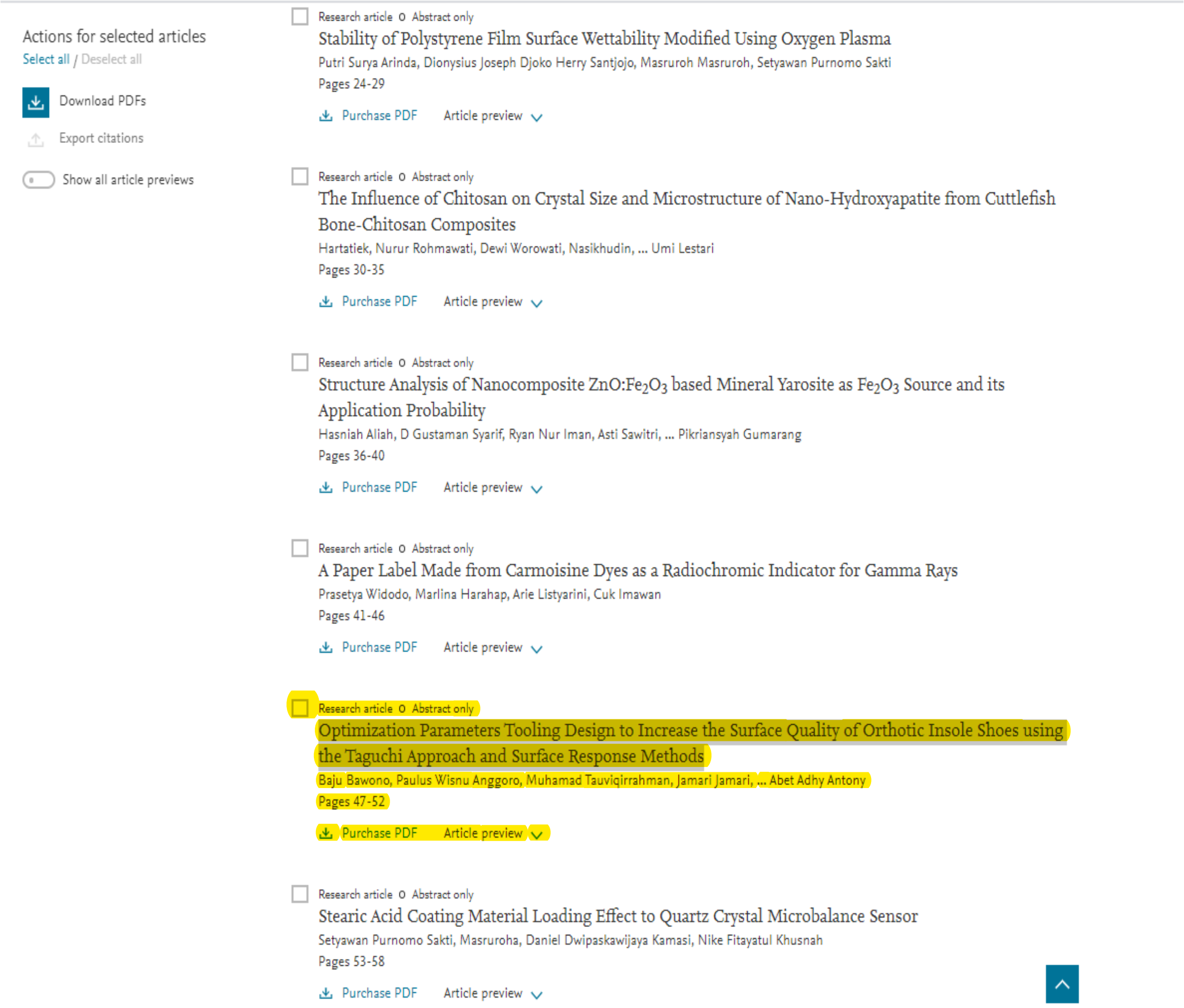

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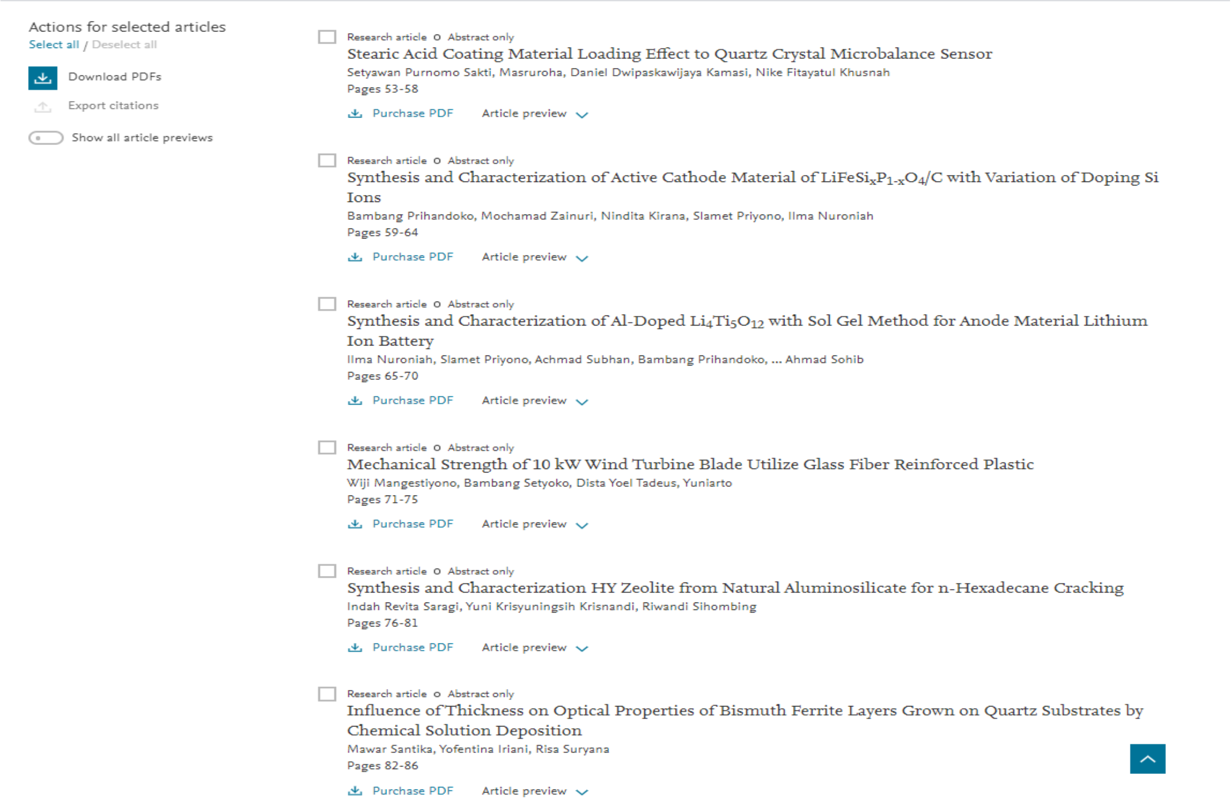

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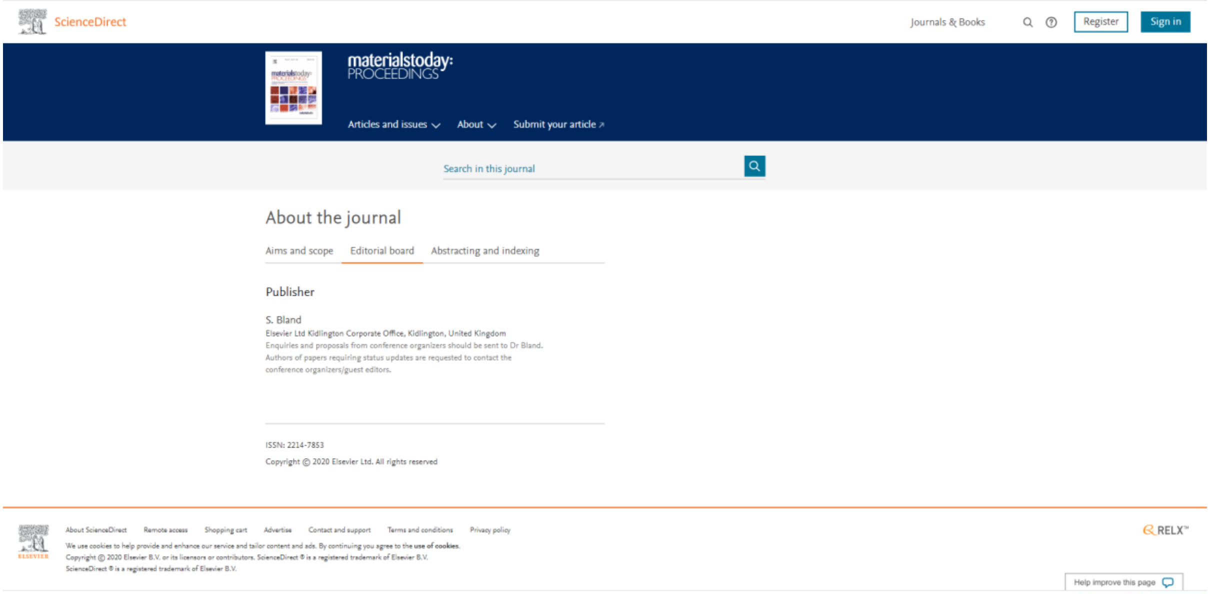

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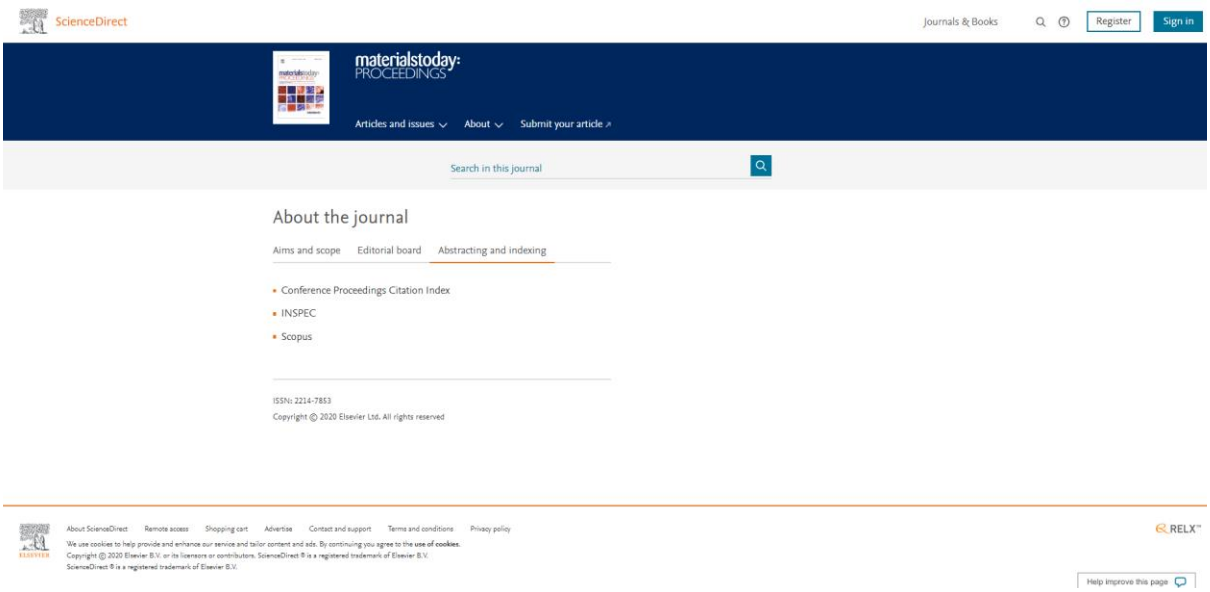

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Optimization Parameters Tooling Design to Increase the Surface Quality of Orthotic Insole Shoes using the Taguchi Approach and Surface Response Methods

Baju Bawono[a,b,*], Paulus Wisnu Anggoro[a,b], Muhamad Tauviqirrahman[b], Jamari Jamari[b], Athanasius P. Bayuseno[b], Abet Adhy Antony[a]

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Abstract

The foot is a part of the human body to undertake many activities using shoes or slippers. The foot deformities tend to make people have always experienced pain when engaging in activities. This has promoted the importance of the need for the product, especially footwear insole shoes orthotic. The technology of computer-aided manufacturing (CAM) PowerMill2016 used to do optimization five parameters, i.e. toolpath strategy, feed rate (B), spindle speed (C), step over (D), and number of flutes (E). The optimum value was obtained for surface roughness R_a = 6.15 µm and Machining Time (T_a = 3.725 hours).

Peer-review under responsibility of the scientific committee of The 6th International Conference on Advanced Materials Science and Technology 2018, 6th ICAMST.

Keywords: foot deformities, care system, CBS-modeling, surface roughness, machining time

1. Introduction

The manufacturing of medical component an ankle foot orthoses (AFO) likely insole and outsole shoe orthotic must meet standards of good quality, accuracy, reliability, and traceability that sometimes exceed and equal

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those required for automotive, aerospace and complex orthopedics replacement part. Also, global competition and efforts to restrain health care expense create great pressure to increase the quality of surface machining, maximize productivity, and reduce manufacturing costs with adopting the computer-aided reverse engineering system (CARESystem) on the orthotic footwear industry. In Indonesia, especially at Central Java, Jakarta and Yogyakarta, these methods are still rare or even no one use it because the doctor or the orthotic laboratory still use the foam box method or manual technology by engineer shoe last that requires long time process, not precise and accurate so the repair of the shoes that happened in the industry. Indonesia, especially on the Central Java and Yogyakarta, this application still not use it at all or there has not been a shoe orthotic industry use it. Most of the machining process is still using the traditional way of the insole with foam box or manual methods that require patience and very long work time (almost 2–3 weeks even more), and the results are not precise to the shape of the patient's foot.

The perfect solution to resolve the demands it is making to order products or customized. The development of the model and the design of the shoe industry is very fast, this turned out to be not fully perceived by some people who were born or because certain cases suffered deformities of feet by Hodge [1], Luigi [2], Piperi [3], and Anggoro [4]. Research on integration of process design and manufacturing *Ankle Shoes* and subtractive manufacturing by Anggoro [5], Anggoro [6] from the design stage to the stage of industrialization and product test to users are very rare. The use of conventional methods in some laboratories orthotic in Indonesia, such as Rehabilitation Centers, Jakarta, and Kuspito Surakarta Karanganyar Fake Legs that become one-factor causes.

The design of insole shoe orthotic applied method this will Reverse Innovative Design (RID) developed by Anggoro [7]. The RID also permits customization of the product so it can be applied in customized products. Method of curve base surface modeling is one of the three methods by Anggoro [8] in an attempt to form a product design based variations of surface curve modeling. This method design by the engineer of the stages of scanning, the process of RE with CAD to 3D modeling phase can be accelerated with such precision were reported by Anggoro [7-9]

2. Materials and Methods

Improving the surface quality and productivity on the production of shoe orthotic insole in CNC milling machine, then set two type design with a tolerance of 0.75 mm. Development of the optimal milling cutter for improving surface quality on CNC milling on this research is done by entering the type of milling cutter ballnose factor based on number of flutes. The addition of this type of flute as a control factor in this research will certainly change the orthogonal Array that has already been done from $L_{27}3^6$ to $L_{27}3^5$ by Octavian [10]. Factor type design of insole around 0.75 to 1.50 mm. Octavian [11] based on the results of the orthogonal change done by researchers, then the orthogonal array $L_{27}3^5$ set out in this research can be presented in Table 1. and Table 2.

Table 1. Parameter control machining

Factor	level		
	1	2	3
A: toolpath strategy	raster 45	raster 90	step & shallow
B: spindle speed (rpm)	13500	14000	14500
C: feed rate (mm/min)	850	900	950
D: step over (mm)	0,1	0,20	0,30
E: number of flute	2	3	4

Table 2. Data surface roughness (*Ra*) and time machining (*Ta*) AFO

No. Exp	A	B	C	D	E	Ra Patient 1(μm)			Ra Patient 2 (μm)			Ta_DM 1	Ta_DM 2
						Ra_1	Ra_2	Ra_3	Ra_1	Ra_2	Ra_3	(hour)	(hour)
1	1	1	1	1	1	6.423	6.838	6.800	6.823	6.662	6.732	8.908	10.008
2	1	1	1	1	2	6.222	6.321	6.323	6.321	6.431	6.233	8.883	9.983
3	1	1	1	1	3	6.156	6.205	6.238	6.233	6.332	6.222	8.892	9.992
...													
25	3	3	2	1	1	6.755	6.341	6.770	6.766	6.666	6.781	10.200	9.333
26	3	3	2	1	2	6.814	6.324	6.429	6.333	6.549	6.324	10.158	9.292
27	3	3	2	1	3	6.333	6.289	6.226	6.144	6.318	6.231	10.117	9.250

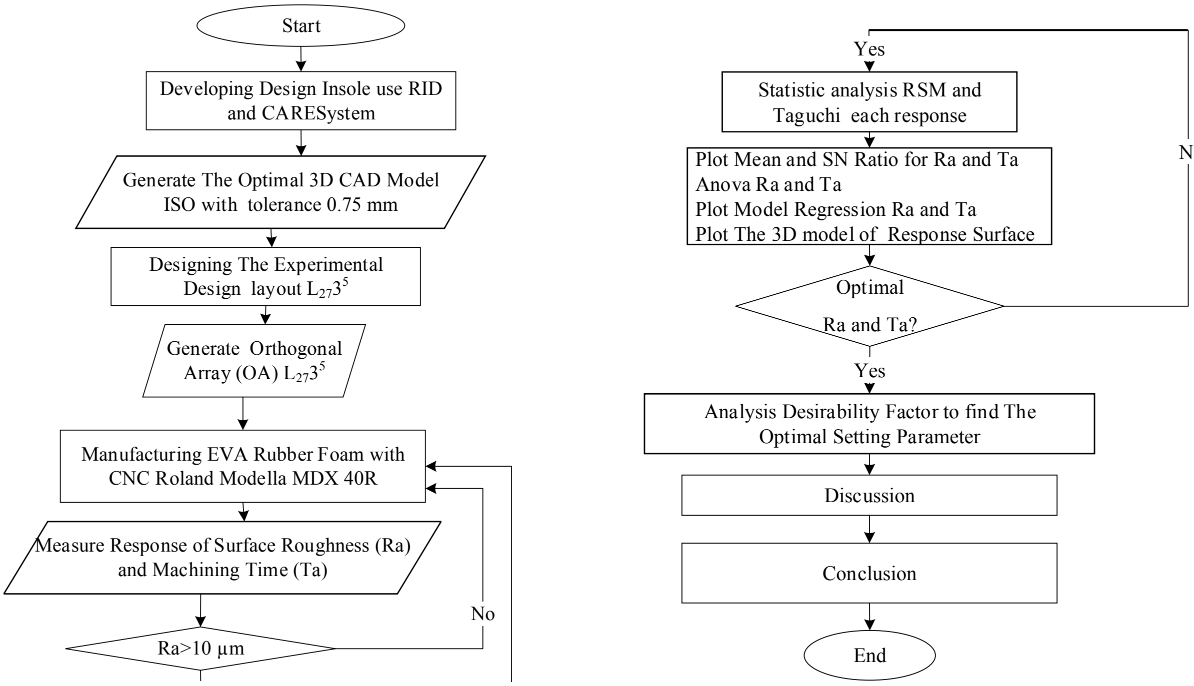

Fig. 1. Methodology research on design and manufacturing experiments for ISO-diabetes.

3. Results and discussion

3.1. Analysis of CAD and CAM orthotic shoe insole

Based on Fig. 1. workflows of design and manufacturing experiments for ISO-diabetes, the 3D image of ISO-diabetes was obtained from the foot scan of the patient using HandyScan700^{TM}. The results of the scan in the STL file format were verified into 3D images and converted into 3D CAD insole Fratia et al. [12].

3.2. Analysis of S/N ratios and their surface plots

The surface roughness of ISO-diabetes range from 4.0 to 7.0 µm was set-up for examining the optimal cutting parameters condition, and DOF was represented as the orthogonal array of $L_{27}3^5$ [13]. Table 2. presents an orthogonal array of $L_{27}3^5$. The experimental results for machining ISO-diabetes were then analyzed by Taguchi and RSM for optimum surface roughness [14-15].

The *Ra* of the milling operations was controlled by the cutting condition parameters. The explanation for the synergy effect of variables on *Ra* parameters, the 3D plots for the measured responses was created based on the model equations (Eq. (6)). These model had four variables, therefore, a total of 4 response surface plots 3D and 2D were produced for the responses and given in Fig. 2(a), Fig. 2(b), Fig. 2(c), and Fig. 2(d) which show the 3D and 2D surface graphs for the surface roughness (*Ra*) and Time Machining (*Ta*).

The 2D and 3D surface plots of the roughness (*Ra*) and Machining Time (*Ta*) were drawn using the developed RSM model by varying the two different parameters *Ra* and *Ta* and keeping the three parameters at the various level. The number flute significantly affect on the surface roughness followed by spindle speed, and feeding rate (Fig. 2(a) to Fig. 2(b)).

This figure indicate that *Ra* level can be enhanced by the increased of the feeding rate, spindle speed, and feeding rate. However, the minimum Ra is found at the first tool path (level 1) with spindle speed and step over but feeding rate was set at level 1 (Fig. 2(a), Fig. 2(c) and Fig. 2(d)). It could be explained that the increased of feed rate yields the vibration and generation of more heat. Thus, it contributes to the higher value of Machining Time (*Ta*) [6].

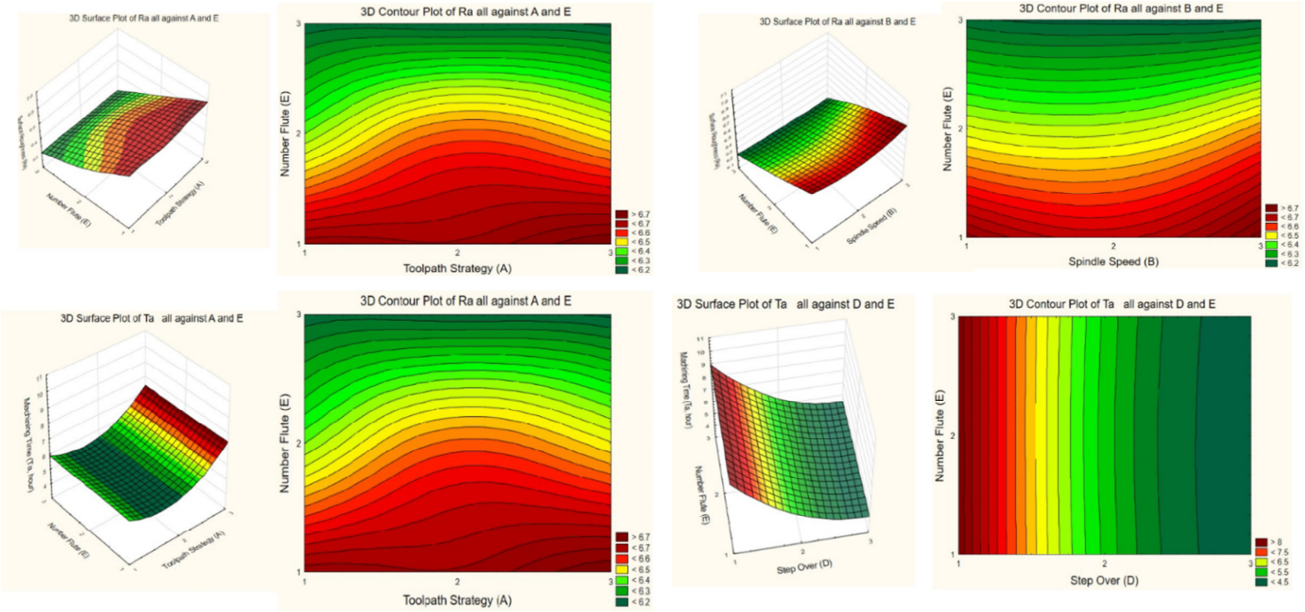

Fig. 2. Plot of 3D and 2D curves (a) The curve of *Ra*, Flute (E), Toolpath Strategy (A); (b) Curve of *Ra*, Spindle Speed (B, rpm), Flute (E); (c) The curve of *Ta*, Flute (E), Toolpath Strategy (A); (d) Curve plot of *Ta*, Stepover (D), Flute (E)

Figure 2(a) to Fig. 2(d) also show the interactive effect of spindle speed and the feeding rate, step over of *Ra*. This figure was shown the *Ra* value that decreases if the value of step over and spindle speed was increased, while the best value *Ra* was observed at a low level of the spindle speed, feeding rate and step over. It seems that at the lower step over resulted in a reduction in the value of surface roughness. In this experiment, factors of A_1-B_3-C_2-D_3-E_3 combination yielded the minimum value of surface roughness.

3.3. Analysis of variance (ANOVA) for surface roughness

In this paper, the ANOVA and effect of column wer used to investigate the effects of a setting parameter such as toolpath strategy (A), cutting speed (B), feed rate machining (C) step over (D), and number flute (E) on the *Ra* value.

Table 3(a). shown the F-ratio and the Rho% indicate the significance level of the variable. The *F-value* (3.5995) and Rho% (65.378%) for factor C is the most prominent, which indicates that feeding rate was significantly contributed on the optimum value of surface roughness. The second significant factor is number of flute E (22.63%), followed by and spindle speed B (6.04%), and step over D (1.47%).

Table 3(b). shown the significance level for machining time (*Ta*) as followed number flute E (73.25%),feed rate C (13.99%), step over D (6.94%), andtoolpath strategy A (1.33%) so in this case factor E is the most prominent.

Table 3(a). Results of the ANOVA for Squares and Rho% for *Ra*

Factor of *Ra*	Sum Square	DF	Mean Square	F ratio	Sq'	Rho%
A	0.0061	2	0.0030	0.0119	0.0178	0.2164
B	0.1695	2	0.0847	0.3329	0.4962	6.0456
C	1.8327	2	0.9164	3.5995	5.3663	65.3771
D	0.0413	2	0.0206	0.0811	0.1209	1.4730
E	0.6345	2	0.3172	1.2461	1.8577	22.6324
error	0.3709	5	0.0742	0.2914	0.3493	4.2555
ST	0.0000	27				100

Table 3(b). Results of the ANOVA for Squares and Rho% for *Ta*

Factor *Ta*	Sum Square	DF	Mean Square	F ratio	Sq'	Rho%
A	9.5830	2	4.7915	0.0789	9.4251	1.3274
B	0.2303	2	0.1151	0.0019	0.2265	0.0319
C	28.8662	2	14.4331	0.2378	28.3905	13.9985
D	50.0718	2	25.0359	0.4125	49.2468	6.9359
E	528.7774	2	264.3887	4.3563	520.0648	73.2455
error	110.7615	5	22.1523	0.3650	102.6758	4.4608
mean	0.2546	27				
ST	0.0000	27			710.0295	100

3.4. Taguchi based selection of optimum cutting conditions

After selecting the optimum result of machining parameters by Taguchi, the final step was to predict and verify the performance improvement using the optimum level cutting parameters. As determined in Fig. 2. the optimum variable levels for surface roughness (*Ra*) and Machining Time (*Ta*) are A_1-B_3-C_2-D_3-E_3 combination factors. Here combinations of A_1-B_3-C_2-D_3-E_3 that used for calculation of the optimal *Ra* and *Ta* of ISO-diabetes. The predicted optimal *Ra* and *Ta* can be calculated according to Eq. (3) by Octavian [10-11]:

$$Ra_{pred} = T_{Ra\_\exp} + (\bar{A}_2 - T_{Ra\_\exp}) + (\bar{B}_3 - T_{Ra\_\exp}) + (\bar{C}_1 - T_{Ra\_\exp}) + (\bar{D}_2 - T_{Ra\_\exp}) + (\bar{E}_1 - T_{Ra\_\exp}) \quad (3a)$$

$$Ta_{pred} = T_{Ra\_\exp} + (\bar{A}_2 - T_{Ra\_\exp}) + (\bar{B}_3 - T_{Ra\_\exp}) + (\bar{C}_1 - T_{Ra\_\exp}) + (\bar{D}_2 - T_{Ra\_\exp}) + (\bar{E}_1 - T_{Ra\_\exp}) \quad (3b)$$

where, $T_{Ra\ exp}$ = 6.15 and *Ta* is 3.652 hour, we get A_1 = 6.4401, B_3 = 6s.507, C_2 = 6.4083, D_3 = 6.4083 and E_3 = 6.1999 are obtained, the estimated value of *Ra* is 6.15 µm and *Ta* is 3.652 hour.

The second order model of surface roughness *Ra* as the machining parameters (toolpath strategy, spindle speed, feed rate and step over). Thus, the relationship between the surface roughness *Ra* and the milling parameters (factor A, B, C, D, and E) on this paper can be expressed using Eq. (4a) and (4b):

$$\begin{aligned} Ra\ all &= 6.837 + 0.168\,A - 0.174\,B - 0.213\,C - 0.072\,D - 0.004\,E - 0.0277\,A{*}A + 0.0570\,B{*}B + 0.0444\,C{*}C \\ &\quad + 0.0770\,D{*}D - 0.0133\,E{*}E - 0.0181\,A{*}E - 0.0161\,B{*}E + 0.0226\,C{*}E - 0.0925\,D{*}E \qquad (4a) \end{aligned}$$

$$\begin{aligned} T\ \ all &= 20.030 - 4.0225\,A - 0.1512\,B - 1.8377\,C - 7.2750\,D - 0.0593\,E + 1.2002\,A{*}A - 0.0025\,B{*}B \\ &\quad + 0.3002\,C{*}C + 1.2537\,D{*}D + 0.0120\,E{*}E - 0.0069\,A{*}E + 0.0042\,C{*}E + 0.0076\,D{*}E \qquad (4b) \end{aligned}$$

With correlation square (R^2 = 91.67% for *Ra*) and (R^2 = 99.98% for *Ta*)

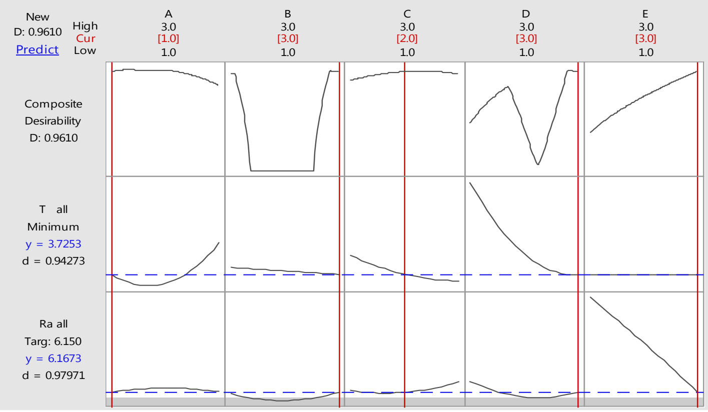

Fig. 3. Response optimization plot for *Ra* and *Ta*

3.5. Optimization using desirability function analysis

In this approach, the measured response properties can be transferred into a dimensionless desirability value (*dF*) [14]. If *dF* equals to 1 or closes to 1, then the response value is perfect of the target value. The desirability function is shown in Fig. 3. The optimal value of *Ra* = 6.15 μm and *Ta* = 3.725 hour while the desirability value is 0.961 or 96.10% that value is close to 1.000. Consequently, the response is considered to be a perfect of the target value.

4. Conclusion

This present research demonstrated the CAD designing of ISO-diabetes and combination method of Taguchi and RSM for determining the optimal setting parameters in CNC milling. In this machining of EVA rubber foam, the minimum value *Ra* = 6.15 μm and *Ta* = 3.725 hour were obtained at the different combinations of cutting conditions. The confirmation tests for Taguchi's optimum value indicated that this experimental result is reliable. Based on the optimization *Ra* and the *dF* RSM methods, the optimal parameters of ISO-diabetes were found as follows. The optimum parameter (A) at the level 1, the spindle speed factor (B) at the level 3 (14500 rpm), the feeding factor (C) at the level 2 (900 mm/rot), the step over control factor (D) at the level 3 (0.2 mm), and number flute at level 3 (4 flute). The optimum surface roughness *Ra* = 6.15 μm and Machining Time (*Ta* = 3.725 hour) with dF = .96 were obtained.

References

[1] M.C. Hodge, T.M. Bach, G.M. Carter , Clin. Biomech. 14 (1999) 567-578.
[2] U. Luigi, G. Claudia, The Diabetic Foot, second ed.,Totowa, New Jerseay, 2006.
[3] E. Piperi, L.M. Galantucci, J.E. Kaçani, E. Shehi, T. Spahiu, From 3D foot scans to footwear designing & production (on Research Gate), 2014.
[4] P.W. Anggoro, B. Bawono, A. Wijayanto, J. Jamari, A.P. Bayuseno, IJMME, 06 (2016) 96-104.
[5] P.W. Anggoro, B. Bawono, I. Sujatmiko, Procedia Manuf. 4 (2015) 521-527.
[6] P.W. Anggoro, B. Bawono, J. Wibowo, J. Jamari, A.P. Bayuseno, Adv. Sci. Lett. 23 (2017) 11910–11917.
[7] P.W. Anggoro, B. Bawono, J. Jamari, A. P. Bayuseno, CAD of Insole Shoe Orthotic and Manufactured in CNC Milling using Design of Experiments for Optimum Surface Roughness, 2018 (under review for J. Eng. Sci. Technol.)
[8] P.W. Anggoro., M. Tauviqirrahma, J. Jamari, A.P. Bayuseno, B. Bawono, M.M. Avellina,, Cogent Eng. 5 (2018) 1470916.
[9] P.W. Anggoro, E. Saputra, M. Taufiqirrahman, J. Jamari, A. P. Bayuseno, IJAERD, 12 (2018) 5254-5260.
[10] C.Octavian, S. Yavuz, H .Selman, Customized Foot Orthosis Manufactured with 3D Printers (on Research Gate), 2012.
[11] C. Octavian, Int. Conf. on manufacturing systems, 4 (2011) 58-65.
[12] D. Fratila, C. Caizar, Mat. Manufact. The process, 27 (2012) 1123-1128.
[13] X. Ye, H. Liu, L. Chen, Z. Chen, X. Pan, S. Zhang, Comput. Aided Design, 40 (2008) 812-827.
[14] X.Z. Ye, W. Peng, Z.Y. Chen, Y.Y. Cai, Comput. Aided Design, 36 (2004) 1451–60.
[15] Z. Xia, Int. J. Multimed. Ubiquitous Eng. 9 (2014) 343-354.