International Journal of New Technology and Research (IJNTR)
ISSN: 2454-4116, Volume-6, Issue-9, September 2020 Pages 18-23

Optimizing EDM Parameters Using AISI M2 Steel by Application of FFD

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***Abstract*— Electric Discharge Machining (EDM) is an alternative machining process to traditional machining process for the precise machining of complex shaped electrically conductive machine parts. The main objective of this research work is to study the impact of EDM conditions (Ton, Toff, Ip, Sv) on MRR, TWR, ROC during machining of AISI M2 steel using FFD. There after ANOVA is applied to find out the percentage contribution of the process variables. It has been found that the Ip is the most effecting variable on multiple responses.**

***Index Terms*—EDM, MRR, TWR, ROC, FFD, ANOVA.**

I. Introduction

Electric Discharge Machining (EDM) is an alternative machining process to traditional machining process for the precise machining of complex shaped electrically conductive machine parts. Now days, due to global competitiveness, manufacturing industries are more concerned about the quality of their products. During EDM machining, the machining conditions play important role. The quality of machined part depends on the proper selection of the EDM conditions . Therefore, for the desired EDM output, judicious selection of the machining condition requires. Therefore, many researchers have applied different techniques for the optimization of EDM conditions for minimum surface roughness during EDM machining of different materials.

Kumar and Kumar [1] employed Taguchi methodology to study the impact of EDM conditions on MRR at the time of machining of mild steel using copper tool. The Ip was found main affecting condition that influence the MRR followed by P_{on}, P_{off} and V .Dhakad and Vimal [2] utilized principal component analysis to optimize the WEDM conditions For MRR, machining time and gap voltage during the machining of 45A Alloy Steel. Among the all WEDM parameters, the open voltage was identified as main influencing parameter. Moghaddam and Kolahan [3] employed Taguchi methodology to examine the impact of EDM parameters on MRR, TW and SR during the EDM machining of AISI2312 steel. The I_p was most significant parameter that affects the MRR while P_{on} found most significant parameter for SR and TW. Vikash et al. [4]made a comparison between two sets of the values of MRR to examine the impact of carbon during the EDM machining of EN19 and EN41steels. The current was found most significant EDM parameter that affects MRR for both materials.

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From the review of literature, it is clear that number of research was done to optimize the EDM conditions for desired responses. Some researchers made efforts to examine the impact of EDM conditions on the various responses. Very less effort was made to investigate AISI M2 steel using Factorial Design Approach.

II. RESEARCH METHODOLOGY

FFD is applied for DOE (Designof Experiment) [5] it allows experiments to have more than one independent variable. Each level of each variable is combined with each level of every other variable. Factorial designs provide information about the effect of each factor on its own, called the main effects. The effect of each combination of factors, called the interaction effect.An interaction between factors occurs whenever two factors, acting together, produce mean differences that are not explained by the main effects of the two factors. In present work total 16 sets of experiments are generated.

1) MRR is calculated using below equation [6];
MRR=(Wt.BeforeMachining-Wt.AfterMachining)÷ Time
2) TWR is calculate using below equation
TWR=(Wt.BeforeMachining-Wt.AfterMachining)÷ Time
3) ROC is calculated using below equation [7];
ROC=(Inner Dia. Of workpiece – Outer Dia. Of Tool)÷2

III. Experimentation

In this study, Ton (PulseOnTime), Toff (PulseOffTime), Sv (Servovoltage), Ip(Current), were selected [8]. The range of EDM machining conditions i.e maximum and minimum values were selected by considering several factors like type of material, type of electrode, range given in the published literature and according to machine specification [9]. The table 1 represents the selected range and levels of. The brass electrode of diameter 9.7 mm was used for EDM machining of work piece. Parafin Oil is used as dielectric for experimentation. For the all experiments CNC based EDM machine manufactured by Electronica India limited was used. 16 electrodes (brass) are fabricated before experimentation.

Table 1 Parameter Details

Factors/	Low	High
Ton (μsec)	100	150
Toff(μsec)	22	26
Ip (A)	20	30
Sv (V)	60	70

Figure 1 Workpiece After Machining

Table 2 Results

S.no	Ton	Toff	Ip	Sv	MRR(gm/min)	TWR(gm/min)	ROC(mm)
1.	100	26	30	70	0.19392	0.00963	0.109
2.	150	22	30	70	0.22195	0.02089	0.15
3.	100	26	20	70	0.17284	0.00216	0.037
4.	150	26	30	60	0.21067	0.01046	0.116
5.	100	26	30	60	0.19989	0.02164	0.137
6.	150	22	20	70	0.20154	0.00536	0.133
7.	150	26	20	70	0.19003	0.00051	0.103
8.	100	22	20	70	0.19946	0.00048	0.112
9.	150	26	20	60	0.20627	0.01353	0.128
10.	100	26	20	60	0.18731	0.00746	0.112
11.	100	22	20	60	0.19486	0.00132	0.099
12.	150	26	30	70	0.21397	0.015	0.138
13.	100	22	30	70	0.21399	0.01569	0.137
14.	150	22	20	60	0.2078	0.01936	0.14
15.	150	22	30	60	0.21786	0.03659	0.14
16.	100	22	30	60	0.22698	0.02899	0.135

IV. RESULTS

A. MRR

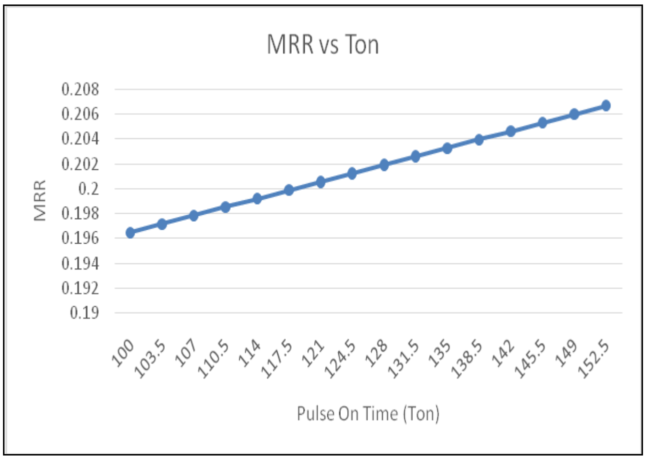

Figure 2 MRR vs Ton

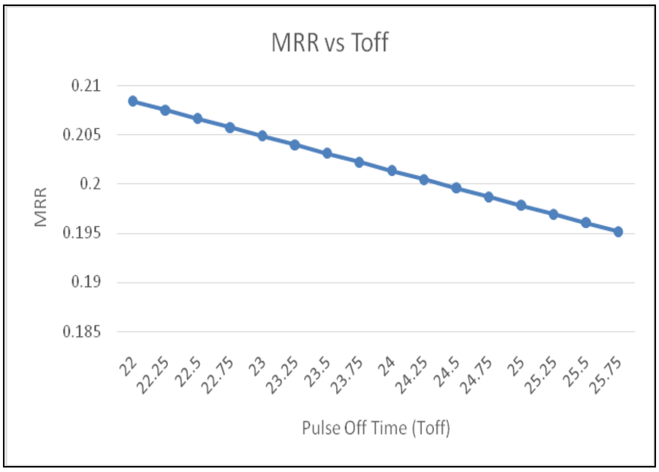

Figure 3 MRR vs Toff

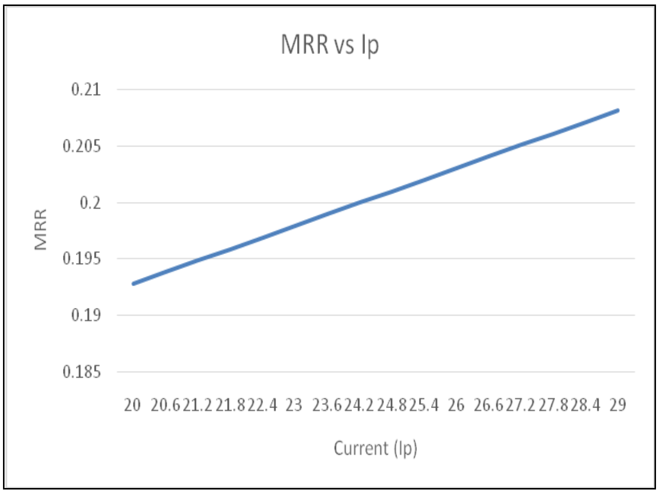

Figure 4 MRR vs Ip

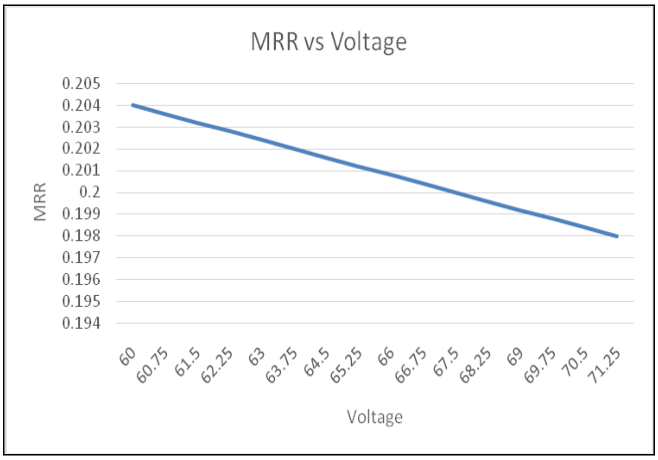

Figure 5 MRR vs Sv

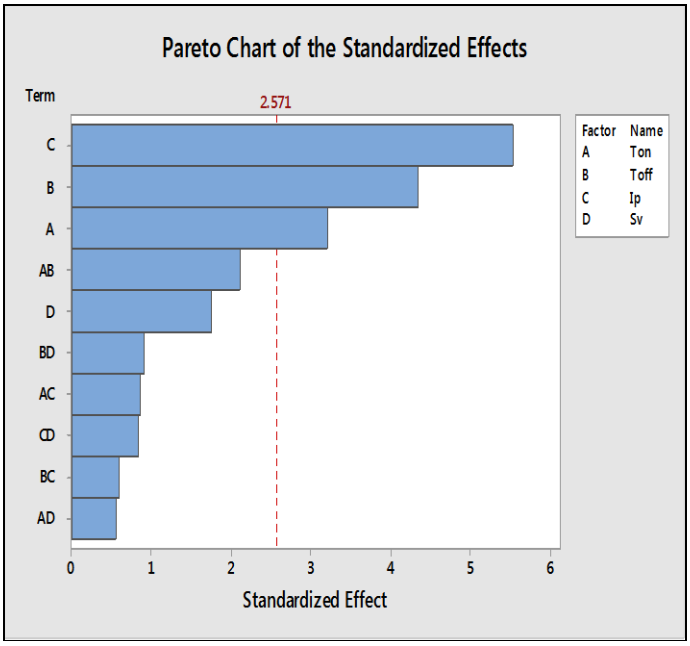

Figure 6 Effects Plot for MRR

Table 3 ANOVA for MRR

Source	% Contri.	Adj SS	Adj MS	F-Val	P-Val
Model	93.35%	0.00278	0.000278	7.02	0.022
Linear	83.58%	0.002489	0.000622	15.71	0.005
Ton	13.72%	0.000408	0.000408	10.31	0.024
Toff	25.19%	0.00075	0.00075	18.93	0.007
Ip	40.62%	0.00121	0.00121	30.53	0.003
Sv	4.05%	0.000121	0.000121	3.05	0.141
2-Way	9.77%	0.000291	0.000048	1.22	0.422
Ton*Toff	5.92%	0.000176	0.000176	4.45	0.089
Ton*Ip	0.97%	0.000029	0.000029	0.73	0.432
Ton*Sv	0.40%	0.000012	0.000012	0.3	0.609
Toff*Ip	0.48%	0.000014	0.000014	0.36	0.574
Toff*Sv	1.09%	0.000033	0.000033	0.82	0.406
Ip*Sv	0.91%	0.000027	0.000027	0.68	0.446
Error	6.65%	0.000198	0.00004		
Total	100.00%				

B. TWR

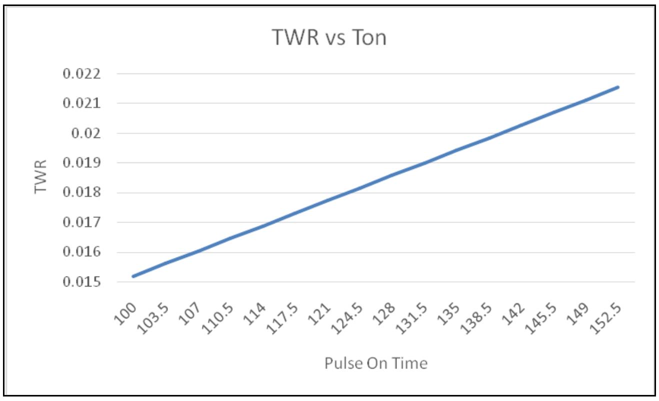

Figure 7 TWR vs Ton

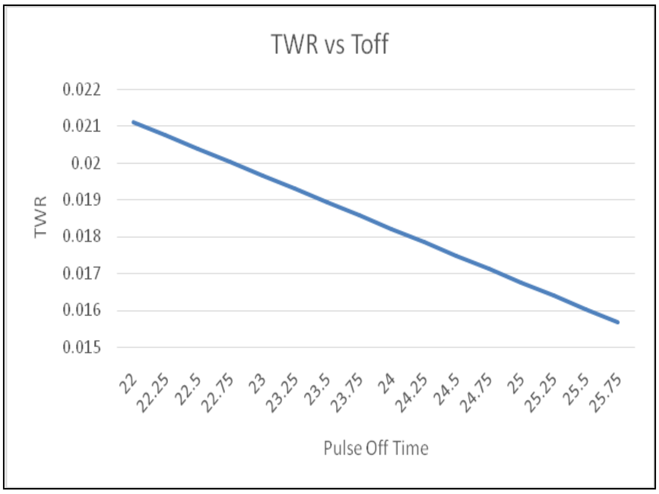

Figure 8 TWR vs Toff

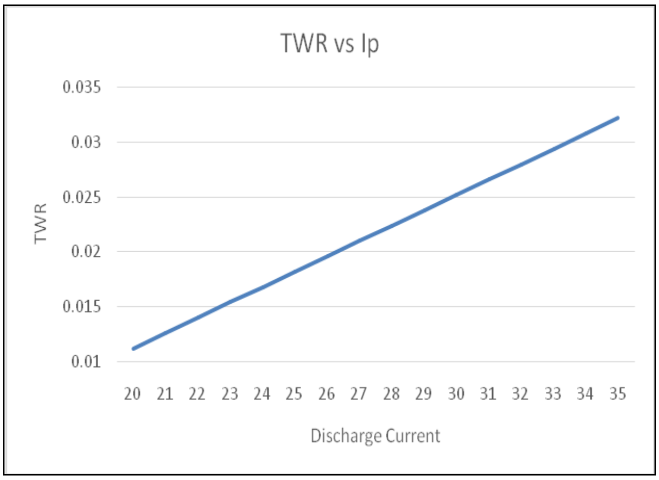

Figure 9 TWR vs Ip

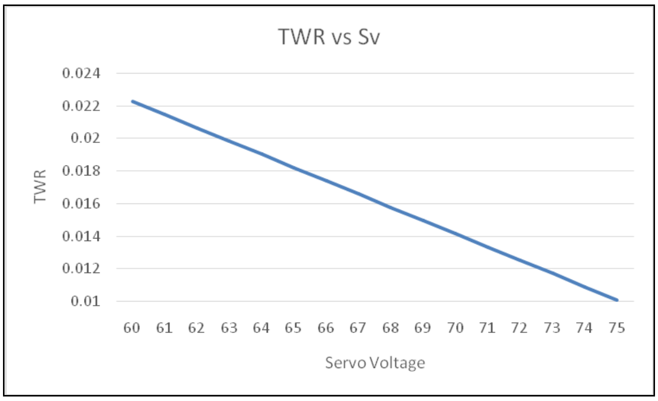

Figure 10 Figure 11 TWR vs Sv

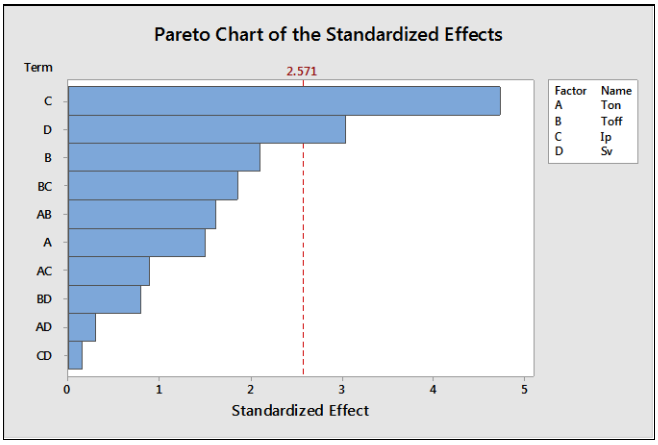

Figure 12 Effects Plot for TWR

Table 4 ANOVA for TWR

Source	%Contri	Adj SS	Adj MS	F-Val	P-Val
Model	90.18%	0.00151	0.000151	4.59	0.053
Linear	75.31%	0.001261	0.000315	9.59	0.015
Ton	4.40%	0.000074	0.000074	2.24	0.195
Toff	8.70%	0.000146	0.000146	4.43	0.089
Ip	44.11%	0.000739	0.000739	22.47	0.005
Sv	18.10%	0.000303	0.000303	9.22	0.029
2-Way	14.88%	0.000249	0.000042	1.26	0.408
Ton*Toff	5.14%	0.000086	0.000086	2.62	0.167
Ton*Ip	1.55%	0.000026	0.000026	0.79	0.416
Ton*Sv	0.17%	0.000003	0.000003	0.09	0.781
Toff*Ip	6.76%	0.000113	0.000113	3.45	0.123
Toff*Sv	1.22%	0.00002	0.00002	0.62	0.467
Ip*Sv	0.04%	0.000001	0.000001	0.02	0.891
Error	9.82%	0.000164	0.000033		
Total	100.00%				

C. ROC

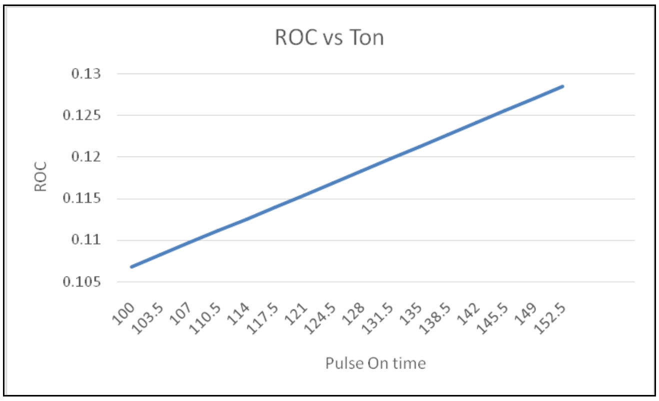

Figure 13 ROC vs Ton

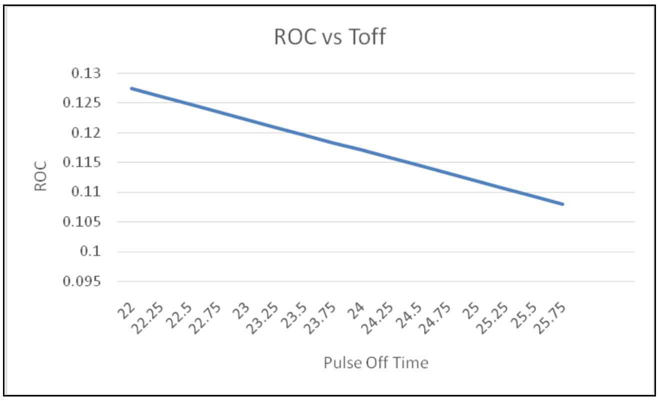

Figure 14 ROC vs Toff

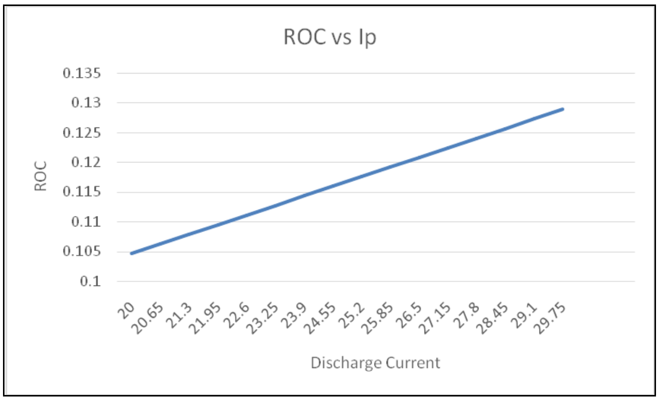

Figure 15 ROC vs Ip

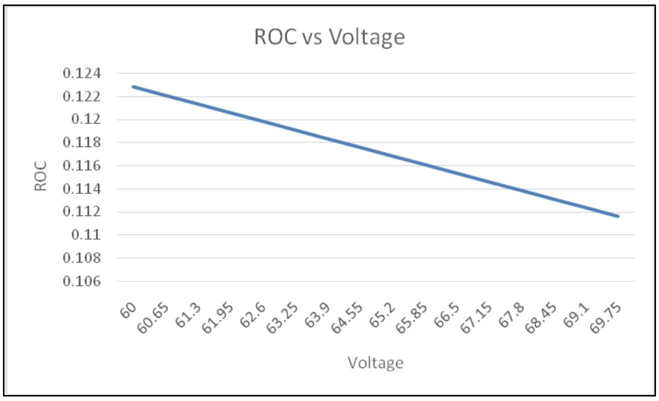

Figure 16 ROC vs Sv

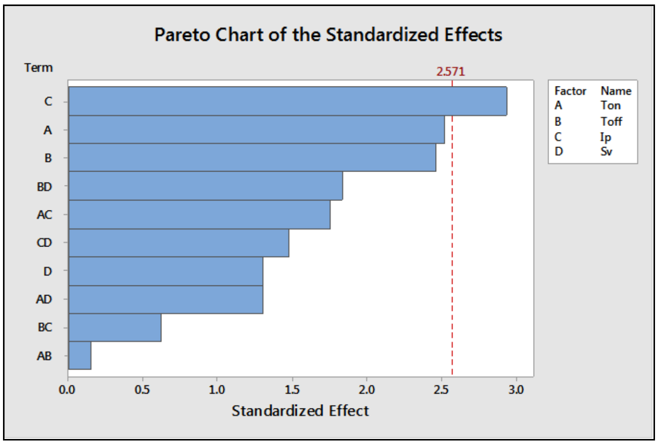

Figure 17 Effects Plot for ROC

Table 5 ANOVA for ROC

Source	%Contri.	Adj SS	Adj MS	F-Value	P-Value
Model	87.00%	0.00952	0.000952	3.35	0.097
Linear	59.07%	0.006463	0.001616	5.68	0.042
Ton	16.51%	0.001806	0.001806	6.35	0.053
Toff	15.74%	0.001722	0.001722	6.05	0.057
Ip	22.39%	0.00245	0.00245	8.61	0.032
Sv	4.42%	0.000484	0.000484	1.7	0.249
2-Way	27.94%	0.003057	0.000509	1.79	0.27
Ton*Toff	0.06%	0.000006	0.000006	0.02	0.888
Ton*Ip	7.95%	0.00087	0.00087	3.06	0.141
Ton*Sv	4.42%	0.000484	0.000484	1.7	0.249
Toff*Ip	1.01%	0.00011	0.00011	0.39	0.561
Toff*Sv	8.78%	0.000961	0.000961	3.38	0.125
Ip*Sv	5.71%	0.000625	0.000625	2.2	0.198
Error	13.00%	0.001422	0.000284		
Total	100.00%				

It is observed from the plots that increase Ip and Ton produce high MRR, TWR, ROC. This is due to the fact that when the pulse current increase along with Pulse on time (Ton), more intensely discharges to strike the surfaces and a great quantity of material is removed. For Toff the response decreases as mainly due to reduced spark discharge time. Similarly for Sv responses decreases due to enlargement of sparking gap when the gap voltage increases

V. CONCLUSION

This study is focus on the examination of the impact of EDM basic parameters MRR, TWR, ROC during the machining AISI M2 steel using FFD. Percentage contribution was determined with the help of ANOVA. The conclusions of this experimental optimization work are summarized as follows:

- For MRR R^2 93.35% and R^2 (adj) 80.04%.
- For TWR R^2 90.18% and R^2 (adj) 70.55%.

- For ROC $R^2$87.00% and R^2 (adj) 61.00%.
- The result of ANOVA & Pareto Chart shows affect of Ip is more, than other input parameters for all responses.

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