International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 08 Issue: 09 | Sept - 2024 SJIF Rating: 8.448 ISSN: 2582-3930

Impact of Robot Programming Methods on Servo Drive Temperature

Dr. B.Saravanan[1]

[1]Department of Mechanical Engineering & VSVN Polytechnic College

---

Abstract - There are various motion commands used for programming ABB Industrial Robot & each command is used for a specific application. Also, there are various parameters in the motion command such as Velocity & Zone Error. Setting different values normally alters the Robot performance and eventually the servo drive temperature.

This paper has made a case study on the temperature of Servo Drive with respect to the Programming Method. Programming is done using different move commands, Velocity values & Zone Error values to move the Robot End Effector between two fixed locations. The impact of these parameters on the temperature rise of Servo Drive is analyzed. Valid results are arrived using Taguchi L9 Orthogonal array. The optimal results obtained from the Taguchi analysis is checked with the real ABB Robot available at Robotics lab of VSVN Polytechnic College

Key Words: ***ABB Robot RAPID Program – Velocity Data – Zone Error Data – Taguchi L9 Orthogonal Array.***

1. INTRODUCTION

Robots are normally programmed using various programming methods and Languages [1]. The ABB Robot is programmed using RAPID Language. This RAPID language has MoveL, MoveJ & MoveC commands to move the Robot arm to perform the tasks. MoveL command moves the Robot Arm along a straight line while MoveJ command moves the Robot Arm along the joint. The MoveC command is used to move the Robot arm along a curve. The MoveL & MoveC commands with higher Velocity & lesser error Zone induces more Heat than the MoveJ command with lower Velocity & higher error Zone.

The study is performed using various velocities & Error Zone values and its impact on the motion time & temperature of servo drive is recorded. The optimal parameter that completes the task in a shorter time with less heat generation and prevents the chance for maintenance is suggested in this paper.

2. THE EXPERIMENT

The analysis done in this paper is a Move command from Position P10 to Position P20 is done using various Move types (MoveL, MoveC, MoveJ), various Velocity data (V100, V1000, V2000) and various Zone error data (Z0, Z50, Z100). The program coding is shown as Fig1 below.

Robots are normally programmed using various programming methods and Languages [1]. The ABB Robot is programmed using RAPID Language. This language has motion command, sensor command and end effector command. Under motion command, there are MoveL, MoveC and MoveJ options. The analysis done in this paper is a Move command from Position P10 to Position P20 is done using various Move types (MoveL, MoveC, MoveJ), various Velocity data (V100, V1000, V2000) and various Zone error data (Z0, Z50, Z100). The program coding is shown as Fig1 below.

```
MODULE Module1
    PROC main()
        MoveJ *, v1000, z50, tool0;
        FOR I FROM 1 TO 10 DO
          MoveJ P10, v1000, z50, tool0;
          MoveL P20, v1000, z50, tool0;
          MoveJ *, V1000, Z50, tool0;
        ENDFOR
        Stop;
    ENDPROC
ENDMODULE
```

Fig 1. Robot Program Code used for Analysis

The criteria varied are as shown in Table1, Table2 and Table3 below.

Table 1

Criteria 1

Velocity Data	Column1
V100	1
V1000	2
V2000	3

Table 2

Criteria 2

Zone Error Data	Column2
Z100	1
Z50	2
Z0	3

Table 3

Criteria 3

Move Types	Column3
MoveJ	1
MoveL	2
MoveC	3

The impact of these variations on the Temperature raise of Servo Drives and the Time for completion are measured. There are 3 criteria with 3 levels. Hence a full factorial experimental design would consist of 3 x 3 x 3 = 27 trials. But in this paper Taguchi L9 experimental design with 9 trials is employed.

3. FLOW CHART

The experiment process can be easily understood if explained through flow chart. Fig 2 Hence the process followed by varying the program parameters (as per Taguchi L9 Array) and the results obtained are explained clearly using the Process Flow Chart. The optimal values (i.e. Minimal Value) is worked out using MRPI Method.

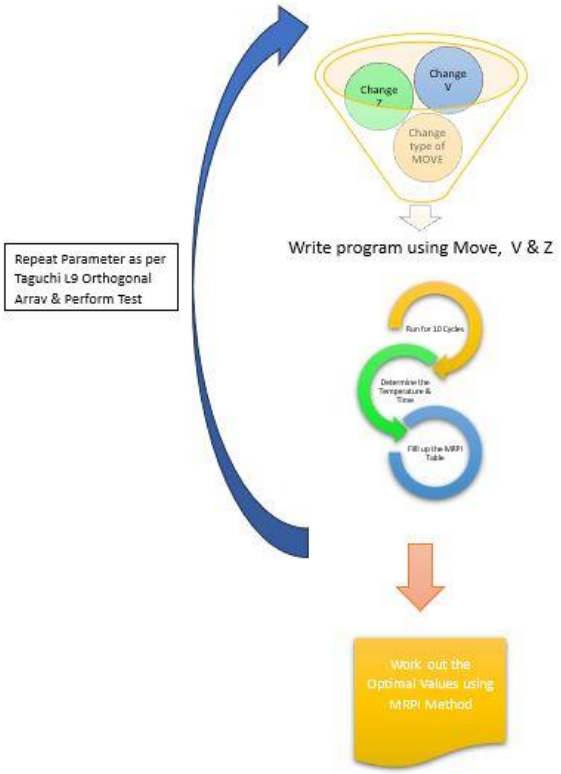

Fig 2. Flow Diagram explaining the Process

The above flow is repeated for 9 times by changing the parameters as per Taguchi L9 Orthogonal array.

4. ANALYSIS

The parameter analysis in Robot can be done using minimum variance model [2]. In this study the analysis and the changes in parameters are done using Taguchi L9 orthogonal array. Taguchi L9 orthogonal array with 9 rows with various parameter and criteria levels are shown in Table 4 below.

Table 4

Trial No	Criteria		
	1	2	3
1	1	1	1
2	1	2	2
3	1	3	3
4	2	1	2
5	2	2	3
6	2	3	1
7	3	1	3
8	3	2	1
9	3	3	2

On substituting the various data from Table 1 to 3 for the Column values, we obtain Table 5 below.

Table 5

Trial No	Criteria		
	1	2	3
1	V100	Z100	MoveJ
2	V100	Z50	MoveL
3	V100	Z0	MoveC
4	V1000	Z100	MoveL
5	V1000	Z50	MoveC
6	V1000	Z0	MoveJ
7	V2000	Z100	MoveC
8	V2000	Z50	MoveJ
9	V2000	Z0	MoveL

The actual analysis is done for these set of 9 trials alone on the Robot and the Time for completion of 10 cycles and the Temperature of the Main Servo Drive were noted for each set of Criteria. The results obtained through the Analysis is shown in Table 6 below.

Table 6

Trial No	Criteria			Output	
	1	2	3	Temp	Time
1	V100	Z100	MoveJ	27	1700
2	V100	Z50	MoveL	30	1800
3	V100	Z0	MoveC	33	1900
4	V1000	Z100	MoveL	36	850
5	V1000	Z50	MoveC	37	950
6	V1000	Z0	MoveJ	34	900
7	V2000	Z100	MoveC	41	500
8	V2000	Z50	MoveJ	38	450
9	V2000	Z0	MoveL	41	550

From the above data, the responses of varying the Velocity, Zone error & Move type on Temperature and Time is analyzed using MRPI method. The details of calculations are exhibited in Table 7 and Table 8

Table 7

Trial No	Temp	1/Temp	W Temp	Time	1/ Time	W Time	MRPI
1	27	0.04	0.15	1700	0.0006	0.05	89.05
2	30	0.03	0.12	1800	0.0006	0.05	93.6
3	33	0.03	0.12	1900	0.0005	0.05	98.96
4	36	0.03	0.12	850	0.0012	0.11	97.82
5	37	0.03	0.12	950	0.0011	0.1	99.44
6	34	0.03	0.12	900	0.0011	0.1	94.08
7	41	0.02	0.08	500	0.002	0.18	93.28
8	38	0.03	0.12	450	0.0022	0.2	94.56
9	41	0.02	0.08	550	0.0018	0.16	91.28
		0.26			0.0111		

The weighted MRPI for each trial is shown in the above table. The impact of each criterion is worked out by adding the respective MRPI's. As both the Temperature of servo drive and the Time taken to complete the task by Robot has to be minimized, the added MRPI with least value should be selected.

The least values are highlighted in Table 8 below.

Table 8

Factors	Level		
	1	2	3
Velocity Data	281.61	291.34	**279.12**
Zone Error Data	**280.15**	287.6	284.32
Move Type	**277.69**	282.7	291.68

5. INFERENCE

From Table 8, it is clear that for Move Type 1 & Zone Error 1, we get a minimal Temperature rise.

That is for MoveJ and Z100 the Temperature of servo drive is less. This is because MoveJ moves only one Joint and hence Servo drive would not be loaded heavy. Further a higher Zone error provides less constraints for Servo drive and this reduces the heat generated in Servo Drive [3].

Further as the rise in Velocity data reduces the Robot operation Time, a higher-level Velocity 3 gives a minimum Time.

So, it is clear that the while programming, using MoveJ commands with higher Z value leads to less heat generation in Servo Drives and the Temperature is lesser. Also, it is evident that, the MoveL can be used only when the Robot path needs to be along a straight line and MoveC can be used only when the Robot path needs to be along a circle.

Further the result obtained through MRPI method is confirmed by providing Robot with MoveJ command with Z100 and Velocity 2000. This option consumes very less time & the temperature rise is also less.

Acknowledgment

The author wishes to convey his sincere thanks to the Management of VSVN Polytechnic College for constantly encouraging and motivated the staff members to present their research works in papers & conference. The author wishes to express his gratitude to the La assistants of VSVN, who have rendered all supports for the performance of the study.

References

[1] Geoffrey Biggs & Bruce MacDonald, "A Survey of Robot Programming Systems", University of Auckland, pp. 1 – 10, 2003

[2] Gavin Simmons and Yiannis Demiris, "Optimal Robot Arm Control using the minimum Variance Model" Journal of Robotics System, vol. 22, pp. 677 - 690, 2005.

[3] Richard H.Welch Jr, George W. Younkin, "How Temperature Raise affects a Servo Motor's Electrical and Mechanical Time Constants", IEEE Transaction.

[4] Sethuramalingam, Prabhu, et al. "Performance analysis of accuracy and repeatability of IRB1410 industrial robot using taguchi analysis with machine learning approach." *International Journal on Interactive Design and Manufacturing (IJIDeM)* 17.4 (2023): 1807-1821.

[5] Bhalamurugan, R., and S. Prabhu. "Performance characteristic analysis of automated robot spray painting using Taguchi method and gray relational analysis." *Arabian Journal for Science and Engineering* 40 (2015): 1657-1667.

[6] Dar, A., & Anuradha, N. (2018). Use of orthogonal arrays and design of experiment via Taguchi L9 method in probability of default. *Accounting*, *4*(3), 113-122.

[7] Sabarish, K. V., and Pratheeba Paul. "Optimizing the concrete materials by L9 orthogonal array." *Materials Today: Proceedings* 22 (2020): 460-464.

[8] Mazon, Isabelle, and Rachid Alami. "Representation and propagation of positioning uncertainties through manipulation robot programs-integration into a task-level programming system." *1989 IEEE International Conference on Robotics and Automation*. IEEE Computer Society, 1989.

[9] Paes, Koen, et al. "Energy efficient trajectories for an industrial ABB robot." *Procedia Cirp* 15 (2014): 105-110.

[10] Nguyen, Toan. "ABB Robot and its own programming language." (2021).

[11] Zhang, Zhijun, and Yunong Zhang. "Variable joint-velocity limits of redundant robot manipulators handled by quadratic programming." *IEEE/ASME Transactions on Mechatronics* 18.2 (2012): 674-686.

[12] Bosga, Sjoerd G., and Marc Segura. "Design and tests of a hybrid servo drive system for a 1000 T mechanical press." *2008 IEEE Power Electronics Specialists Conference*. IEEE, 2008.

[13] Fischer, Kerstin, et al. "A comparison of types of robot control for programming by demonstration." *2016 11th ACM/IEEE International Conference on Human-Robot Interaction (HRI)*. IEEE, 2016.

[14] Bravo, Flor A., Alejandra M. González, and Enrique González. "A review of intuitive robot programming environments for educational purposes." *2017 IEEE 3rd Colombian Conference on Automatic Control (CCAC)*. IEEE, 2017.

[15] Gao, Liming, Jianjun Yuan, and Yingjie Qian. "Torque control based direct teaching for industrial robot considering temperature-load effects on joint friction." *Industrial Robot: the international journal of robotics research and application* 46.5 (2019): 699-710.

BIOGRAPHIES

Dr. B.Saravanan, is working as a Senior Lecturer at V.S.V.N. Polytechnic College, Virudhunagar. He has completed his B.E., and M.E with First Class & Distinction from Thiagarajar College of Engineering Madurai and PhD at Anna University, Chennai.