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Design and analysis of dual arm robot for automatic assembly

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Abstract*—a dual arm robot is one of the most popular issue in the robotic field. Because a dual arm robot has two arms like humans, it can conduct the complex handling task and the jigless assembly task which cannot be performed by a single arm robot. Also, it is expected to substitute for humans and do better performance than humans in the industrial manufacturing. In the paper, we proposed a dual arm robot system with a mobile platform for the automatic assembly of electrical devices and it was developed through kinematic and dynamic analysis. Kinematic analysis was performed for the workspace and dynamic analysis was carried out for the robot specification.

***Index Terms*—Dual arm robot, Dynamic simulation, Workspace analysis, Robot design.**

I. INTRODUCTION

Industrial robots have performed the simple repetitive work and the heavy duty work instead of human. Nowadays, there is a growing need of human-like robot which can do more intelligent and complex work such as the assembly in the manufacturing line. Therefore, a dual arm robot becomes one of the most popular issues on the robotic field, because it can conduct the complex handling task and the jigless assembly task like human. There are some researches about the development of a 7 DOF robot arm which has kinematic redundancy to perform the complex task like a human arm.[1]-[6] Also, the design and the control of the dual arm robot have been researched for the service robot.[7] To apply the dual arm robot into the assembly task in the real manufacturing line, kinematic analysis and dynamic analysis which are optimized to the manufacturing environment are necessary. In the paper, we proposed a dual arm robot system with a mobile platform for the automatic assembly of electrical devices. It was developed through kinematic analysis and dynamic analysis. Kinematic analysis was performed for the real workspace for the electric product assembly and dynamic analysis was carried out for the robot specification.

II. WORKSPACE OF DUAL ARM ROBOT

We proposed a dual arm robot system with a mobile platform for the automatic assembly. The objective of the proposed dual arm robot is to assemble electric devices such as mobile phones and televisions. To perform the complex ask instead of humans, it is designed to have the same degree-of-freedom and the similar size. Therefore, each arm of dual arm robot is designed to have 7 DOF and its waist is designed as 3 DOF shown in the Fig.1.

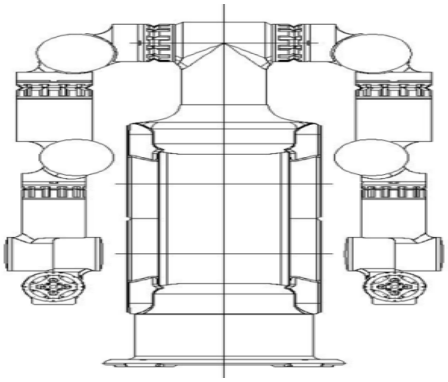

Fig. 1 The proposed dual arm robot

The first step of robot design is to decide robot dimension and configuration for necessary workspace. The objective of the workspace is 500x1000x500mm for the single arm and 500x500x500mm for the dual arm robot. First, we carry out the workspace analysis for the dual arm without waist joins. It varied according to the length of the link and Fig 2 shows the workspace when the length between second axis and sixth axis is about 600mm. The workspace of only dual arms is about 300mm x 300mm x 300mm as shown Fig. 2.

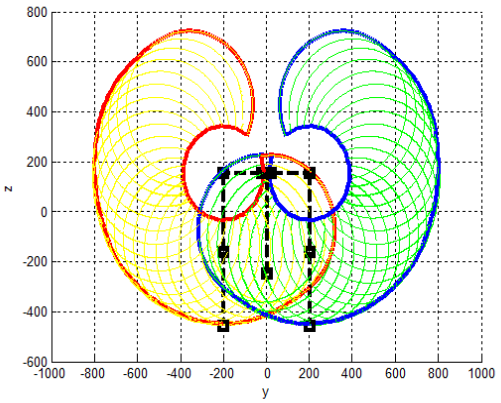

Fig. 2 Workspace analysis of dual arm robot

Therefore, three torso joints including two bending joints and one rotational joint are added for the larger workspace. Workspace for three additional joints is analyzed through the similar method ant its result is represented in Fig.3 and Fig.4. We changed the length parameter of the waist joints to expand the workspace by more than 200x200x200mm. Fig.3 shows that the workspace expands only by lower than 150mm and Fig.4 shows that the workspace expands by more than 200mm for all directions. Finally, the kinematic parameters are determined to satisfy the objective workspace.

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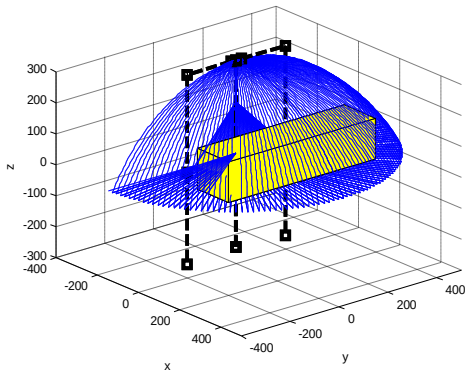


Fig. 3 Workspace analysis of dual arm robot (Length parameter 200mm, 400mm)

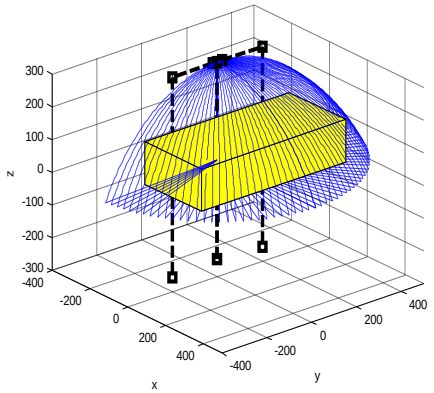


Fig. 4 Workspace analysis of dual arm robot (Length parameter 300mm, 300mm)

III. DYNAMIC SIMULATION

The next step of the robot design is to decide the specification of each actuating modules. We performed the dynamic simulation in the various conditions using Recurdyn which is a kind of commercial dynamic simulator. The robot moved at its maximum velocity without and with the payload. The simulation was carried out at the almost posture of the robot for each joint and acceleration was changed from 0.2sec to 0.6sec. Figure 6 shows an example of the result and table 1 and table 2 show the dynamic simulation result.

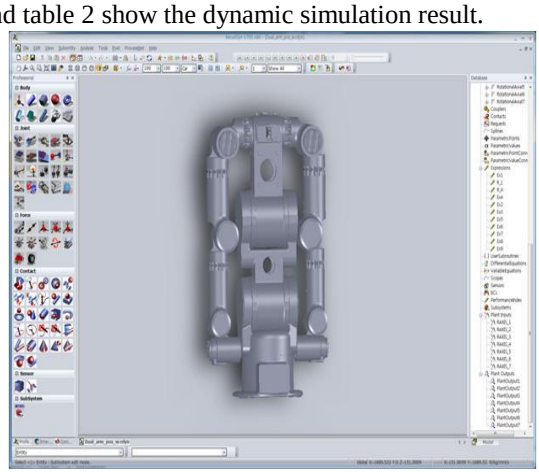
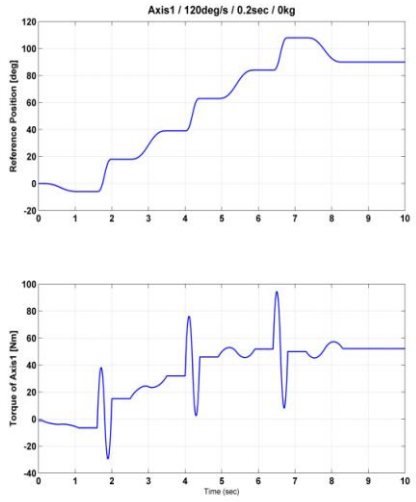
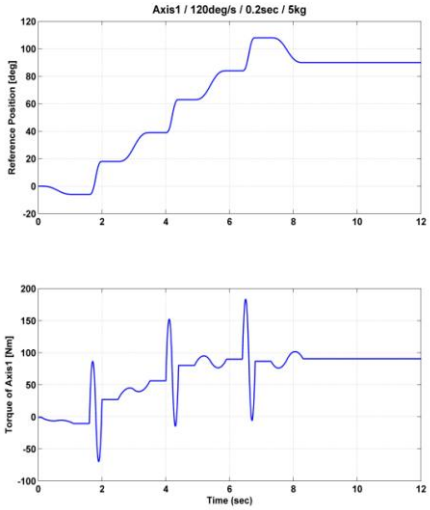


Fig. 5 Dynamic simulation with Recurdyn



(a) Acceleration time 0.2sec, no payload



(b) Acceleration time 0.2sec, payload 5kg

Fig. 6 Dynamic simulation result

Table 1 Maximum dynamic torque (no load)

		Dynamic torque (Nm)	
	Acc./Dec. time(sec)	0°	90°
		0kg	0kg
Joint 1	0.2	38.12	94.46
	0.4	15.53	72.86
	0.6	15.09	65.34
Joint 4	0.2	4.92	24.58
	0.4	1.42	20.36
	0.6	-0.90	18.91
Joint 6	0.2	0.40	1.90
	0.4	0.28	1.74
	0.6	0.14	1.68
Joint 7	0.2	-0.02	0.02
	0.4	-0.02	0.02
	0.6	-0.02	0.02

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Table 2 Maximum dynamic torque (payload 5kg)

		Dynamic torque (Nm)	
	Acc./Dec. time(sec)	0°	90°
		5kg	5kg
Joint 1	0.2	86.58	183.50
	0.4	36.54	136.28
	0.6	27.49	119.94
Joint 4	0.2	19.66	64.77
	0.4	6.51	51.52
	0.6	1.35	46.89
Joint 6	0.2	2.78	13.98
	0.4	2.40	12.33
	0.6	0.37	11.76
Joint 7	0.2	0.62	5.48
	0.4	0.15	5.05
	0.6	-0.10	4.91

The additional dynamic simulation was carried out as Fig. 7. The proposed dual arm robot is adopted on the mobile platform. Therefore, it has to keep the balance of the mobile platform when it moves at the high acceleration. The dual arm robot can be successfully attached on the mobile robot through the balance simulation.

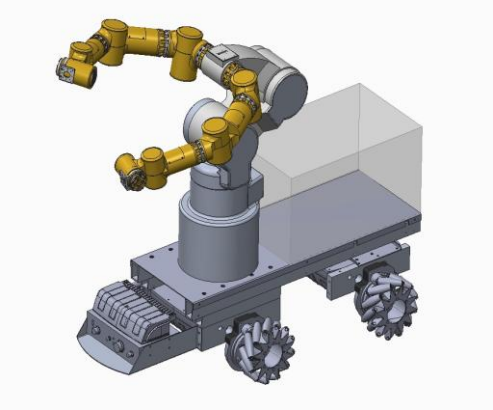

Fig. 7 Dynamic simulation with mobile platform

IV. CONCLUSION

Fig. 8 Dual arm robot with the mobile platform

In this paper, we proposed a dual arm robot system with a mobile platform for the automatic assembly of electrical devices and it was developed through kinematic and dynamic analysis as Fig. 8. Kinematic analysis was performed for the workspace and dynamic analysis was carried out for the robot specification. In the future, we will research the control technology about the automatic assembly using the developed robot to apply it into the industrial manufacturing.

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AUTHOR'S PROFILE

Dong Il Park received a BS degree in Mechanical Engineering from Korea Advanced Institute of Science and Technology (KAIST) in 2000, a MS degree in Mechanical Engineering from KAIST in 2002 and a PhD degree from KAIST in 2006. He has been researching the robotics in Korea Institute of Machinery and Materials (KIMM) since 2006. His research fields are the design, control and application of robot manipulators and mobile robots.