Research on Laboratory Safety Management and Teaching in Applied Universities -- An Example of Industrial Robot Laboratory

Xiang Li[1*], Yaping Lu[2]

[1]*Applied Technology College of Soochow University, Suzhou, Jiangsu, 215325,China*
[2]*Applied Technology College of Soochow University, Suzhou, Jiangsu, 215325,China*
[*]*Corresponding author's e-mail: 271591635 @qq.com*

Abstract.
At present, the use of industrial robots has become a powerful means for the transformation and upgrading of China's manufacturing industry, realizing the " robot employment ". With the improvement of production efficiency, it brings frequent safety accidents, and the industrial robot laboratory in applied universities can not be avoided. Therefore, the safety management of industrial robot laboratory in applied universities and the research on the safety teaching content of industrial robot are of great significance. This study carries out safety management construction from three aspects: safety equipment, safety devices and safety management regulations of industrial robots, and carries out safety teaching for practitioners from five ways: emergency braking way, speed increment control, safety path planning, J and L instructions, CNT and FINE mode of industrial robots.

Keywords: *safety management, safety teaching, industrial robot*

1 INTRODUCTION

At present, China is in an important period of accelerating transformation and upgrading. Industrial robots have become irreplaceable important equipment and means in advanced manufacturing industry. With the wide application of industrial robots, their safety problems are becoming more and more prominent. Due to its high flexibility, wide range of motion, fast speed, large load and strong rigidity, the robot is likely to cause serious safety accidents when an abnormal situation occurs.

Applied Universities laboratories are also places where accidents occur frequently, and the safety problems of industrial robot laboratories are also particularly prominent. How to improve the safety of industrial robot laboratory construction; how to make the safety management imperceptibly cultivate the professional quality of practitioners, and make practitioners consciously develop the habit of practicing the 5S requirements of the factory environment; how to improve the safety awareness of practitioners in the safety teaching content of industrial robots; how to learn knowledge and improve practical ability in the laboratory, at the same time, it also enables practitioners to keep in mind the experimental safety knowledge, improve safety awareness, and prevent accidents [1].

While industrial robots liberate people from heavy and dangerous labor, there are also dangerous factors. Due to the frequent occurrence of personal injury accidents caused by industrial robots, industrial robot laboratories in Applied Universities cannot be avoided. It is necessary to study the safety issues of industrial robots, strengthen safety management, and improve prevention awareness. According to statistics and analysis of industrial robot accidents, the root causes of safety problems are as follows:

(1)The operator's safety education and training is insufficient, they do not participate in safety training or the training quality is not high. The threshold of safety access examination is low.

(2)The safety protection facilities are not perfect, and there are no isolation fence and safety doors. Safety helmets are not worn during work.

(3)The emergency handling capacity is insufficient, and the operator does not master the safe operation skills in emergency.

(4)The operator's awareness of safety risk prevention is weak, and he cannot pay attention to the places with risks, such as: speed increment control, safe path planning, J and L instructions, CNT and FINE, etc.

2 SAFETY MANAGEMENT RESEARCH

In the laboratory construction, the configuration of fire-fighting appliances and safety appliances, laying insulating carpet and insulating traffic trunking, Posting safety warnings, do a good job of safety protection. In laboratory management, the configuration of safety management personnel, repair, inspection, testing work,

B. Fox et al. (Eds.): IC-ICAIE 2022, AHCS 9, pp. 1549-1554, 2023.
https://doi.org/10.2991/978-94-6463-040-4_233

and regular equipment maintenance to ensure good equipment performance. Formulate safety management regulations, formulate safety management accounts, and strengthen emergency plan drills [2].

2.1 *Safety equipment*

Safety equipment are various special tools and equipment to ensure the personal safety of staff, it mainly includes work clothes, safety shoes, safety helmets, goggles, etc. In the industrial robot experiment, due to the problems of very fast movement speed, uncontrollable running direction and wide operation range of industrial robots, in order to ensure the completion of tasks without personal accidents, the laboratory must be equipped with necessary safety equipment, and practitioners must wear safety equipment before operation. As shown in figure 1.

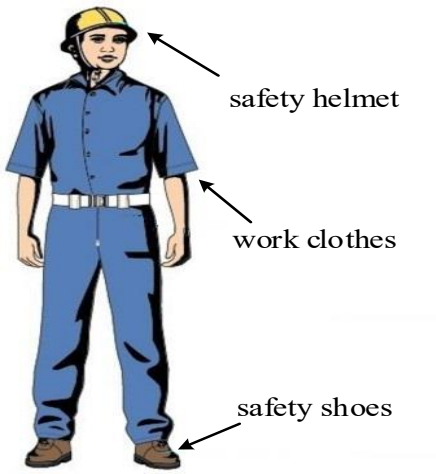


Fig.1 safety equipment

2.2 *Safety devices*

Safety device is an intrinsically safe accessory used on mechanical equipment. Its function is to prevent personal accidents during the normal operation of industrial robots. It mainly includes safety fence, safety door, safety latche and slot. As shown in figure 2. In the initial stage of the construction of the industrial robot laboratory, according to the size of the working space of the industrial robot, a non-safe area is set, and safety fences and safety door locks are set up. If the safety door is not closed, the automatic operation of the robot cannot be started to ensure the safety of the working area. The fence must be permanently fixed in one place and can withstand predictable operation and surrounding impact [3].

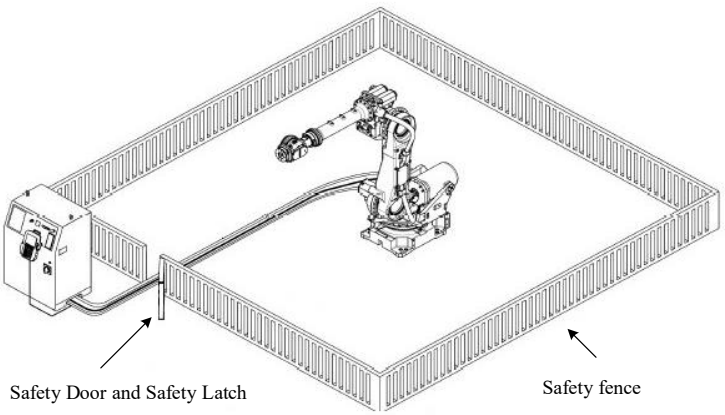


Fig.2 safety devices

2.3 *Safety Management Regulations*

Industrial robot laboratory is a place to provide students with practical training related to robot system knowledge. In order to ensure that students can safely and efficiently complete the learning tasks of practical links, it is necessary to formulate a series of rules, such as safety operation specifications of industrial robots, safety management regulations of industrial robot laboratory, opening management regulations of industrial robot laboratory, etc., which are managed from the system to people. Strengthen safety access examination, pre-job safety training, carry out activities such as safety publicity and popularization into laboratories, and strengthen safety publicity and warning education [4].

3 SAFETY TEACHING RESEARCH

3.1 *Emergency braking method*

The safety education of industrial robot course is the key teaching content, so that students can understand the ways and means of emergency formulation, be familiar with the position of emergency stop button, and master the use of Deadman. Industrial robots provide some emergency braking modes, including teaching pendant emergency stop (1), controller emergency stop (2) and external emergency stop (3), as shown in Figure 3. By understanding the above emergency stop positions and ways, it is convenient for students to make timely judgments and perform emergency stop actions when encountering safety problems [5].

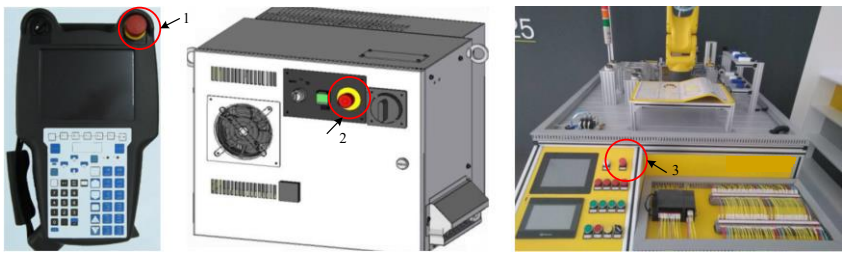


Fig.3 emergency braking

The Deadman switch is equivalent to an "enable device", which can reflect the operator's emotional changes at this time. As shown in Figure 4, the robot can be moved only when the Deadman switch is properly pressed. During practice, students are often unable to grasp the power in their hands because of emotional agitation, unstable mood, and lack of concentration. If they continue to operate the robot in this state, safety problems may occur. Therefore, in the teaching content, students must correctly master the use method of deadman in order to avoid the occurrence of safety problems.

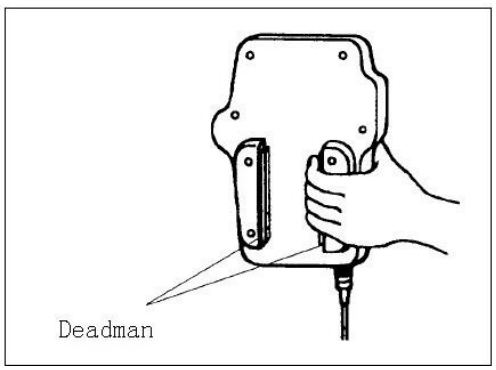


Fig.4 Deadman

3.2 *Speed increment control*

Speed increment control is one of the main factors that cause safety problems. When teaching robots, it is often necessary to continuously adjust the speed ratio of the robot. However, students who are not proficient in the rocker of the teaching device often collide or get stuck due to too fast speed and too large increment, and in serious cases, there will be device damage or personnel safety. Therefore, in the safety teaching, it is necessary to focus on the influence of speed magnification key +%, -% on movement speed, so that students can master the operation skills of " first rough adjust the approach, and then fine tune the fit ". As shown in Figure 5.

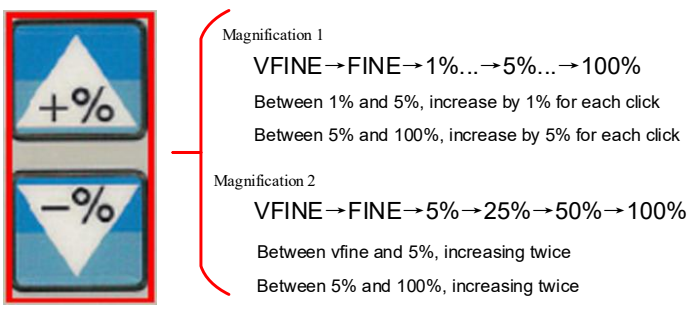
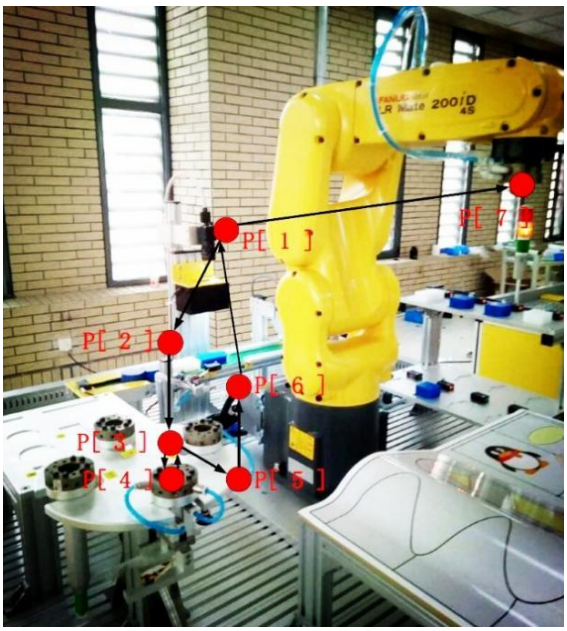


Fig.5 speed magnification

3.3 *Safe path planning*

Before formal programming, it is necessary to plan the walking path of the industrial robot manipulator. A good walking path can effectively avoid danger and improve work safety. As shown in Figure 6, the planned route is the trajectory of the robot to replace the tool. The robot moves to the top of the tool holder, moves to the pick-up point, move to grab tool escape point and returns to the HOME position. By setting HOME point P [7], transition point P[1]P[2]P[6], approach point P[3], pick-up point P[4], escape point P[3]P[5], etc., the walking path of the robot arm is planned, and the safety problem of collision is reduced [6].



1: J P[1] 20% FINE; （transition point1）
2: RO[1]=ON;
3: RO[2]=OFF;
4: J P[2] 20% FINE; （transition point2）
5: L P[3] 50mm/sec FINE; （approach point）
6: L P[4] 30mm/sec FINE; （pick-up point）
7: WAIT 0.50(sec);
8: RO[1]=OFF;
9: RO[2]=ON;
10: WAIT 0.50(sec);
11: L P[3] 50mm/sec FINE; （approach point）
12: L P[5] 80mm/sec FINE; （escape point）
13: L P[6] 100mm/sec FINE; （transition point3）
14: J P[1] 20% FINE; （transition point1）
15: J P[7] 20% FINE; （HOME point）
[END]

Fig.6 safe point setting

3.4 *J and L instructions*

The skilled use of J and L commands can effectively avoid the walking collision caused by the misuse of commands. Joint motion J is an arbitrary movement between two target points without trajectory control and posture control; Linear motion L is a linear movement between the two target points, moving in a linear manner. Practitioners do not distinguish between the two instructions when writing programs, and collisions often occur during automatic operation. Especially after using the J instruction, the robot moves in a curve rather than a linear motion, which exceeds the pre-walking posture and causes a collision. As shown in Figure 7. Therefore, in the teaching process of the J and L instructions, we focus on explaining the difference between the two instructions to prevent safety accidents[7].

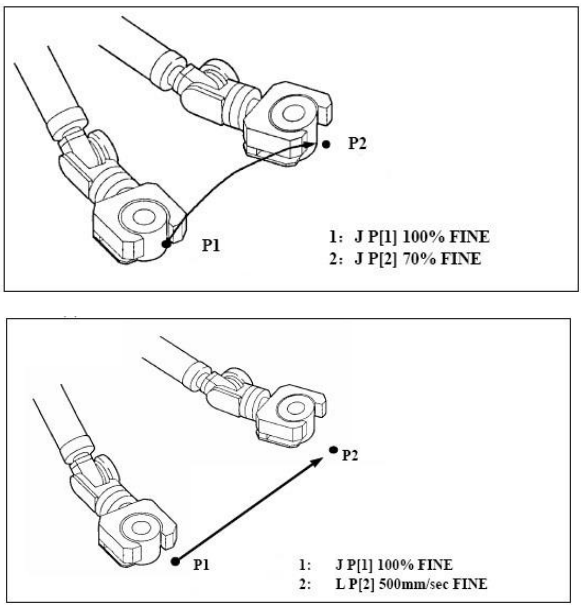


Fig.7 J and L instructions

3.5 *CNT and FINE*

CNT and FINE are the positioning types in the action instructions. By specifying the positioning type of each program segment, we can effectively avoid the risk of collision during automatic operation. During FINE positioning, the robot needs to reach the target position and then move to the next target position. During CNT positioning, the robot approaches the target position but does not stop at this position. The proximity between the robot and the target position is defined by the value behind the CNT, as shown in Figure 8. When writing a program, practitioners often ignore the positioning type behind the program, so that everything is normal in the debugging process, but there is a collision when running automatically. In the teaching process of CNT and FINE, we should focus on the difference between them to eliminate potential safety hazards[8].

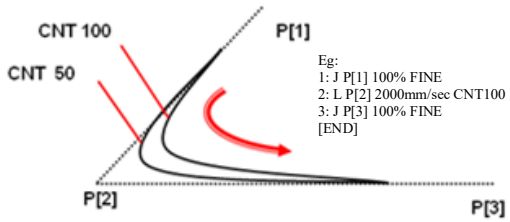


Fig.8 CNT positioning

4 CONCLUSION

With the development and wide application of robot technology, safety has become one of the most concerned and important indicators of robot. The research on robot safety technology and the establishment of robot protection system are of great significance to ensure the life safety of workers and the safe production of enterprises. Therefore, there is an urgent need to strengthen the safety education of talents in the direction of industrial robots to prevent trouble in the future. Through the safety management and teaching research of industrial robot laboratory, it can effectively enhance the safety protection capability of university laboratories, reduce the probability of safety accidents in enterprises, and ensure the bottom line of practitioners' life safety. Create a manufacturing talent team with strong technical skills, excellent professional quality and strong safety awareness.

ACKNOWLEDGMENTS

Fund Project: Jiangsu 2021 University Philosophy and social science research project, No.:2021SJA2374, Project Name: Research on Ideological and political education of industrial robot course through the whole process of education and teaching under the three integration mode.

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