Promotion of Standardization Activities on "Collaborative Safety"

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ABSTRACT

Recently it is commonly understood that one of the biggest issues in manufacturing industry is a lack of working force because working-age population is gradually declining. New concept “Collaborative Safety” is explained in IEC white paper that Collaborative safety is achieved when humans, machines and the operational environment share digital information with one another, communicate and collaborate. To widely propagate “Collaborative Safety” concept, we are necessary to develop and publish some more documentations such as guideline, technical specification, and conformance etc. As a result of this activity, international standardization of “Collaborative Safety” will contribute human well-being. Also, wide range of technologies would be required, such as not only basic manufacturing technologies but also low-latency communication technologies, various kinds of sensing technologies, cyber security technologies etc. In this paper, we present measures and focusing technical areas etc. from international standardization point of view.

1 INTRODUCTION

With the advent of the 4th Industrial Revolution: the era of Connected Industries, advances in ICT (Information and Communication Technology) have led to the development of technologies such as IoT, AI, Big Data, and cloud computing, which are beginning to connect all things to each other. When these technological innovations are applied to production sites, they are said to increase productivity and enable flexible production, which will drastically change the nature of industry [1, 2].

Collaborative Safety is a new safety concept that was born from the idea that ICT technology could be used for safety functions. This new concept of safety is growing in a wide range of industries, including civil engineering, construction, and agriculture, as well as manufacturing, and it is important to establish globally accepted international standards in order to spread and promote Collaborative Safety widely. In this paper, an introduction to Collaborative Safety and international standardization activities are presented.

2 CHALLENGES AND CHENGE IN THE MANUFACTURING INDUSTRY

Considering the history of Japanese manufacturing, Japan has led the world by producing high-quality, high-performance products. In today's manufacturing sites, issues such as

1) a shift from mass production to high-mix low-volume production due to the diversification of customer needs,
2) a decrease in the working population due to a decline in the customer birth rate (see Figure 1)
3) diversification of workers such as women and the elderly due to a decrease in the working population have become apparent

requiring changes from conventional manufacturing sites in order to address these issues.

For example, in robot systems, manufacturing lines have conventionally utilized a safety fence around the robot and an interlock switch installed in the safety fence door to stop the robot if a worker enters the safety fence. Today, collaborative robots are becoming popular due to the increasing need for cooperative and collaborative work between machines and workers without installing safety measures. Assistive robots, which reduce the physical load on workers, and Autonomous Mobile Robot (AMR), which transport parts and products, are also being introduced.

At workplaces where people and machines work in the same space and time, it is increasingly impractical to isolate people and machines by physical means (e.g., safety fences) based on conventional safety concepts. This situation calls for a new safety concept that enables collaboration and coordination between man and machine, rather than relying solely on safety measures based on the isolation of man and machine at workplaces where man and machine work in the same space.

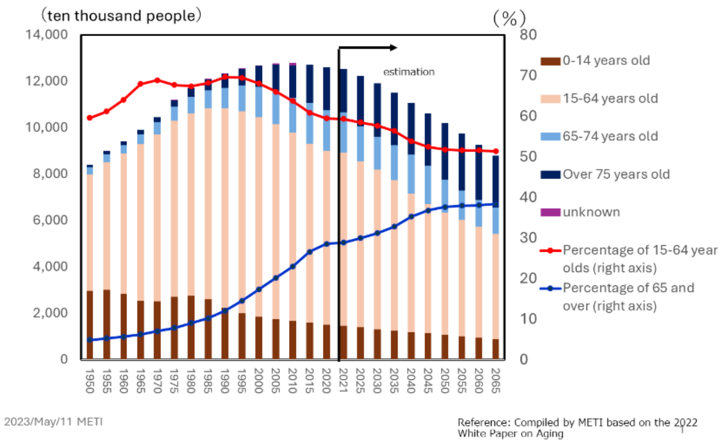

Fig. 1 Working-age Population in Japan

3 CHANGES IN SAFETY TECNOLOGY AND THE NEW ERA OF SAFETY "COLLABORATIVE SAFETY"

A brief review of the history of safety technology in machinery and equipment. When machines were introduced in manufacturing, occupational accidents occurred due to the high energy of the machines, such as cutting and crushing. There was a time when the focus of efforts to prevent industrial accidents caused by machinery was on preventing accidents through the attention of workers, such as hazard prediction and pointing out hazardous sources and events to alert workers to them. The next step was the introduction of machine safety, a concept that began in Europe to realize safety by utilizing safety technology in the design of machines, which are a source of danger. The design principle of machine safety is the idea that since most accidents occur in hazardous areas where human and machine workspaces overlap, safety should be ensured based on the "principle of isolation" and the "principle of stoppage" to prevent this mechanism from occurring. New technologies for machine safety, such as electrical safety, control safety, and functional safety, have been developed and spread. As a result, machine safety has been introduced at Japanese manufacturing sites to help prevent disasters.

As a further step, Collaborative Safety has been proposed as a new safety concept. Collaborative Safety is a new concept of safety in which people, objects, and the environment share risk information through ICT and other means to achieve safety in collaboration with each other (Fig, 2).

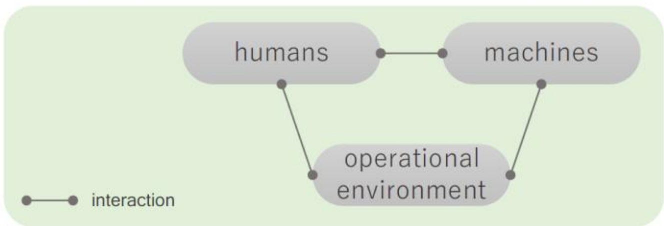

Fig. 2 Information sharing model for Collaborative Safety

By introducing Collaborative Safety, the following risk reductions are expected.

(1) Based on the idea that people can contribute to risk reduction, risk reduction and risk avoidance are achieved by providing people with specific hazard information at the appropriate time.
(2) Before the hazardous source stops the machine, avoid the hazardous condition as much as possible before the machine is brought to a protective stop, either by human evacuation or by avoidance actions of the machine.
(3) Based on the idea that the possibility of avoiding hazards varies depending on the operator's competence and experience, machine control is based on the operator's competence and experience, from binary control (stop, start) to multi-level control (stop, low-speed, medium-speed, high-speed).
(4) In risk assessment, static and dynamic factors should be considered, and when risk reduction or avoidance measures are implemented by human operators, validation through analysis of human behaviour should be conducted.
(5) Although not directly related to risk reduction, the visualization of safety through the use of ICT and other technologies will enable constant monitoring of people's physical condition, work areas, and machine conditions.

4 INTERNATIONAL STANDARDIZATION OF COLLABORATIVE SAFTY

The new concept of Collaborative Safety is an attractive safety concept for various industries, including manufacturing, but it is important to establish international standards such as guidelines and standards that can be applied globally in order to spread and promote it widely both domestically and internationally. By positioning the "Collaborative Safety" initiative as an important international standardization activity in the IEC (International Electrotechnical Commission), and with Japan taking the initiative, the white paper on Collaborative Safety, "Safety in the future: 2020," was published as an IEC white paper by the Market Strategy Board (MSB) in November 2020. Following the publication of the IEC White Paper, ACOS: Advisory Committee on Safety, one of the IEC's Technical Advisory Committees, has begun discussions on the publication of a "Guide on Collaborative Safety" as well as standardization. The Japanese committee is also collecting use cases of Collaborative Safety in Japan and abroad to promote international standardization activities. Since this is a new concept of safety in discussing standardization issues, discussions based on specific Collaborative Safety use cases (use cases) will lead to efficient international standardization. As examples of Collaborative Safety applications, 23 use cases will be collected and analysed, mainly in Japan and Europe, in order to investigate and analyse shortcomings and technical issues in existing standards.

Here are two typical examples of Collaborative Safety applications.

4.1 Collaborative work system between man and machine

This line enables work without physically isolating man and machine, and realizes "collaboration" between man and machine (Fig. 4). This production line is both flexible and productive, with manpower shortages and variations in work quality eliminated through mutual collaboration between man and machine, and is capable of producing variable types of products in variable quantities. The ceiling camera detects the positional information of workers, and the progress of the process is visualized by combining that positional information with information on manufacturing and machine operation (Fig. 5).

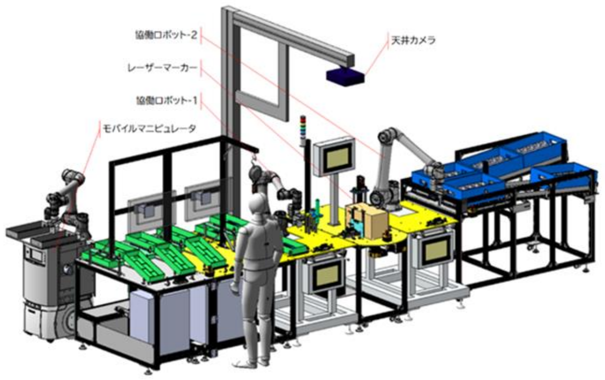

Fig. 4 Production line where man and machine collaboration

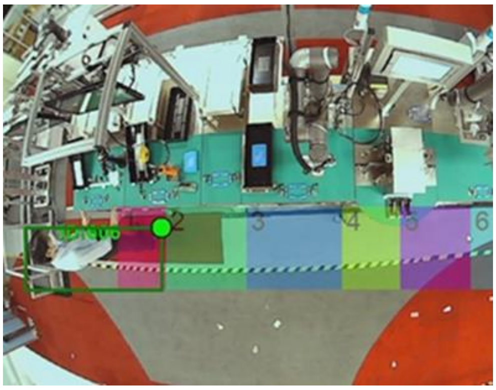

Fig. 5 Images from ceiling camera

By controlling the speed of the robot in accordance with the operator's ability and skill level stored on his/her ID card, the machine operates in accordance with the speed of the operator's work cycle. Therefore, the worker is not forced to work according to the machine, but the machine operates according to the worker's level of skill and other abilities, making it possible to realize a worker-friendly and work-friendly production line (Fig. 6).

Fig. 6 The robot operates at a set upper operating speed limit (SLS function) according to the operator's competence.

In addition, as a measure based on the concept of Collaborative Safety, ceiling cameras are used to prevent production line stoppages through robot operation based on confirmation of the worker's predetermined position and voluntary evacuation behaviour based on warnings to third-party intruders in the hazardous area.

4.2 Production line where man and machine collaborate

This is a "human-machine collaborative production line" in which workers and machines can collaborate with each other. Here, workers and robots are not physically separated by fences or other barriers, and they perform the same tasks in the same space. Based on the assumption of a variable variety of work, a worker and an autonomous mobile robot with a hand arm perform picking work while moving along the same fixed route in the same space according to work instructions that are constantly changing in content. In this process, what the worker and robot can do, and the characteristics of the work differ and change, so under the Cyber-Physical System (CPS) that has been constructed, the human-machine collaborative system optimizes the entire process in real time, making the production line both flexible, productive, and safe (Fig. 7).

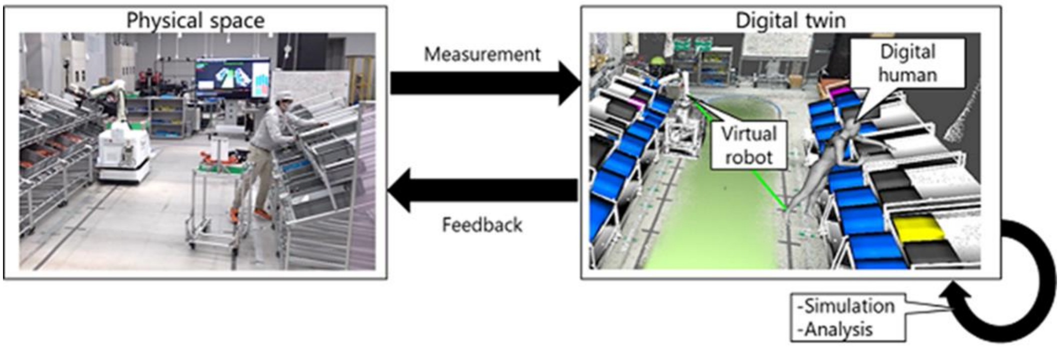

Fig. 7 Actual and cyberspace work sites managed by CPS

Dynamically optimized work instructions from CPS allow man and machine to collaborate and dynamically exchange information with each other. This allows humans and robots to work at a safe distance and perform highly productive work by picking objects in which each is proficient (Fig. 8). Compared to the case in which work was performed by man and machine without information exchange of dynamic work instructions, the average work time in the optimized system could be reduced by about 17% (Fig. 9). Regarding the workload, it was verified that the increased load allocated to the robot (8-11%) reduced the burden compared to the case where only a person performed the work.

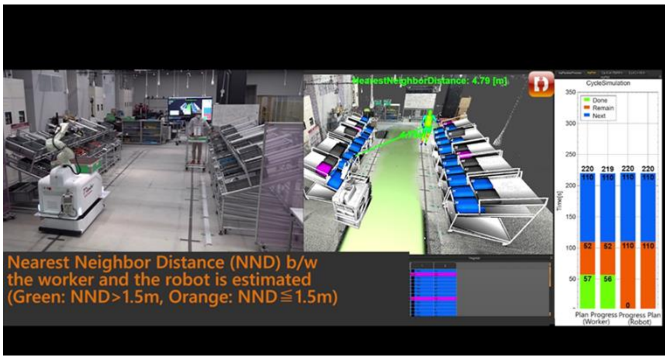

Fig.8 Control the distance between the shortest part of the operator and the robot

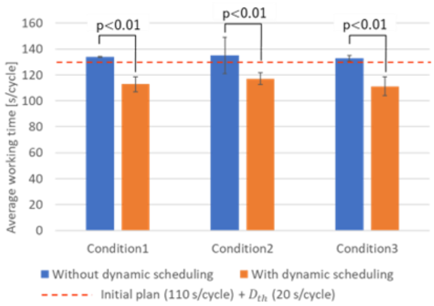

Fig.9 Reduced work time.

5 CONCLUSIONS

Collaborative Safety not only reduces risk and prevents accidents, but also places human capabilities on the same level as risk reduction and management, putting human at the forefront and emphasizing worker satisfaction, peace of mind, and job satisfaction. Therefore, we believe that introducing the concept of Collaborative Safety is an activity that will lead to the wellbeing of workers. The concept of Collaborative Safety can be used not only in the manufacturing industry, but also in a wide range of industries, including civil engineering, construction, and agriculture. By advancing the concept of Collaborative Safety, the market for a wide range of technologies, including communication technology, various sensing technologies, and cyber security, is expected to expand.

International standardization is important for the dissemination and promotion of the concept of Collaborative Safety, and we would like to propose international standardization through the Japanese domestic committee.

6 REFERENCES

The reference should include the author (last name, first name), the name of the publication, the place and year of publishing, the edition and the pages referred to. References should be sorted according to the order of appearance in the text. The publications should be numbered. When referring to the publications in the text, use numbers placed between two brakets, e.g. [1].

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