Safety Service Engineering
-An additional concept for safety of machinery

Takashi Kabe
NPO The Safety Engineering Laboratory, 3-39-8 Shoan,Suginami-ku,Tokyo 167-0054, Japan, kabe@safetylabo.com

Abstract:
The well examined CE-Marking System has been carried out almost since 20 years in EU and became nowadays a model to achieve the safety of machinery worldwide together with A-B-C standard-structure.. The basic philosophy of the CE-Marking System is a) to cover the dangerous machine to avoid human approach and b) shut off the energy, which leads to dangerous movement of machinery. The responsibility for safety lies clearly on manufacturers of machines. In many cases the manufacturers will not always be informed, what happen with machines after the distribution. Therefore it would be helpful to consider the life cycle of machine to optimize the requirement of machine users in design phase. The problem of defeating machine, which cause severe accidents was researched by IFA (BGIA) several years ago and certain changes were required in European machine directive and also relevant standards to optimize these problems. This problem is so called undefined factors, which will be led because of different interests between manufacturer and users of machine. In this case, further development of safety devices and advocating certain rules between machine manufacturer and user are necessary to enable human-machine-interaction in certain phases of machine operation. Therefore the new way of thinking to increase customer's satisfaction will be proposed as Safety Service Engineering on the base of PEST-analysis.

Keywords: safety of machinery, Safety Service Engineering ,machine lifecycle, productivity

1. Introduction

Systems engineering seeks a safe and balanced design in the face of opposing interests and multiple, sometimes conflicting constraints. Optimize the overall design, including safety as a essential part of design methodology, now a days in a "Risk Society", where a social evolution is going on because of rapidly technological changes. Systems Engineering is an interdisciplinary process that ensures that the customer's need are satisfied throughout a system's entire life cycle. The purpose of systems engineering is to produce systems that satisfy the customers' needs, increase the probability of system success, reduce risk and life-cycle cost.

Systems engineering is a methodical, disciplined approach for the design, realization, technical management, operations, and retirement of a system. A system is a construct or collection of different elements that together produce results not obtainable by the elements alone.

Systems Theory is a response to limitations of the classic analysis techniques in coping with the increasingly complex system being built and means the change of the worldview of "decomposition", or analytic reduction and linear way of thinking and approach. N.Werner applied the approach of systems theory to control and communications engineering and L.v.Berantalanffy developed ideas for biology, that the emerging ideas could be combined into a general theory of system. The systems engineering in consideration with whole system and whole life time of equipment and machines became also a base of MIL-STD-882 series.

The New Machinery Directive 2006/42/EC applied since December 2009 provides the regulatory basis for the harmonization of the essential health and safety requirements for machinery at EU level. This is nowadays a ideal model to achieve safety of machinery also in consideration of increasing Human Machine Interaction (HMI). ISO 12100:2010 specifies basic terminology, principles and a methodology for achieving safety in the design of machinery, which is essential and well tried systematic design method of prevention, but the user's matter is out of scope, whereas machines are used and operated by machine users. The effectiveness and efficiency of the prevention is well known[1,2)].

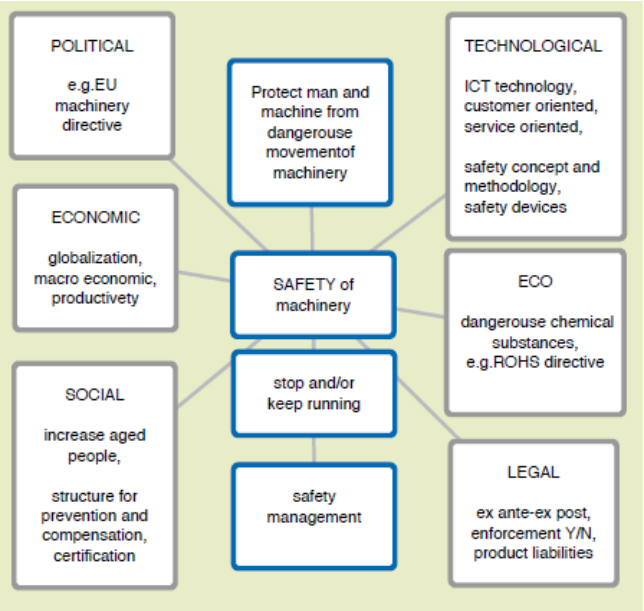

Figure 1. PESTEL-Analysis on Safety

2. PESTEL-Analysis for safety

Safety is an emergent property of systems and can only be determined by the relationship between the components and the system. While safety and safe life have social factors, it is necessary to look around, which factor influence safety. A rough observation of this issue, based on PESTEL-Analysis[3)] is summarized in Figure 1.

Safety is a matter of technique originally, but has to do with economic factor, especially Cost Benefit Analysis(CBA) during the lifecycle of machine.

Would the existing safety technology and social system overcome also the problem of rapid aging populations, which is expected worldwide? Here lots of social factors should be considered.

3. Safety Service Engineering(SSE)

To discuss the possibility and limitation of existing technology and social system, a working group “Safety Service Engineering (SSE)” was formed in the Division of Industrial, Chemical Machinery and Safety of Japan Society of Mechanical Engineering in April 2010.

Service Science or Service Engineering[5,6,7)] from the viewpoint of customer are also new scientific trend, especially since about 10 years. Also the basic concept of Human-centered design processes for interactive systems – ISO13407 was considered in the working group.

Concerning the lifecycle process we refer ISO/IEC 15288:2008 – Systems and software engineering – System life cycle processes, which describe lifecycle of systems created by human. The life cycle processes are based on Agreement-Organizational-Project-Technical and system life cycle[4)] is composed of Concept-Development-Production-Use/Support-Disposal. Because of increasing of aged people, it is sufficient to take also consideration on Gerontology. The defined processes can be applied at any level in the hierarchy of a system’s structure, and can be applied throughout the life cycle for managing and performing the stages of a system’s life cycle. This is accomplished through the involvement of all interested parties, with the ultimate goal of achieving customer satisfaction, which is defined also in ISO 9004.

Nowadays almost 70% or more people are engaging in service factor, while around 20% are engaging in the manufacturing sector for instance in case of Japan. Therefore it is essential to take consideration on customer’s satisfaction through qualitative services.

The project management, for instance defined in ISO21500 is also an essential methodology for the successful implementation of systems engineering.

The main stakeholder of safety of machinery and it’s legal base or standard is clearly manufacturer of machine, it means from the view point of provider, whereas machines are used and operated from machine customers. SSE invited special speakers especially in the field of Safety of Machinery, Process Safety, New Clear Power Plant, Service Engineering, Gerontology, Engineering Ethics, Automobile and Electric Industry, Certification Bodies etc. and discussed with members of SSE, which consist out of representatives of academic and industrial sectors in Japan. After 2 years works we have achieved certain conclusions, especially from the viewpoint of machine-users are shown in Figure 2.

- Systems thinking is effective
- To overcome the trade-off problems between manufacturer and user is welcome

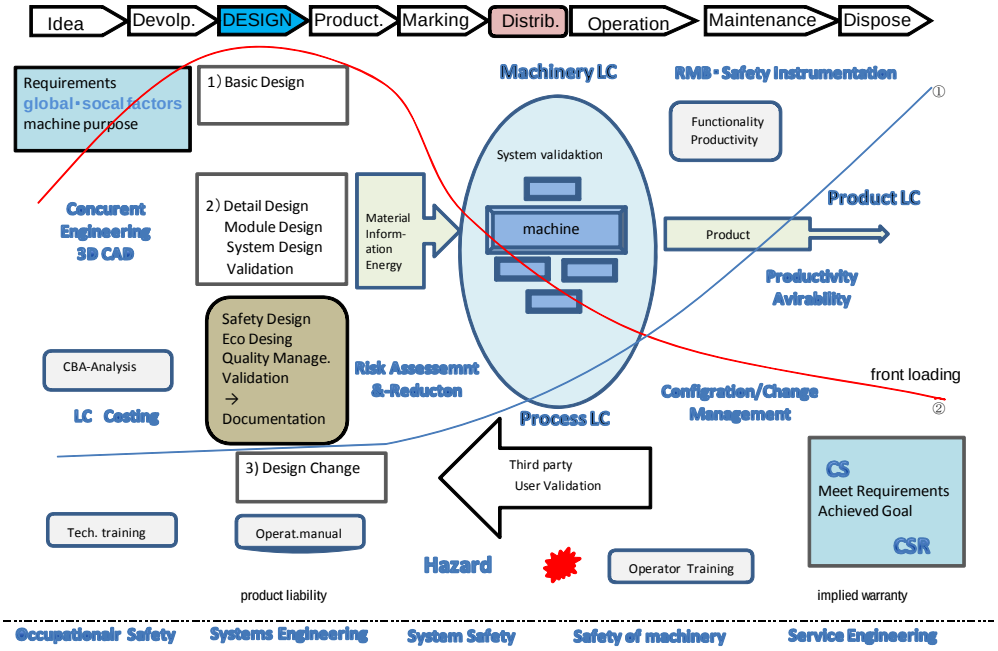

Figure 2. Concept of Safety Service Engineering(SSE)

- Frontloading of design is a key factor to optimize the efficiency during the whole lifecycle
- The design knowledge can be combined in CAD-system for utilization
- Configuration- or change management should be carry out to enable efficient management
- Comply with international standards is effective

4. Discussion

Back to the technical issue of safety of machinery, it is obvious, that the New Approach of EU was originally based on two principles, namely 1) cover the machine, which cause dangerous movement and/or 2) stop the machine in case of dangerous movement of machine. The machine user try not to stop the machine during the operation because of productivity obviously. The report of BGIA on defeat safety devices in 2006 showed clearly, that lots of safe machines are manipulated to enable or continue production. To overcome this realistic problem, some changes were put in legal or standard basis, as shown in Figure 3.

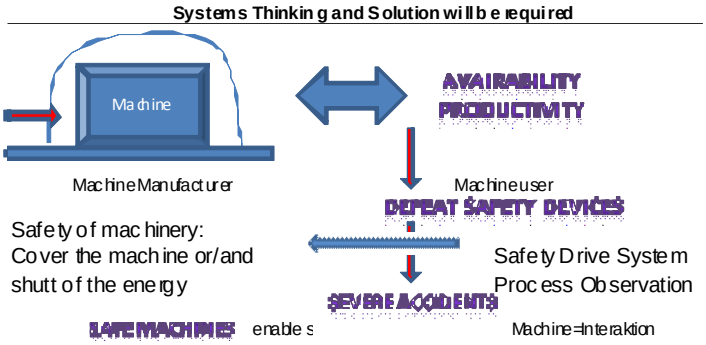

Figure 3. Basic methodology to achieve safety of machinery

The EU-directive 2006/42/EC, Cl.a.2.5 allows certain HMI as "Process Observation". The standard on interlocking devices EN1088 requires machines with safety guard with less possibilities of defeating.

The traditional way of safe guarding of machine based actually on treating I/O-signals to shut of the machine. The ISO13849-1: Safety-related parts of Figure 3. Basic methodology to achieve safety control systems describes requirements and guidance on the principles for the design and integration of safety-related parts of control systems (SRP/CS). The safety drive system according to IEC61800-5-2, based on the functional safety IEC 61508, defines the possibility to realize HMI by controlling the drive system e.g. Safety Limited Speed, Safely Monitored Direction, Safely Limited Position, Safe Braking And Holding System etc.

In case of HMI, additionally to keep machine safe, the approaching of human being to dangerous machine should also be observed and detected, ideally by 3D-camera system, which is still not yet

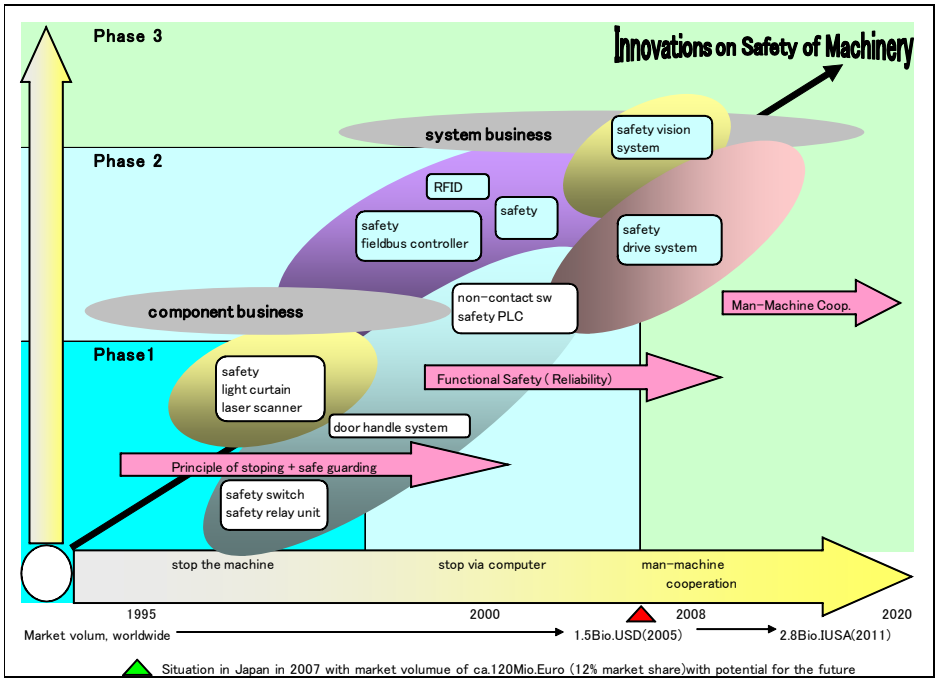

Figure 4. Development of safety devices

provided for factory automation with high dynamic movement. The development of safety devices with influence of functional safety is shown in Figure 4. Technical specification providing the guidelines for the safe operation of collaborative robots, including safety devices are right now in discussion in the working group of ISO TS 15066.

5. Conclusion

The Article 28-2 of Japanese Industrial Safety and Health Law requires carry out of risk assessment and risk reduction to machine users, but this has no punishment, it means no enforcement. Therefore it is necessary to make more consideration in case of Japan, how the in EU or America implemented risk-based-approach could be implemented in domestic machinery market. The PESTE+-Analysis is therefore necessary.

Even the Europe's machinery directive requires cover the machine or stop the machine, which cause more costs for machine and disturb in certain process the productivity or availability of machine, this could be well balanced, when the concept of SSE will be adopted, even in Japan. Take a balance means, the systems thinking will be required for the optimization of machine system.

Because of continuously and rapidly developing technology it is necessary, that safety devices and social system to imply safety make changes also in future also from the viewpoint of SSE..

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