THE CONCEPT OF PREVENTION THROUGH DESIGN AND ITS PRACTICAL IMPLEMENTATION

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Abstract. Many researches have considered and studied the concept of Prevention through Design; however, in Ukrainian scientific society the notion of this approach and the way of applying this concept in a real-world cases remains to be accomplished. This scientific paper contains a brief overview of PtD concept along with the example of its implementation followed by calculations using simple thermodynamics techniques.

Keywords: occupational safety and health, hazards, preventive measures, design, risk management.

Анотація. Багато дослідників розглянули та вивчили концепцію запобігання нещасних випадків через дизайн; проте в українській науковій спільноті знання про цей підхід і шляхи його імплементації в реальних умовах залишаються нерозкритими. Ця наукова стаття містить короткий опис концепції PtD разом із прикладом її застосування та розрахунками, використовуючи прості методи термодинамічного аналізу.

Ключові слова: безпека та охорона праці, небезпеки, превентивні заходи, проектування, ризик-менеджмент.

Introduction. It’s impossible to imagine constructions, working facilities, manufacturing plants of all sizes without hazards such as a fire hazard, risk of being injured by some mechanism, risk of ignition of any flammable liquid or gas. Thus, if we are concerned about prevention of such occasions, it’s far more convenient, cheaper and more reliable to think about the ways and approaches of how to minimize such risks at the very beginning – at the stage of design such facilities. And that’s where PtD (Prevention through Design) comes.

Analysis of the state of the issue. Prevention through Design (PtD – from now on) is thoroughly “young” initiative, being developed only in recent years with its origins dated back to 2007. According to the initiators of this concept, The National Institute for Occupational Safety and Health (NIOSH), the mission of the PtD National initiative is to prevent or reduce occupational injuries, illnesses, and fatalities through the inclusion of prevention considerations in all designs that impact workers [1]. PtD is a risk management technique that has been applied successfully in many industries, including manufacturing, healthcare, telecommunications, and construction. Also, one of its goals is to help educate and enable designers, engineers, manufacturers, principles in the design and redesign phases of facilities, processes, equipment, tools and organization of work.

Purpose. It’s going by itself that some steps of calculating (either precise or approximate) must be taken in order to obtain required results that will eventually help to define the state at which given device/mechanism/apparatus operates and ways to prevent possible threats that may be caused to human being. One of such examples of how to design system with prevention measures is given to the reader below.

Methods, materials and research result. In many manufacturing plants, individuals are often working around high temperatures. Exposed hot surfaces that are potential for thermal burns on human skin tissue are considered to be hazards in the workspace. Metallic surface of temperature above 70 °C is considered as an extremely high temperature in the context of thermal burn, where skin tissue damage can occur instantaneously upon contact with the hot surface. Let's consider an AISI 1010 carbon steel strip of 2 mm thick and 3 cm wide that was is conveyed into a chamber to be cooled at a constant speed of 1 m/s; the steel enters the chamber at 597 °C and exits at 47 °C to avoid instantaneous thermal burn upon accidental contact with skin tissue. We are to find the amount of heat rate needed to be removed from the strip in the cooling chamber.

The AISI 1010 carbon steel strip properties can be gathered at the average temperature:

$$\overline{T} = \frac{T_{in} + T_{out}}{2} = \frac{597\,°C + 47\,°C}{2} = 322\,°C$$

Using tabular data: average density $\overline{\rho}$ = 7832 kg/m^3 and isobaric specific heat:

$$c_p = 682\ \frac{J \cdot kg}{K}.$$

The mass of steel strip enters and exits the chamber at a rate of:

$$\dot{m} = \overline{\rho} \cdot V \cdot A_C,$$

where A_C – cross-sectional area of the strip in a control volume:

$$A_C = thickness_{strip} \cdot width_{strip} = (0.002 \cdot 0.03)\,m^2 = 6 \cdot 10^{-5}\,m^2.$$

Thus:

$$\dot{m} = \overline{\rho} \cdot V \cdot A_C = 7832\frac{kg}{m^3} \cdot 1\frac{m}{s} \cdot 6 \cdot 10^{-5}\,m^2 = 0.47\frac{kg}{s}.$$

Considering chamber as a steady-flow (any property change with time is negligible) system, mass flow rate is given as $\dot{m}_{in} = \dot{m}_{out} = \dot{m}$. Hence, the net heat rate needed to cool steel strip is:

$$\dot{Q}_{cool} = \dot{m} \cdot \Delta h = \dot{m} \cdot c_p \cdot \Delta T = 0.47\frac{kg}{s} \cdot 682\frac{J \cdot kg}{K} \cdot (597 - 47)°C = 176.3\ kW.$$

As you may see, such simple and unsophisticated but very useful approach can serve as the first approximation to the real-life common situations. In the same manner, any other task could be examined using various concepts of such fields of study as Heat and Mass Transfer, Thermodynamics, Electrical Engineering, Chemistry etc., and solved using proper techniques and equations.

Conclusions. Being developed as a measure to prevent risks, PtD is invaluable when it comes to the analysis of working environment. It was shown in the example above that by considering possible risks of being injured and hazards that are present in a working environment, it's possible to eliminate such ones on the stage of construction of facilitates and not when workers face to them in person.

References

1. The National Institute for Occupational Safety and Health (NIOSH). Prevention Through Design. URL: https://www.cdc.gov/niosh/topics/ptd/ (date of application: 17.05.2022).