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INCREASING OF OPERATIONAL SAFETY ROBOTIZED WORKPLACES BY SENSOR EQUIPMENT

The article describes the sensors of the robotized workplace to ensure of theirsecurity. Also there are described a basic reasons of hazardous statues. To avoid these problemswas developed different security sensors. Some of them are described inside this article.

Keywords: *sensor, security, workplace, robot*

Introduction to the topic

The importance of safety and separation of processing zones and subzones with to the risk of injury obtain particularly significant role with regards to the designing and implementing of automated technological workplaces with the application of industrial robots and manipulators as progressive elements of the production techniques. The requirements of safety are taken into account already when are planning and designing workplace. Into the safety of work is included a protection of environment before emissions and noise, protection before negative products of technological process, if necessary before crash or possibly of resulting in the release of tool and ultimately protection of other workers from contact with the working parts of machines or manipulated objects during production[1]. The main requirements for protective optical equipment which is part of the workplace:

- to protect workers in handling, especially his hands,
- should not to be a reason for slowdown in performance,
- does not interfere during work,
- does not cause problems when sorting machinery, simply removing and putting,
- simple designing and easy controlled, carefully checked due to his possible defect
- may be the cause of accidents.

All moving parts of production equipment, which could cause injury or operator must be enclosed to depth of 2m from the floor cover [2]. Further, the issue of emerging risks in the workplace can be divided into:

- risks that are begins in the behavior of workers,
- risks that are begins in working order of production equipment and solutions of workspace.

In the second case it is necessary to consider operational status and also condition of malfunction, respectively accident at one of the equipment part. The threats to safety occur in most cases are caused by direct influence from the part of equipment [3]. Robotized accidents can be divided into four categories:

- Impacts or collisions which are part of fault or change associated with arm robot, where the device may occur to the contact accidents.
- Capturing of clothing worker or another part of the body with robot arm lead into contusions or crushed limbs and that becomes an injury.
- The accident caused by mechanical parts of robot arm or its power source.
- Other accidents which may become in order to robot arm. These include liquids, which are under pressure (hose rupturing) which can create dangerously high pressure streams, squirting the liquid on the floor, and more [4].

The sources of danger can be divided into:

- Human mistakes – incorrect activation at control panel. The biggest problem is redundant robot movements and so person remains in a dangerous position during the programming a robot or when carrying out maintenance.

- Control mistakes – it is inside type of mistakes of control system robot arm, mistakes in the software, electromagnetic interference and radio frequency interference called regulatory errors. In addition, the following errors occur due to a failure in hydraulics, pneumatic or electric sub control associated with a robot or its control system[5].
- Unauthorized access - unauthorized entry into the space robot, because concerned person may not be aware of conditions in the work workplace or its condition of activation.
- Mechanical fail - operational program does not correspond with current status of robot arm where may lead to unexpected movements.
- Improper installation - realization of poor installation, equipment, layout and the involvement of the robot can also lead to risks.

Requirements for sensor equipment

Into the safety of work is included a protection of environment before emissions and noise, protection before negative products of technological process, if necessary before crash or possibly of resulting in the release of tool and ultimately protection of other workers from contact with the working parts of machines or manipulated objects during production [6]. The main requirements for protective optical equipment which is part of the workplace:

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With regards to the approach of human factor, respectively of possibility for intervention into the defined danger zone system may be protective devices classified as follows:

- Direct protection: Person without disconnecting of protective equipment cannot access or interference into the danger zone. Distance of protection equipment from danger zone must be selected so as to eliminate any hazards to the persons.
- Indirect protection: Allows intervention into the danger zone.

Minimum safe distance

Because an operator can walk or reach directly into the cell, it is important that the time required to stop the cell is less than the time for the operator to trip the safeguard and reach a dangerous spot [7]. Accurate determination of the safe mounting distance is important in maintaining safety and productivity. The goal is to keep the light photocell as close as possible to the hazard in order to avoid interfering with the operator's normal motion and conserve floor space while at the same time ensuring that the robot will stop before the operator's hand or other body part can reach a hazardous point.

The American National Standard Institute provides the following formula for calculating the minimum safe distance:

$$D_s = K (T_s + T_c + T_r + T_{spm}) + D_{pf}$$

$D_s$are the minimum safe distance. K is the maximum speed at which an individual can approach the hazard in inches per second. A common value for K is 63 inches per second.$T_s$are the total time in seconds for the hazardous motion to stop or for the hazardous portion of the cycle to be completed.

T_c is the response time in seconds for the machine control circuit to activate the machine's brake.T_r is the response time in seconds of the safety system.T_{spm} is the additional time in seconds allowed by the stopping performance monitor before it detects stop time deterioration.

The stopping performance monitor will halt the machine when the stop time exceeds the set limit. If the workplace does not have a stopping performance monitor then a percentage increase factor should be added to the measured stop time ($T_s + T_c$) to allow for brake system wear. A typical value is 20 percent. D_{pf} is the depth penetration factor.

Sensor equipment

Protective equipment's are constructed so that the operators are being protected immediate stop before dangerous movements through appropriate supervisory equipment's (two handed switching device or immediate stop hazardous motion by photocell or pedal)[8]. Security light gate consists of separate transmitter and receiver units, among them there is a security zone (Fig. 1).

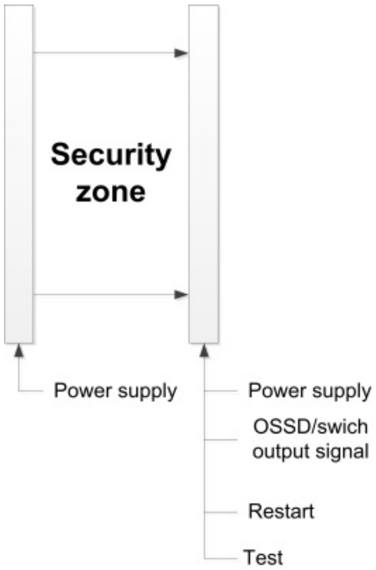

Fig. 1 Security light gate

The transmitting unit is equipped with variety of sources of infrared (red) light, which cyclically emit short bursts of light falling on the photosensitive sensor in the opposite of the receiver unit. But when comes into protected field opaque object and at least one light beam is interrupted, i.e. that posted pulse of light fall on the corresponding sensor, receiver unit generates an output signal which can be easily inferred as command to stop the dangerous movement of the robot arm, possibly for his movement into the safe position which does not endanger anyone[9].The width of protected field is determined by maximum range of light gate, i.e. distance between transmitter and receiver unit, in which the receiver reliably captures all transmitted light pulses.

It ranges from zero to several tens of meters. The amount of protected field is given by the construction height of transmit and receive unit, which is usually a function of the transmitted light beams and their mutual spacing, and from the reasons of production is limited to about 2 m. When the numbers of transmitted light rays less than six, we talk about safety light photocell.An extreme case are safety light photocells with a single broadcast light beam, which for its simplicity and low cost are often used for some less demanding applications[10].Spacing of adjacent light beams of light photocell defines a security distinctive character and effectivity.

If the spacing of light photocell has smaller beams so smaller object can be determined which enters a light photocell. Resolution of light photocells must answerthe desired level of protection, Fig.2.

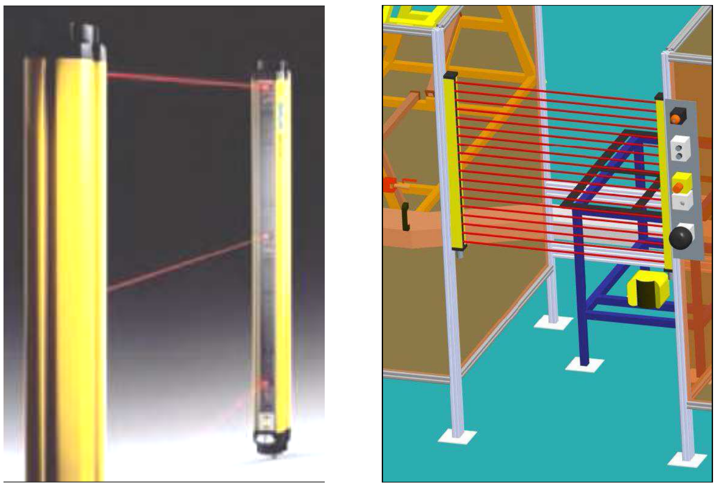

Fig. 2 Security light photocell Sick

For these simple light photocell transmitter may be a receiver in a single housing, then it is so-called retro-reflective Fig. 3. Reflector is placed on the opposite side and reflected beam back to the receiver. A target object interrupts beam and reflected light causes a change in state of the output signal[11].The transmitter and receiver are working with a common lens. Transmitted light passes through a splitting mirror and the lens reflector. Reflector reflects the emitted light back to the lens.

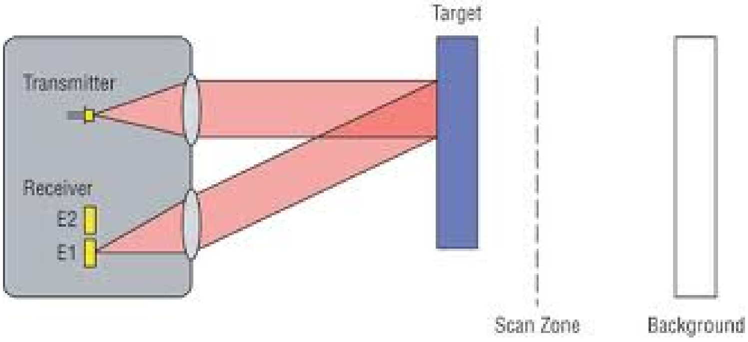

Fig. 3Retro-reflective sensor

For more light photocells are beam spacing or distance between light rays can be defined as ability to distinguish as more effective[12].Resolution of light photocell must respond to the required degree of protection. It should be e.g. prevent the operator's finger cannot penetrate into the protected area is to be used light photocell with a resolution of 14 or 20 mm, Fig. 4.To protect the operator's hands the resolution is 30 or 50 mm, and for the protection of person's access to protected areas of sufficient resolution greater than 100 mm. By setting photocell, appropriate for the requirements of a particular application, the robot arm again actuated either by manual approval detected, or automatically as soon as the light barrier detects that the security protection zone has no unwanted object does not exist.

Conclusion

Safety at robotized workplace is in the field of industrial automation currently highly discussed topic.It is not, of course, only to guarantee an adequate level of security, but also to ensure it rational and cost-effective way.

Robotic workstation must be designed so that its operation, adjustment and maintenance using the expected conditions did not cause personal injury.

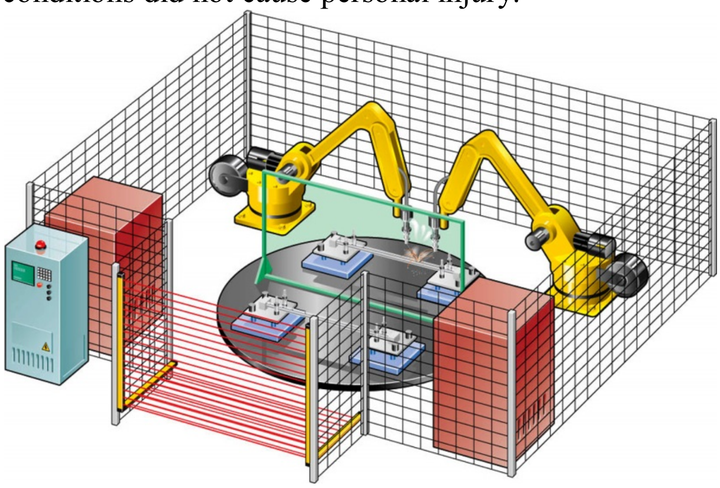

Fig. 4Example of light photocell use

The aim of measures taken must be to eliminate any risk of injury during the expected life of the department, including assembly and dismantling, even in cases of unusual but predictable situations.

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