Investigation: # 01MI002

Mold Setter's Head Struck By a Cycling Single-side Gantry Robot

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SUMMARY

On January 19, 2001, a 29-year old male died from injuries sustained when he was struck on the head by a cycling single-side gantry robot. The victim had recently performed a mold change on a 1500-ton horizontal injection-molding machine (HIMM). He was apparently looking for tools that he may have left within the machine during the set-up operation. The victim climbed on top of the purge guard and leaned over the top of the stationary platen of the HIMM in an attempt to see if the tools were left within the mold area, and placed his head beneath the robot's gantry frame. His position placed him between the robot's home position and the robot's support frame on the stationary platen. While trying to look inside the mold area, the robot cycled, and the victim's head was struck from the side and crushed between the robot and the robot's support frame. Another employee noticed the victim on top of the HIMM and went to investigate. Upon seeing the victim's condition, fellow employees were called to move the victim to the floor. Emergency responders were called, and awaiting emergency responder arrival, employees began chest compressions and other first aid procedures. The victim was pronounced dead on arrival at the local hospital.

RECOMMENDATIONS:

- **The robot and the point of operation should be safeguarded to prevent entry during automatic operation.**
- **Users should conduct a risk assessment of the robot/robot system to identify equipment, installation, standards, and process hazards so adequate employee safeguards are provided.**
- **Users should ensure that personnel who interact with the robot or robot system, such as programmers, teachers, operators and maintenance personnel are trained on the safety issues associated with the task, robot and robot system.**

INTRODUCTION

On January 19, 2001, a 29-year old male died from injuries sustained when he was struck on the head by a cycling single-side gantry robot. The same day, MIFACE investigators were informed by the Michigan Occupational Safety and Health Administration (MIOSHA) 24-hour fatality report system that a work-related fatal injury occurred on January 19, 2001. On February 5, 2001, a MIFACE researcher accompanied the MIOSHA compliance officer to the facility. The MIFACE researcher and the MIOSHA compliance officer accompanied company officials to see the HIMM and robot system functioning. The machine was in manual mode, with an operator retrieving ejected parts; the robot was not in operation. After the closing conference, the MIFACE researcher had an opportunity to interview a company representative. The death certificate, autopsy results, police report, a video and the MIOSHA narrative were obtained during the course of the investigation.

MIFACE returned to visit the company a second time to gather more information on the robotic system. At this visit, MIFACE had the opportunity to talk with other company employees about the circumstances surrounding the fatality.

MIOSHA did not issue any employer citations for this incident.

INVESTIGATION

The employer, a custom plastic injection molding company, operated a manufacturing facility, which contained injection molding machines of varying sizes. The company had been in business for 15 years at the time of the incident. The decedent had been working for the company for 4 months. Company safety responsibilities were defined and the company had a written health and safety plan. The decedent was trained in the classroom and on-the-job, and training documentation was available. During on-the-job training at the company, employees were instructed and supervised until the supervisor determined that an individual was ready to undertake a task on their own. The company had specific written procedures for lockout/tagout for each machine and for written safe work procedures machine operation.

This injection molding machine had required safety devices, which prevent the operation of the machine under certain circumstances. The machine had a sliding operator gate, which is used to access the area where the mold is located and parts are produced. There are three safety devices on the HIMM that re activated by the gate operation. One safety device is a hydraulic valve that prevents the clamp from closing when the operator gate is opened. Another safety device is an electrical interlock. When the operator gate is opened, the electrical interlock prevents the clamp from closing. The third safety device is a mechanical stop bar between the HIMM's platens that prevents the clamp from closing when the gate is opened. Additionally, a safety mat is located in the molding area. If a person is standing on the mat, the mold cycle cannot be initiated. All robot and HIMM controls, indicators and displays were located outside the HIMM on a work platform that is used by the operator to gain access to the mold area during semi-automatic operation. The work platform was located adjacent to the operator gate and on the opposite side of the conveyor location where the robot discharged the finished piece.

The robot circuitry was integrated with the HIMM operator's gate; thus if the sliding operator gate was opened, the robot would not continue to cycle. Written start-up procedures were available to the operator when the automatic cycle of the HIMM/robot arm was interrupted. Start and restart of the machine required deliberate actions outside the HIMM's safeguarded space, and could be done at any time without management approval.

The employer had a written lockout/tagout procedure for each piece of equipment, and the employees had documented training.

Plastic injection molding is a molding procedure where a heat-softened plastic material is injected from the barrel of the HIMM injection unit into a relatively cool mold cavity, giving the article the desired shape. First, plastic granules or pellets are heated until they melt. The mold is comprised of two separable halves; one half is attached to the stationary platen, the other half to the moveable HIMM platen. The melted plastic is injected into a closed mold via a screw type mechanism while the mold is held together under pressure (referred to as clamping force). Once the mold is packed (full), cooling of the plastic begins. When the plastic is cooled and has solidified in the shape of the mold, the mold opens (moveable half) and the finished (molded) part is ejected from the mold. A process cycle is one complete operation of the injection molding machine, encompassing the mold closing, filling, packing, cooling, mold opening and ejection stages. The size range of the HIMM is usually stated in tons, which refers to the clamping force applied to the mold halves during the injection cycle.

A single-side gantry robot transported the molded part from the mold area to the part delivery area. The robotic system was added to the machine about 6-8 months prior to the incident. The gantry frame was mounted atop the HIMM machine stationary mold side. The robot moves along the gantry frame starting from the home position, located about midway between the locations for part pick-up and part delivery. At the appropriate time in the injection molding process cycle, the robot travels along the gantry frame to the mold area. The robot arm lowers when instructed, and the end effector removes the ejected part from the mold half. The robot arm then lifts the part over the HIMM and moves in the opposite direction along the gantry frame to the delivery location, dropping the part to a conveyor for further handling by an operator. After part delivery, the robot returns to the home position. The process cycle time for the machine involved in the incident was approximately 50 seconds.

The robot was not safeguarded in accordance with ANSI/RIA R15.06-1992 American National Standard for Industrial Robots and Robot Systems – Safety Requirements. On the day of the incident, both the robot and the HIMM were operating in automatic mode, i.e. the robot and HIMM were performing unattended programmed tasks. At an afternoon meeting held the day of the incident, a fellow employee reminded the victim to return some tools the victim had borrowed earlier in the week while setting up the machine. After "clocking out", the victim returned to the HIMM that he had set up a few days before to see if the tools were at the machine. Video cameras set up to monitor the machine process cycle documented a portion of the events leading to the fatality. One camera angle captures the victim walking up steps onto the operator platform used during semi-automatic mode of the machine when an operator manually unloads the molded parts. While the victim is walking up the steps the mold is closed. When the mold opens, the victim can be seen looking into the HIMM through the sliding operator gate, presumably to see if the tools were inside the mold area. The victim spends about 12 seconds looking through the closed operator gate. As the mold closes, the victim is seen leaving the operator platform.

The victim is next seen on camera approximately 20 seconds later. The victim climbed on top of the purge guard and placed his head between the moving arm of the robot and the robot gantry frame mounted on top of the stationary platen of the HIMM. presumably to see into the machine. While the victim is looking for the tools the robot moves from the home position to the mold area to retrieve the molded part, and strikes the victim on the right side of his head. The robot movement crushes the victim's head between the robot arm and the vertical support for the robot frame.

An employee passing by the HIMM noticed the victim at the top of the machine and walked around to the purge guard to investigate. When the employee reached the victim and noticed the extent of the injury, the employee called for help from other employees to help lower the victim to the ground. One of the company employees stopped the HIMM; other company employees initiated first CPR, while others called 911. The police and emergency responders arrived, began medical treatment and transported the victim to the local hospital where he was pronounced dead on arrival.

The company had instructed personnel not to enter any area around the HIMM and cycling robot when the HIMM was in automatic mode.

CAUSE OF DEATH

The medical examiner recorded the cause of death as blunt force head trauma. Phencyclidine (PCP) cross-reactives were detected in the victim's urine; phencyclidine was not detected in the victim's blood. No alcohol or other drugs of abuse were detected in the victim's blood or urine.

Cross-reactivity is a measure of relatedness of compounds; testing specific for one class of compounds may detect similarly structured compounds. Some over-the-counter medications, prescriptions and health conditions, after being broken down by the body, can cross-react (yield a false positive) for the class of compounds being tested in the laboratory. In this case, PCP cross-reactives were detected in the victim's urine. Examples of over-the-counter medications that, after being broken down by the body, cross-react in the PCP test are Nyquil or cough suppressants containing dextromethororphan. Because PCP was not detected in the victim's blood, it is not thought that the victim had PCP in his system.

RECOMMENDATIONS/DISCUSSION

• The robot and the point of operation should be safeguarded to prevent entry during automatic operation.

There are two American National Standards that specifically address the use of robotics in the horizontal plastic injection molding industry. An employer's use of an American National Standard is voluntary. In 1999, the American National Standards Institute (ANSI) approved a

Robotic Industry Association (RIA) revision of the ANSI/RIA R15.06-1992 American National Standard for Industrial Robots and Robot Systems – Safety Requirements. In 1994, ANSI approved a Society of the Plastics Industry (SPI) revision of ANSI B151.27-1994 and a new revision to that standard in 2002 and redesignated ANSI/SPI B151.27- 2002, American Nation Standard for Plastics Machinery – Robots Used with Horizontal and Vertical Injection Molding Machines – Safety Requirements for the Integration, Care, and Use.

ANSI/RIA R15.06-1999 defines an industrial robot as "an automatically controlled, reprogrammable multipurpose manipulator programmable in three or more axes which may be either fixed in place or mobile for use in industrial automation applications. ANSI/SPI B151.27-1994 defines a robot as "a multi-functional manipulator designed to move material, parts, tools or specialized devices through variable programmed motions for the performance of a variety of tasks. The term robot is meant to include reprogrammable manipulators and non-reprogrammable manipulators such as "pickers" This term does not include automatic mold changers or conveyors." ANSI/SPI B151.27-1994 incorporates ANSI/RIA R15.06-1999 as a normative reference.

Robot systems are defined in ANSI/SPI B151.27-1994 as "the integration and use of a robot in conjunction with the operation of an injection molding machine."

ANSI/RIA R15.06-1999 Section 7, Safeguarding of Personnel states that the user is responsible to ensure that the appropriate safeguarding devices are in place, functioning, and that personnel are trained to use them as intended. When the robot was installed on the machine, the robot travel area (operating space) was left unguarded and was not identified. The employer had determined that the purge guard side of the HIMM was an unsafe area; employees stated that the employer had instructed them not to go into this area when the HIMM/robot system was operational. The employer had identified this area of the HIMM as a hazardous area, but they had not identified the robot operating space as hazardous nor safeguarded it.

Safeguarding of the restricted space (maximum area of robot movement with part) would be required by the ANSI standard and must: (1) prevent the operator from being within the space during automatic robot operation or, (2) stop the robot's motion while any part of an operator's body is within the space. Engineering controls are an employer's first choice to prevent employee access to identified hazards, such as perimeter guarding or presence sensing devices. The employer provided employee training to stay out of the area. The employer could also place awareness means, such as awareness barriers or an awareness signal to provide an audible or visual signal to personnel as they approach the area. Awareness means can include chain or rope barriers, warning signs, flashing lights, presence sensing devices, guards, etc. Awareness means cannot be used in place of safeguarding but may be used to augment safeguarding.

• Users should conduct a risk assessment of the robot/robot system to identify equipment, installation, standards, and process hazards so adequate employee safeguards are provided.

ANSI/RIA R15.06-1999, Section 7.4, Sources of Hazards requires that hazard sources, such as equipment, installation and process hazards be identified. Several examples of hazard sources are given by the standard, such as moving mechanical components causing trapping or crushing, human error and deliberate or unintended actions by personnel. ANSI/RIA R15.06-1999, Section 7.5, requires that a safeguarding strategy be developed for identifying and controlling hazards, including process-specific hazards. In addition to identifying and controlling hazards, the user is required to either of the following actions: (1) install safeguarding consistent with the requirements of Clauses 7 and 8 of ANSI/RIA R15.06 or (2) conduct a comprehensive risk assessment in accordance with R15.06 clause 9, and install the safeguards determined by the risk assessment to be appropriate in accordance with clause 10.

Clause 9 of the ANSI/RIA R15.06-1999 requires that the risk assessment take into account intended use of the robot and robot system, anticipated operator skill and training, and additional risk exposure and processes. There are a number of different risk assessment methodologies; any methodology that results in safeguards equivalent to or more stringent than the requirements of Clause 9 may be used. The robot system was installed on the HIMM recently, and a risk assessment was not conducted. Task and hazard identification is the first step in the assessment that identifies all reasonably foreseeable tasks associated with the robot system and identifies hazards associated with each task assuming that there are no safeguards installed.

• Users should ensure that personnel who interact with the robot or robot system, such as programmers, teachers, operators and maintenance personnel are trained on the safety issues associated with the task, robot and robot system.

The employer provided lockout/tagout training of both the HIMM and the robot to the mold setter; the mold setter demonstrated understanding of the lockout/tagout procedure and equipment hazards involved to the training supervisor.

The employer did not have specific robot safety issues addressed during the lockout-tagout training, nor did the employer have specific robot safety training for employees. ANSI/RIA R15.06-1999, Section 14 contains suggested components that should be included in a robot safety training program. These include training objectives, training requirements, safeguard training, and specific training for the tasks performed and potential hazards identified in the risk assessment that could be encountered by the person interacting with the robot.

RESOURCES

ANSI/RIA R15.06-1999 American National Standard for Industrial Robots and Robot Systems – Safety Requirements.

ANSI/SPI B151.27-1994, American National Standard for Plastics Machinery – Robots Used with Horizontal Injection Molding Machines – Safety Requirements for the Integration, Care, and Use.

ANSI/SPI B151.1-1997, American National Standard for Plastics Machinery – Horizontal Injection Molding Machines – Safety Requirements for Manufacture, Care, and Use.

Acknowledgement

MIFACE gratefully acknowledges Mr. Loren Mills for his assistance in developing this report. Mr. Mills is a Member of the following ANSI Committees: ANSI B151.1 Committee for Horizontal Injection Molding Machines Safety Requirements, ANSI B151.27 Committee for Robots Used with Horizontal injection Molding Machines – Safety Requirements for the Integration, Care and Use, and Member of ANSI B151.29 Committee for Vertical Injection Molding Machines Safety Requirements. He was also a Canvassee member of ANSI/R15.02 Committee for the Human Interface of Industrial Robots - Human Factors and Ergonomics and Canvassee member of ANSI/R15.06 Committee for Industrial Robots and Robot Systems - Safety Requirements.

ADDENDUM TO 01MI002
1/20/03

HIMM Description

The HIMM's purge guard was approximately 15 feet off of the ground. The HIMM did not have a ladder or any method to access the top of the top of the purge guard. The company did not consider the purge guard to be an operator area and did not have an operator platform at the purge guard location.

Employee Actions

Based on the statements in the police report of this incident and conversations with company officials and employees, the MIFACE investigator included the possibility that the employee may have been looking for the borrowed tools. This statement is not intended to be conclusive, only speculation as to why the employee would have climbed up the machine to the top of the purge guard and placed his head in a position to see inside the machine.

MIOSHA clarification of consensus standards

While MIOSHA may adopt voluntary safety and health standards such as ANSI Standards, or use generally accepted standards as the basis for a general duty violation, routine compliance with consensus standards is not required.