MIFACE INVESTIGATION: #04MI180

SUBJECT: Mill Hand Dies When Drill Was Thrown From Shattered Hardened Steel Tool Extension and Strikes Him In Chest

Summary

On November 18, 2004, a 23-year-old male mill hand died when a drill was thrown from a shattered hard steel tool extension and struck him in his chest. He was operating a high-speed computerized numerical control (CNC) machining center. The CNC programmer asked the victim to determine if a 3/4-inch drill that was 10 inches in length "ran true". The drill's three-inch long, 1/2-inch outside diameter (O.D.) tool was placed in a purchased six-inch long, one-inch O.D. hardened steel tool extension. The hardened steel tool extension was threaded onto an in-house manufactured soft steel tool extension that was 10-inches long and had a one-inch O.D. Two inches of the soft steel tool extension was inside of the tool holder. The victim attached this tooling to the tool holder and pressed the "clamp" button on the computer console. The machine was operating in manual data input mode. The victim entered 3000 revolutions per minute (rpm) for the spindle rotation instead of entering 300 rpm. The machine doors were wide open and the machine was in override mode. The victim pressed the start button, and because the over ride was set 110%, almost instantaneously the machine reached 3300 rpm. The victim was standing near the open door looking at the spinning tooling that was in the "home" position. He nodded to the programmer and indicated that everything was working appropriately. His left side was facing the open machine doors as he turned to stop the spindle rotation at the control panel. At that moment, the soft steel tool extension bent approximately 90 degrees. As a result, the hardened steel tool extension struck a part of the automatic tool changer and the extension shattered. The drill was thrown from the hardened extension. Both the shattered extension pieces and drill struck the victim. The programmer hit the emergency stop button. A supervisor who heard the tool break went to the location and attempted first aid measures. Emergency response was called and the victim was taken to the hospital where he died.

Figure 1. CNC machine involved in incident

RECOMMENDATIONS

- Conduct a job safety analysis when performing non-routine tasks or using non-routine tools.
- Use only equipment manufacturer-approved components when conducting work operations.

Key Words: Machine-Related, CNC, Struck By

- Employee training should include confirming entered program values on a CNC machine prior to initiating the machine cycle.
- Employers should consider reviewing their standard operating procedures to include keeping machine doors closed when possible.
- Employers should evaluate whether providing additional reinforcement for machining window areas is appropriate.
- Employers should ensure equipment is maintained according to manufacturer's instructions.

INTRODUCTION

On November 18, 2004, a 23-year-old male mill hand died when a drill broke away from its rotating shaft and struck him in the chest. On November 18, 2004, the Michigan Occupational Safety and Health Administration personnel, who had received a report on their 24-hour-a-day hotline that a work-related fatal injury had occurred on May 28, 2004, notified MIFACE investigators of the fatality. On February 23, 2005, the MIFACE researcher interviewed the company owner at the site. The company permitted the MIFACE researcher to photograph the CNC machine involved in the incident. During the course of writing the report, the autopsy results, death certificate, and police report were obtained, and the MIOSHA file was reviewed.

The company for whom the victim worked was a designer and producer of a wide range of tooling for aluminum extrudes. The company had numerous locations and employed approximately 200 people. It had a written safety program. The corporate safety team had monthly walkthroughs at all plants. The plant safety committee also conducted monthly walkthrough inspections at a time separate from the corporate safety team. Supervisors and the safety committee have the right to shut down an operation if they observe unsafe conditions. All personnel are involved in, at a minimum, a five-minute safety meeting on a weekly basis. Some departments have more frequent meetings. All new employees attend a safety orientation. There are a total of 85 employees at this plant, and approximately 20 employees were on site at the time of the incident. The company did not have a union. The victim was wearing eye protection, Z87 safety glasses with side shields, as required by plant policy.

The firm had 18 machine operators trained to run the style of computerized numerical control (CNC) machine being operated by the victim on the day of the incident. The company had an internal training matrix that specified different training regimens for the various milling machines in its workplace. The operators are required to train side-by-side with an experienced operator. After training is completed and the operator was operating the machine independently, the work leader conducted ongoing inspections of his/her work to determine the amount of scrap pieces produced. The amount of scrap was recorded, and if an operator had too much scrap, then training was reviewed.

The victim had worked third shift the week before; this was his first day on first shift. He normally worked third shift but was on first shift to cover for other employees taking time off. His workday began at 6:00 am. He had been with the company for five years and had been operating the CNC machines for this five-year period. The victim had one and one-half years of experience running the machine on the day shift. The victim was experienced at operating higher speed machines. The victim had been working on the high-speed (7500-10000 rpm) line of CNC machining centers for approximately three years. He had also run and been trained initially on the low speed machines and had spent over a year operating them before moving to the high-speed machines. Approximately a month before the incident, the victim was moved back to the low speed machines and was getting refresher training from two other operators.

MIOSHA did not issue any citations to the employer. MIOSHA recommended that the firm prohibit the use of mild (soft) steel tool extensions and use only properly hardened tooling.

INVESTIGATION

The victim was operating a MC-600-H CNC machine with a spindle capability of 5000 rpm. The machine was purchased new in 1997. See Figure 1. The CNC machine was equipped with automatic tool loading. The machine's tool magazine contained many drilling tools, and due to the various milling operations required, it was often necessary to change from one drilling tool to another in the same milling program. The tool used was mounted in a spindle and could move as needed to perform whatever cutting operation was required. The material machined was held steady in a fixture or precision vice on a table. The table was moveable, and the computer controlled the movement. The emergency stop button was clearly identified and accessible on the machine the victim was operating.

The CNC machine was coded to run clockwise. The CNC computer screen was 14 inches by 14 inches and digits were approximately 1/8- to 1/4-inch high. The firm had all CNC machines manufactured by the same manufacturer. The CNC machine operations were similar as was the layout of information on the operator's screen. Due to the age of the CNC machine involved in this incident, there was not a feature to limit rpm on the machine; newer machines have this limit within the operation parameter. The company explored this option with the manufacturer and according to the manufacturer the option could not be incorporated into the programming of the machine.

The CNC machine doors were on an angle and opened to approximately 25 inches. The control was approximately one foot away from the doors and was fixed in position by the manufacturer so there was minimal distance between the tool and the control panel. The machine screen was designed so when the operator entered the data, all data showed on the screen, and then the data moved to the bottom of the screen. To lock the tool, the operator pushed a button on the panel.

On the day of the incident, the CNC programmer asked the victim to determine if a 3/4-inch drill that was 10 inches in length "ran true". The company had used this hardened steel/soft steel tool extension in the past for other low-speed applications. The drill's three-inch long tool shank had a 1/2-inch outside diameter (O.D.). The drill was placed in a purchased six-inch long, one-inch O.D. hardened steel tool extension. The hardened steel tool extension had a 1/2-inch internal diameter thread that was connected to an in-house manufactured soft steel tool extension that was 10-inches long and had a one-inch O.D. Two inches of the soft steel tool extension was inside of the tool holder. The victim attached this tooling to the tool holder and pressed the "clamp" button on the computer console. The overall extended tool length was estimated at 24 inches. Figure 2 shows a sample tool (not the tool involved in the incident) placed in a tool holder within the CNC machine with the machine's doors in the open position.

Figure 2. Example of tool in holder within the CNC machine with doors open

The CNC machine was operating in manual data input mode. The victim entered the rpm for the spindle rotation. Testing speed was 300 rpm. Instead of entering 300 rpm, he apparently entered 3000 rpm. The machine doors were wide open and the machine was in override mode. The victim pressed the start button. The override was set for 110%, therefore the actual spindle speed was 3300 rpm; 3300 rpm was reached almost instantaneously. The victim was standing near the open door looking at the tooling operation. After checking and ensuring that the tool was running true, the victim nodded to the programmer indicating that everything was operating appropriately. A high-speed mill and programming supervisor, who had just spoken to the victim and was approximately 30 to 50 feet away on the opposite side of the machine, heard the machine vibrating and shaking. Then he heard a bang.

The spindle speed force exertion caused the soft steel tool extension to bend to an approximate 90-degree angle. The bending caused the hardened steel tool extension to strike part of the automatic tool changer. The hardened steel tool extension shattered and released the drill. The drill shank bent approximately 10 degrees. Both the shattered extension pieces and the thrown drill struck the victim. The extension pieces struck the upper side of his cheekbone, his jaw and neck. The drill entered the victim's body below the left collarbone point first. The programmer hit the emergency stop button. The supervisor who heard the bang went to the location, attempted first aid measures and tried to stop the bleeding. Emergency response was called and the victim was taken to the hospital where he died.

MIOSHA examined the CNC machine after the incident. An interlock switch on the doors at the CRT position was out of adjustment. This interlock would prevent the machine from operating if the doors were opened. This non-interlock was not a factor in the incident. It was possible to see damage on the automatic tool change arm. The tool changer swing arm assembly above the machine spindle was dented. Also the dent's distance from the machine's "face" appeared to "line up" with the bent tool extension.

After the incident and in compliance with the MIOSHA recommendation, the company incorporated the use of hardened steel extensions. They also developed a color-coding system when unusual tools are required.

CAUSE OF DEATH

The death certificate indicates that the cause of death is a penetrating wound to the chest. Toxicological tests were not performed.

RECOMMENDATIONS/DISCUSSION

- Conduct a job safety analysis (JSA) when performing non-routine tasks or using non-routine tools.

Although the task was routine (ensuring the tool ran true), the circumstances were not. The company had used this hardened steel/soft steel tool extension combination in the past for other low-speed applications. In this instance, the hardened steel/soft steel tool extension combination was used in a high-speed machine. A soft steel tool extension is more prone to deformation (being bent or broken) when a load is applied than a hardened steel extension. The load, 3300 rpm instead of 300 rpm, caused the soft steel extension to bend. If a JSA had been performed, the hazard presented by the use of the long soft steel tool extension may have been identified and a hardened tool extension used instead.

A written or oral JSA should be conducted before performing any new activity during the shift, any activity for the first time, and for non-routine activities. A written JSA would benefit larger projects while an oral JSA would better suit small short time activities. For each new and/or non-routine activity, a determination of whether a JSA is needed should be made. Ask "what are the hazards?" If several hazards can be identified, then a JSA should be performed. To conduct a JSA, determine the job tasks, what could go wrong, what could the consequences be, how could the hazard arise (are the tools and equipment right for the job and are they in good condition?), what are other contributing factors, and how likely is it that the hazard could occur.

- Use only approved tooling when conducting work operations.

The company was using a homemade soft steel tool extension. When original equipment is retrofitted with homemade tooling or altered, unintentional consequences may result. A procedure for a qualified person(s) to review equipment change, modification or use should be developed and implemented. The company may also wish to consult with the equipment manufacturer to ensure that the tool as designed and intended for use is compatible for the work operation.

- Employee training should include confirming entered program values on a CNC machine prior to initiating the machine cycle.

Although the employee had received extensive training on operating this equipment, the incident still occurred. Familiarity with a task may lead to complacency regarding the steps to be followed to perform a job safely. After the spindle speed value was entered, the value stayed on the computer screen. Employers should emphasize the importance of taking the time to confirm the accuracy of entered values for the program prior to initiating the machine cycle. This is especially important on older computer screens as the numbers fade and become "fuzzy". The victim was currently receiving refresher training; reinforcement of safety training serves to remind experienced workers that they can never become complacent. Reinforcement of the importance of safe work procedures and the expectation that they would be followed is an important element the prevention of injuries.

- Employers should consider reviewing their standard operating procedures to include keeping machine doors closed when possible.

The victim was observing the tooling rotation through open doors. It is unknown if this was a common practice. It is also unknown that if had the doors been closed whether the extension and drill airborne paths would have been deflected or slowed to a degree that may have avoided or caused a lesser injury to the victim. Employers should review machine operation standard operating procedures to determine if what protective measures, such as closing the machine doors during testing procedures can be identified and are appropriate for the operation.

- Employers should evaluate whether providing additional reinforcement for machining window areas is appropriate.

The window area, both for the viewing area of the machine and the windows in the door were a thermoplastic, polycarbonate resin that had high impact strength. These window areas could be reinforced against impact, especially on high-speed machining centers, with a chicken wire mesh-type material. The selection of such material should not create additional hazards, such as reduced visibility.

- Employers should ensure equipment is maintained according to manufacturer instructions.

Although not a factor in this incident, an interlock switch on the doors at the CRT position was out of adjustment. An out-of-adjustment interlock switch could be a contributing factor in a future injury/fatality. Newer machines have a program override to ensure that doors may not be open when machining is being performed.

Maintenance of equipment is an especially important means of anticipating potential hazards and preventing their development. Planning, scheduling, and tracking preventive maintenance activities provide a systematic way of ensuring that they are not neglected. Maintenance and servicing equipment is a prerequisite to a properly working, functional machine. I

The employer should provide regular preventive maintenance following the manufacturer's recommended schedule and retain complete maintenance records. Preventive maintenance is an organized, planned program to prevent the gradual breakdown or sudden failure of machines and equipment. It includes periodic cleaning and lubrication as well as regular inspections of machine functions to detect faults. A preventive maintenance program includes maintenance schedules, procedures for keeping records of maintenance work, and procedures for ensuring the availability of spare parts.

REFERENCES

Occupational Safety and Health Administration. Job Hazard Analysis. OSHA 3071, 2002 (Revised). Internet resource: http://www.osha.gov/Publications/osha3071.pdf

MIFACE
Investigation Report #04 MI 180
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To improve the quality of the MIFACE program and our investigation reports, we would like to ask you a few questions about this report:

Please rate the report using a scale of:

Excellent	**Good**	**Fair**	**Poor**
1	2	3	4

What was your general impression of this MIFACE investigation report?

Excellent	**Good**	**Fair**	**Poor**
1	2	3	4

Was the report…	**Excellent**	**Good**	**Fair**	**Poor**
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How will you use this report? (Check all that apply)

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