EMPLOYEE HAND THERMAL BURN INCIDENT

Case Study

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A division of a large multinational company[1] makes a variety of polymer products. In addition to manufacturing existing products, this division also develops new products and processes. Three production technicians were working to start-up an extruder for an experimental product on the evening shift. As part of the process of starting up a new trial material, they purged the system and were cleaning out a key component, the water box, Figure 1. The technicians are required to wear specific personal protective equipment (PPE), including leather gauntlet gloves with an insulated palm. These gloves are typically used to handle hot metal parts during a turnaround. One technician was using a long-handled spatula to scrape residual polymer from the component. A second technician noticed that some molten material was still present, and had begun to drip down or "drool" out, potentially entering the piping directly below. The technician instinctively reached in with their gloved hand to prevent contamination to the piping. The molten mixture stuck to the gloved hands, resulting in second degree burns to the backs of the fingers on both hands. The worker was initially treated on site, and then transported to a local hospital. Upon release from hospital, they returned to work to brief their supervisor on the incident, and then went home.

The Safety Health and Environment (SHE) leader at the site was required to investigate this incident and make suitable recommendations.

Figure 1: Fully open water box

[1] This is a description of a real incident, but the name of the company has been removed at their request.

Polymer Production

Plastic products are ubiquitous in modern society. The wide range of use reflects the number and variety of polymers available, each having specific physical properties making them suited to a particular application. A wide variety of product manufacturing processes (such as injection moulding, blow moulding, extrusion, film blowing, etc.) have been developed, enabling the manufacture of an almost limitless variety of different products.

The polymers themselves are produced from a wide variety of low-molecular-weight monomer feedstocks, which may be derived from petroleum products, recycled plastic products, or renewable resources (such as cellulose from wood). These monomers undergo polymerization reactions under carefully controlled conditions to produce high-molecular-weight polymer. Different polymers are formed depending on the particular monomer feedstocks used, reaction conditions, and additives used. The required properties of the polymer are dictated by the end-use considering factors such as cost, density, heat resistance, chemical resistance, impact strength, etc. Polymers are typically formed into pellets that can be easily transferred to product manufacturing facilities.

The production of the pellets, called pelletization, is a key part of this overall process and is accomplished by an extrusion process. A hot well-mixed polymer "melt" is created (this step often includes the blending of different polymer materials and additives) to produce a viscous material which is extruded through a die (a series of small holes) into a water-filled chamber called a water box. The water flow quickly cools and solidifies the strands of molten material so that it can be cut into small solid pellets by a rotating cutting head. The pellets are transported out of the water box in the flowing water, before being separated and dried, ready for packaging and shipment to downstream processers.

Pelletization is a continuous process which requires precise control of ingredients, temperatures, and flow rates. These parameters must be properly adjusted at the start of the process, while pellets are being made. The production of start-up material, also known as purge material, is packaged as rework and fed back into the process once all parameters have been met. This often requires trial and error, especially with new material combinations. To begin the start-up phase the cutter remains disconnected and rolled back away from the die end of the auger while the auger is being purged or filled with material. A metal sleeve (spool piece with handles) is slid into the water box and attached to the die during the pre-start-up purge stage. The extrusion process is started by raising the temperature and starting the screw auger while extruding material from the die (drooling into a bucket or onto the floor). This is important to ensure the auger is full of polymer and the die holes are full (no air pockets). Once steady-state has been achieved, and there are no more air bubbles, the auger is stopped to stop the flow of material. The die face and spool piece inside the water-box are scraped clean of residual molten polymer. The die face and spool piece are cleaned with a long-handled spatula (drool tool). In most cases, very little material remains on the outside surface of the die face and it can be quickly removed through scraping with the drool tool. The spool piece or "water box sleeve" is removed and the cutter head is then 'buttoned up' (put in place and the water-box sealed), water flow is started, the cutter is spun up, and the auger is restarted to begin processing. This process must happen quickly so that the material remains molten and material in the die face holes does not freeze upon contact with the water.

Incident Details

For the incident in question, three technicians were starting a run for a trial material. This was the third of four different materials to be trialed in the course of a few days. The material was significantly different from materials they were used to: it had a higher operating temperature (220°C more), a lower viscosity, and was 'stickier'. This trial included three technicians, one close by at the control station, and two at the water-box. All were wearing standard personal protection equipment (PPE) for working at the water-box, including leather gauntlet gloves, insulated only on the palms. The purge was started at around 8:30 pm and reached steady state at around 10:20 pm. When the auger was stopped, there was a ribbon of molten material extending from the die to the cutter spool. One operator worked to clean the spool with the long-handled spatula. After this, the second operator returned the spool to the cutter, with their back to the first operator. The first operator noticed that there was some molten polymer starting to drool down into the water-box from the supply side. Knowing that this material could solidify in the water piping, which would require significant effort to clean, and necessitate a shut-down of this trial, they instinctively reached their right hand into the water-box to catch the drool so that the test could continue. The second operator buttoned up the cutter and the process restarted.

The molten polymer stuck to the first operator's glove. They tried to remove the material from their right hand with their left. Now both hands had molten polymer on them. They were able to remove the left glove by shaking it towards the ground. However, the right glove would not come off. The technician crouched down to use their foot to step on the glove and remove it. Once the gloves had been removed, they proceeded to grab another set of gloves. It was only at this point that they noticed the extent of the injuries to their hands. The molten material was less viscous and stickier than others previously used, so the very hot material had covered the back side of the fingers in the time required to catch the drool and during the various manoeuvers used to remove the gloves.

About three minutes later, the worker reported to the lead hand that they had to leave the area. They walked through the control room and asked a crew member to page the crew leader as they were on route to the nurse's station. The injured employee ran water over their hands and the crew leader applied first aid. An ambulance was called shortly thereafter. The worker was treated and released from the hospital within a few hours. They returned to the site, reported to the crew chief, and then went home.

Situation of Concern

The site Safety, Health and Environment (SHE) leader was required to investigate this incident. Several additional background items came to light as part of the investigation. As per normal safety and operational procedures, a test protocol had been created and test authorization had been completed and signed off on by the technical and operations manager. The technical and operations managers had met to discuss the process and related issues, but safety was not specifically addressed. The site had previously run one of the four materials, as well as commercial grade materials, at similar temperatures. No special precautions were therefore identified. The injured employee had not been present for two shifts prior to the incident, so was not there at the start of this series of trials.

Problem Statement

The SHE leader was required to identify the root causes of this incident and recommend changes to procedures as necessary to mitigate the risk of this type of incident in the future.