Gas Mask

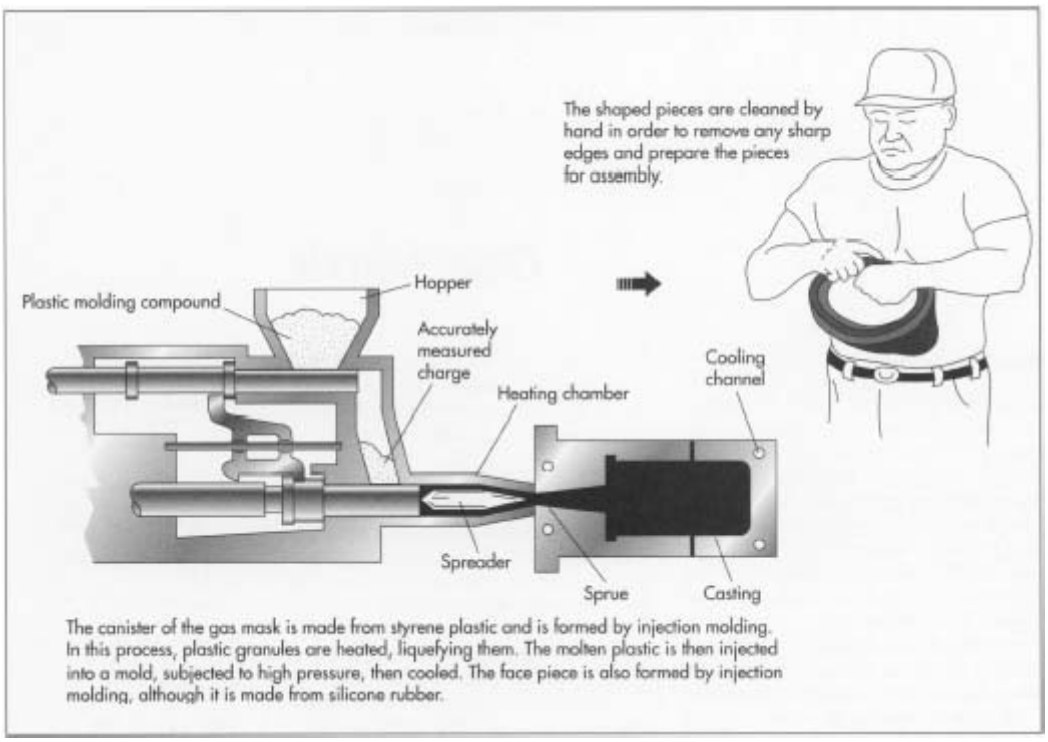
A gas mask is a device designed to protect the wearer from noxious vapors, dust, and other pollutants. Masks may be designed to carry their own internal supply of fresh air, or they may be outfitted with a filter to screen out harmful contaminants. The latter type, known as an Air Purifying Respirator (APR), consists of a tight-fitting face piece that contains one or more filter cartridges, an exhalation valve, and transparent eye pieces. The first APR was patented in 1914 by Garret Morgan of Cleveland, Ohio, an African American inventor also credited with major improvements in the traffic signal. When the Cleveland Waterworks exploded in 1916, Morgan showed the value of his invention by entering the gas-filled tunnel under Lake Erie to rescue workers. Morgan's device later evolved into the gas mask, used in World War I to protect soldiers against chemicals used in warfare.

A gas mask is a mask put on over the face to protect the wearer from inhaling "airborne pollutants" and toxic gases. The mask forms a sealed cover over the nose and mouth, but may also cover the eyes and other vulnerable soft tissues of the face. Some gas masks are also respirators, though the word gas mask is often used to refer to military equipment (e.g. Field Protective Mask, etc.) (The user of the gas mask is not protected from gas that the skin can absorb.)

Since that early time, there have been significant advances in gas mask technology, particularly in the area of new filtration aids. In addition, masks have been made more comfortable and tighter fitting with modern plastics and silicone rubber compounds. Today APRs are used to filter many undesirable airborne substances, including toxic industrial fumes, vaporized paint, particulate pollution, and some gases used in chemical warfare. These masks are produced in several styles, some that cover only the mouth and nose and others that cover the entire face, including the eyes. They may be designed for military as well as industrial use but, even though the two types are similar in design, the military masks must meet different standards than those used in industry. This article will focus on manufacture of the full face type of mask used for industrial applications.

Raw Materials

A full-face gas mask consists of a filter cartridge, flexible face covering piece, transparent eye lenses, and a series of straps and bands to hold the device snugly in place. The filter cartridge is a plastic canister 3-4 inches (8-10 cm) across and 1 inch (2.5 cm) deep, which contains a filtration aid. Carbon based filtrants are commonly used because they can adsorb large quantities of organic gases, especially high molecular weight vapors like those used in chemical warfare. However, inorganic vapors are not usually strongly adsorbed on carbon. The adsorptive properties of carbon can be enhanced by impregnating the particles with specific reactants or decomposition catalysts. Such chemically treated carbon is known as "activated carbon." The type of activated carbon employed in a given filter cartridge depends on the specific type of industrial contaminant to be screened. For example, carbon treated with a combination of chromium and copper, known as "Whetlerite carbon," has been used since the 1940s to screen out hydrogen cyanide, cyanogen chloride, and formaldehyde. Today, due to concerns about chromium toxicity, a combination of molybdenum and triethylenediamine is used instead. Other types of activated carbon employ silver or oxides of iron and zinc to trap contaminants. Sodium-, potassium- and alkali-treated carbon are used to absorb sewage vapors (hydrogen sulfide), chlorine, and other harmful gases.



The canister of the gas mask is made from styrene plastic and is formed by injection molding. In this process, plastic granules are heated, liquefying them. The molten plastic is then injected into a mold, subjected to high pressure, then cooled. The face piece is also formed by injection molding, although it is made from silicone rubber.

The "skirt," or face-covering piece, of the mask is used to hold the other components in place and to provide a secure seal around the face area. Depending upon mask design, an exhalation valve may be inserted in the face piece. This one-way valve allows exhaust gases to be expelled without allowing outside air into the mask.

The eyepieces used in gas masks are chemically resistant, clear plastic lenses. Their main function is to ensure the wearer's vision is not compromised. Depending on the industrial environment in which the mask is to be used, the eyepieces may have to be specially treated to be shatterproof, fog resistant, or to screen out certain types of light. Most gas mask manufacturers do not make their own eyepieces; instead they are molded from polycarbonate plastic by an outside supplier and shipped to the manufacturers for assembly.

The elastic straps that hold the mask on the face are typically made of silicone rubber. Supplementary straps may be added to allow the mask to be comfortably hung around the neck during breaks in work.

Design

The design of the mask itself varies by the industrial application. Some masks are designed with speech diaphragms, some are built to accept extra filters, and others are made to be connected to an extenal air supply. Although the fundamental design does not vary for a given type of mask, the kind of filtrant used will vary depending on the product's intended use. Manufacturers stock a variety of mask styles and cartridge filtrants. When they receive orders for a specific type of mask, they can custom design a mask that has the appropriate features.

The Manufacturing Process

1. The canister is made from styrene plastic, which is resistant to water and other

chemicals, has good dimensional stability, and is specially designed for injection molding. Injection molding is a process by which molten plastic is injected into a mold under high pressure. The mold used for gas mask canisters consists of two disk-shaped pieces of metal that are clamped together. The plastic resin is liquefied by heating and then injected into the mold via an injection plunger. The mold is then subjected to high pressure. Most injection machines compress the mold with a pressure ranging from 50-2,500 tons (51-2,540 metric tons). After the molten plastic has been compressed, cooling water is forced through channels in the mold to cool and harden the plastic. The pressure is released, the two halves of the mold are separated, and the finished canister is ejected.

Styrene is a thermoplastic resin, which means it can be repeatedly remelted, so the scrap pieces can be reworked to make additional canisters. Therefore, there is very little wasted plastic in this process. A similar molding process is conducted to create small circular screens that fit inside the canister. The screens are designed to hold the activated carbon in place inside the cartridge. As the canisters travel down the assembly line, one screen is inserted, the

canister is filled with the appropriate filtrant, then the second screen is put into place.

2. The face piece is injection molded from silicone rubber. Silicone rubber has outstanding stability, is resistant to high temperatures, and can conform to curves in the face and head. It is also thermoplastic and can remolded as necessary. The molding process is very similar to the one described above. After molding the skirt must be removed from the mold, and any rough edges must be cleaned off by hand before the other components can be attached.
3. The pieces are assembled on a partially automated assembly line with two to four line workers supervising the process. The completed filter canister is attached to the face piece and the eyepieces are inserted and held in place with adhesive. Finally the straps and bands are attached to the face piece with metal rivets. When assembly is complete, the mask is given a final quality check. When the masks pass inspection, they are identified with the appropriate markings in accordance with the American National Standard for Identification of Air Purifying Respirator Cartridges and Canisters. The finished masks are packaged for shipping. The containers used to package the masks must also designate the identity of the mask. Furthermore, they must be designed for easy access if the masks might be used in the event of an emergency.

Byproducts/Waste

Depending on the type of chemical treatment the activated carbon has been exposed to, it may be classified as chemical waste. This is the case with some filtrants, such as chromium-treated carbon. The injection molding process used for the canisters and the face pieces generates little waste since any lost resin can be remelted and used again. The lenses are manufactured by an outside vendor, so gas mask manufacturers do not have to address the issue of waste polycarbonate.

Quality Control

Gas masks, and air purifying respirators in general, are regulated by the Code of Federal Regulations (CFR). These regulations specify the type of masks to use for a

specific application. Examples of the different mask types recognized by the CFR include self-contained breathing apparatus, non-powered air purifying particulate respirators, chemical cartridge respirators, and dust masks. The regulations stipulate the exact kind of testing that must be done to ensure the quality of the finished product. The type of testing depends on the masks' final application, that is, what kind of contaminants it will be expected to filter. The CFR specifies the types of contaminants that the gas must be tested with, and it also stipulates the conditions under which the testing must be conducted. For example, some masks must be exposed to the contaminant for long periods of time. Others must be tested under specific temperature and humidity conditions. This is done by drawing an air stream contaminated with a known amount of poison through the mask. The amount of time required for the contaminant to saturate the filter and begin to pass through is then measured.

Testing is done at several points in the manufacturing process. There is an initial inspection of incoming goods to ensure they meet minimum quality specifications. This includes the filtrants, the resins used for molding, and the finished eyepieces as they are received. The canister must be tested after assembly to ensure it has proper seal and that the carbon filter works. The gas mask is tested once again after all componentry has been assembled. The final mask may be placed on a mannequin head to ensure that the seal is tight and that the mask maintains its seal in movement.

The Future

Over the last 80 years, the basic technology of gas masks has been tested repeatedly, and so is not likely to change in the future. The challenge for the APR industry will be to develop products for special purposes, such as infant respirators or masks for persons with head wounds and other disabling injuries. The future of these products also relies on advances in the material sciences, which allows production of smaller, more lightweight products. In fact, current research efforts in carbon chemistry are anticipated to result in the development of a filter canister that is only half the size of the current standard and is more effective. These and other improvements in materials will result in new generations of respirator devices for industrial use, as well as for medical and military applications.