The Future of Plastics

By John D. Welsh

PLASTICS in one form or another have been a part of our daily lives for more than a quarter century. The first plastic made its appearance more than 75 years ago. The first plastic in molding powder form was developed and put on the market about 1909. Since that time the family of plastics has been added to until to-day we have a group of about 15 different basic materials which, according to the popular magazines, are about to usher in the Plastics Age.

This review will, therefore, tell something of what the different plastics are —what they can do and are doing—as well as a hint as to what they may be honestly expected to do in the post-war years.

The way in which plastics have stepped into the breach during World War II has given industry a new and amazing insight into the possibilities of plastics. The ease and rapidity with which plastics can be fabricated in large volume to desired shapes and true dimensions direct from molds made it possible for the plastics industry to undertake an important role in the early critical stages of Canada's war effort. Those were the days when certain metals, rubber and other vital materials were in short supply. The plastics industry mobilized to meet the challenge of pressing demands for output of unprecedented variety and volume.

The aircraft industry, for example, called for transparent bomber noses and gun turret enclosures, for instrument panels and antenna housings, and many other parts and components. Canada's young plastics industry delivered the goods. "Many of these items, molded to exacting specifications and close dimensional tolerances, with molded-in threads, holes and undercuts, represent a high degree of ingenuity and engineering skill. More important than the saving of critical metals in these parts, has been the tremendous decrease in man-hours required."

Let us agree upon a definition of the term plastics as it is used to-day. The term plastics is applied to a group of materials which, though rigid and permanent in use, are plastic at some stage in their manufacture and are shaped or formed by the application of heat or pressure or a combination of both heat and pressure.

Plastics are organic materials, mainly synthetic, but they include the semi-synthetic cellulose group as well as casein. The term plastic is, in its own field, analogous to the term metal. It is a family name, whose individual members may be as different from each other in appearance and characteristics as are iron and lead.

This definition of plastics excludes inorganic materials such as metal and glass which can be softened by heat and will harden when cooled.

The range of organic compounds having suitable structure for the formation of materials having plastic properties is so extensive, that it is possible to produce a plastic material to satisfy any given set of requirements within the limits set by economic considerations. This means that the range of plastic products will continue to expand.

The term plastics was selected as a generic name because the ease of molding these materials appeared to be their outstanding characteristic. But a large percentage of the total volume of the materials now classed as plastics are not molded at all. Some are cast and machined, others are laminated and rolled, many are used in protective coatings such as paint, and as an adhesive for plywood bonding.

However, all plastics fall into one of two groups, the thermoplastic and the thermosetting types. Briefly, thermo-

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plastics are those that once formed into shape can be re-shaped by heat. A thermosetting material is one that once formed by heat cannot be reformed.

Pyroxylin was the base for the first commercial plastic. It was not developed because someone foresaw that one day it would be used for spectacle frames, buttons, badges, eyeshades, babies' rattles or washable collars. Rather, its discovery was an accident. A young American printer was trying to develop a substitute material for the manufacture of billiard balls. After countless futile attempts to create a synthetic ivory he finally treated some cotton cellulose with nitric acid and discovered what we now know as pyroxylin plastic or celluloid or "Pyralin" (cellulose nitrate). This plastic has been modified considerably since its original discovery and literally thousands of different articles have been made from it.

First of the thermosetting plastics, and first to be available in molding powder form, Bakelite was discovered by Dr. Leo Baekeland during his search for a suitable substitute for shellac. Following the commercial development of Bakelite there was a considerable lapse before any really new plastic appeared.

But when new plastics did come on the scene, they did so not by accident but because man wanted new materials for certain specific uses. Indeed, the purpose has not always been known before the plastic was developed.

Plastics' excuse for existence is that they do a good job, cheaper perhaps, certainly better than some natural material could do the same job.

Plastics are chemical products and they depend for their raw materials very largely upon the chemical industry. The basic raw materials are coal, water, air and limestone. But elaborate and costly plants are necessary to convert these plentiful raw materials into the required plastic form. These forms may be rods, sheets, tubes or molding powders.

There are several systems of molding and each system is particularly adapted to certain types of materials. Compression and transfer molding are generally used for thermosetting materials. The injection molding process is used in nearly all cases for the thermoplastic materials.

The injection molding process is simply a further development of the die casting of metals. The complete molding cycle may be as low as 20 seconds and the rate of production is very high. A metal object may have to be built up from several separate pieces, the making of which may involve a wastage of 25 to 50 per cent of metal. The same object in plastic, polished and colored throughout, can be produced, one, two or a dozen at a time in less than a minute, with virtually no waste of raw material.

Perhaps the most important advantage of plastics is their ability to reproduce in faithful detail the most intricate design of the mold or die. The die maker is an important part of the organization behind the production of plastic items. Plastic objects must have a smooth finished surface which does not scratch readily, and this smoothness depends upon the finish on the die.

The mechanical properties of plastics are difficult to describe in general terms. They can be varied considerably by the composition of the molding powder used —that is, by the use of different or varying quantities of plasticizers and fillers.

Roughly speaking, plastics can be said to be somewhat stronger than wood but not as strong as some metals. They are heavier than wood but lighter than some metals such as aluminum. Usually they are more brittle than wood or metals and, in general, do not stand impact to the same degree. They can, however, be varied in properties so that they withstand considerable impact. For example, "Butacite" (polyvinyl butyral) is used as an interlayer in safety glass. If the glass is broken by impact, the pieces adhere and do not scatter. This is due to the fact that the plastic acts as a tough elastic adhesive.

Plastics are adapted pre-eminently to mass production. They are pleasant to touch, light in weight, incorrodible, in many cases self-colored, unbreakable for many practical purposes, without grain, of equal strength in all directions, available in every degree of thickness and flexibility.

The designer in plastics has at his disposal materials which cover a wide range of physical, thermal, electrical and chemical properties. His choice of the correct material is as important as the choice between nickel steel and cast aluminum is to the designer in metals.

Let us look at a few typical applications of some of the different plastics. Pyroxylin plastic has gone to war in such uses as aircraft mileage indicators, binocular parts and navigation guides. Civilian applications include pens and pencils, clock dials, optical frames and drawing instruments. Shoe lace tips of this material have solved a war-time problem by replacing three pounds of metal by one pound of plastic; they last longer and eliminate cuts and scratches; they do away with the finish problem because the color of the plastic is not skin-deep but goes all the way through.

The acrylic plastics include methyl methacrylate, commonly known as "Lucite"—one of the most fascinating of all plastics. This is a light, transparent material, actually four per cent more transparent than glass and about half its weight. It is doing an outstanding war job in bomber noses, gun turret enclosures, and flying light lenses. It has one remarkable quality which may be described as internal light reflection. In other words, it bends light and can literally pipe light around curves. This property is of great value in surgical and dental instruments. "Lucite" is also used for magnifying glasses, cutlery, highway reflectors, and artificial eyes. Thousands of people including many members of the armed forces now wear contact eye lenses of this plastic. These lenses, which are worn for the correction of vision, weigh only 40 per cent as much as optical glass and are, for practical purposes, unbreakable and invisible. A further development of this plastic is "Lucitone," which is used extensively for making dentures.

The phenolics, or phenol-formaldehyde plastics, are typified by "Bakelite" and are widely used in electrical parts, buttons, ash trays and the like. Large quantities have been sent to war in land mines, tank parts, hand grenades, protective helmets and telephone equipment.

A disadvantage of the phenolics is that pure colors are difficult to obtain. This led to the development of heat-setting urea-formaldehyde plastics such as Plaskon which could be obtained in hundreds of shades until war conditions made it necessary to confine that range to a modified diversity of colors. Melamine-formaldehyde type Plaskon is useful for electrical insulation, tablewear, buttons, caps and closures. Its chief advantage over the urea-formaldehyde type lies in its greater resistance to the effects of heat and moisture.

Another important group is the laminated phenolic plastic type including Micarta, Formica and Dielecto. Quiet gears made of these materials have long been in use. Laminated plastics are easily machined, sawn, punched or sheared into intricate shapes at high fabricating speeds.

Metal, wood, paper, leather, cloth—even glass—may be inter-laminated with synthetic resin adhesive to result in a component which will resist moisture, fungi, bacteria and extremes of heat and cold. Wood test pieces bonded with Plaskon glues and subjected to shear tests fail to show the strength of the glue since the wood itself fails before the glue line begins to weaken. Test pieces immersed in water for more than a year show no signs of deterioration of the glue line.

Although many of these plastics are now being molded or fabricated in Canada, only three are actually being made in Canada. These are vinyl chloride, vinyl acetate and phenol formaldehyde.

The relatively small consumer market in Canada is likely to limit Canadian production of plastics—that is, the manufacture of the raw materials. A plastics manufacturer is a manufacturer of plastics in such forms as sheets, rods, tubes and molding powders, for use by others in the manufacture of plastic articles. The correct term for those who use plastics in their manufacturing operations is a "molder" or "fabricator."

At the present time there are 44 molders operating in Canada but the list is growing. These are concentrated in the mid-eastern industrial area where the largest consumer markets exist.

The type of labor required is, generally speaking, semi-skilled. Women are being used effectively for inspection and other repetitious jobs.

Largest potential uses of plastics in Canada are likely to be: (1) for plywood and other resin glue applications; (2) electrical insulation and parts; and (3) novelties. The transportation industry promises to be a sizeable consumer of plastics in various forms. In the construction field, notably housing, a variety of applications are possible and a number have already been proven in actual use. The chemical and process industries represent an important potential market by reason of their extensive use of piping, fixtures, etc.

The kinds of plastic articles which may be made in Canada after the war depend upon many factors, including tariff protection. The problem of export markets is deserving of special attention. Canada's possession of vast timber resources and her war-time production of plywood components for military aircraft and other needs, provides a background that can be turned to the manufacture of furniture and other wood products likely to find ready acceptance in world markets. Canada may be the world's largest exporter of plywood in which modern synthetic resin glues now form so vital a part. Canada may also be active in the sphere of plastics manufacture utilizing waste wood products.

It must be admitted that some misuse of plastics has occurred during recent years. This probably branches from the tendency in industrial, business and trade circles to apply the term "plastics" to plastic materials of widely varying properties and characteristics. Some articles in which the wrong type of plastic was used, have been made and marketed with consequent dissatisfaction on the part of the consumer who is inclined to form a poor opinion of all plastics. The need for education is recognized, and forward-looking manufacturers and molders are planning an active scheme of education that will help to keep the right plastic in the right place.

The speed up in research and production has resulted in a phenomenal expansion in range of applications and volume of production. Plastics are emerging from the narrow field they once occupied, comprising mainly the manufacture of small articles. Plastics are firmly entrenched in new and larger fields.

Many projected applications for plastics are still in the blueprint stage. Until the manpower and productive facilities required to perfect these plans have been released from war work, it is too early to predict what the post-war years will offer. The exception will be those applications for which plastics had been available in pre-war years and in which plastics had been well established.

In the post-war period all industry will face a product-starved market, both domestic and export. Plastics will continue to fill the gaps among available materials. But they will go even further, by permanently replacing some of the older materials whose places they take to-day as war-time substitutes.

Plastics are more than substitute materials. They will spur competition on the part of other materials, thus contributing to the opening of new markets, the creation and meeting of new needs.

These processes will, in turn, result in more jobs for more people, more consumers for more and better products for peace-time living.