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POLYMERS AS DESIGN MATERIALS FOR TOY INDUSTRY

A Thesis in
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ABSTRACT

In this thesis it is intended to investigate the superiority of plastics as a material for a specific product design. Plastics with their intrinsic capabilities, have too many improved characteristics to offer to individuals which makes any research very valuable.

When making this research, the methods to be employed were not only limited with library researches but also contained bilateral relations with various producers of either the material or the toys. Under the light of these findings and experiences the formation of the most convenient material was selected for the product. The second point was to design a toy and/or a system for children which would help them get prepared for the coming years. It is found out that, for children toys are more meaningful when combined with their imagination. That is why it is intended to design for preschool children when their imagination is as pure as it can be.

Finally it is concluded that with the debut of plastics materials in individuals lives, the characterization of forms, functions and ideas were highly and easily achieved.

ÖZ

Bu tezde,bir malzeme olarak plastiklerin, özel bir ürün tasarımı için üstünlüklerinin araştırılması amaçlanmıştır. Plastikler iç yapılarından kaynaklanan yeterlilikleri ile, her bireye birçok iyileştirilmiş özellik sunabilmektedirler ve bu da konu ile ilgili her araştırmayı değerli kılmaktadır.

Bu araştırma yapılırken, uygulanan araştırma yöntemi, salt kütüphane araştırması ile sınırlandırılmamış, ayrıca hem oyuncak hem de malzeme üreticileri ile irtibata geçilmiştir. Edinilen bilgi ve tecrübeler ışığı altında, ürün için en uygun malzeme seçimi yapılmıştır. Ikinci aşamada, çocukları gelecek yıllara hazırlayabilecek bir oyuncak ve/veya oyun sistemi tasarımı çalışmaları yer almıştır. Oyuncakların, hayalgücü ile birleştirildiklerinde, çocuklar için daha anlamlı oldukları belirlenmiş ve bu yüzden hayalgüçlerinin en saf olduğu okul öncesi dönem için bir tasarım geliştirilmesi yoluna gidilmiştir.

Son olarak ise, plastiklerin bireylerin hayatına girmesi ile, formun, fonksiyonun ve de fikirlerin şekillendirilmesinin ve değerlerinin iyileştirilmesinin çok daha kolaylaştığı belirlenmiştir.

LIST OF FIGURES

LIST OF TABLES

TABLE OF CONTENTS

CHAPTER 1

INTRODUCTION

"What material may be as hard as stone, as transparent as glass, as elastic as rubber? What material that can be strong yet light, moisture and chemical resistant, and any of a rainbow colors?" (Richardson 1989, p.1). It is proven that by the year 2000 production by volume of plastics will surpass that of steel and all other combined materials which proves that today is the age of plastics.

Plastics, with such a percentile and potential of use, deserve to be investigated. In this thesis it is aimed to make a research on this topic, for there were many studies both on plastics and children but almost none on what is in the intersection of two. The intersection point is of course, toys made of plastics. Plastics enter the lives of individuals in the very early years. Children get in touch with this material when they are only a new born or in another words, at the very beginning .

Toys are the products that all of us have had in our minds carved in our early years when not much of things had so much value. They are fun, freedom, the basic tools to enrich our lives. They are the tools children can put the blame on and scold yet share their anger, happiness, and sorrow. At any given moment, toys and play may engage a child's physical intellectual and emotional being. From their early days on children need toys for quiet time and active time toys for indoors and out, toys for playing alone and together. Toys for everything that consists life. That is what makes them very important for humanity.

In this thesis, by making a research about toys, as mentioned at the top, it is intended to fill the gap of a source, about the intersection point of both children and polymers, which led this thesis to start with polymers, continue with children and finally have the intersection designed.

1.1 POLYMERS

The word polymer is derived from the Greek poly, meaning many, and meros, meaning unit or part. Polymers are also called resins(incorrectly), macromolecules (from the Greek macros meaning long), elastomers, and plastics.

Elastomer describes any polymer that can be stretched more than two hundred percent. The American society of testing materials(ASTM) defines an elastomer as " a polymeric material which at room temperature can be stretched at least twice it's original length and upon immediate release of the stress will return quickly to approximately it's original length"

The word plastic is an adjective meaning pliable and capable of being shaped by pressure. It is often incorrectly used as the generic word for the plastic industry and it's products. A major reason for confusion is that the word may be used as a noun or as an adjective with both singular and plural meanings.

The word plastics comes from the Greek word plastikos. It means " to form or fit for molding." The society of the Plastics Industry has defined plastics as follows:

Any one of a large and varied group of materials consisting wholly or in part that a combination of carbon with oxygen, nitrogen, hydrogen, and other organic or inorganic elements which, while solid in the finished state, at some stage in its manufacture is made liquid, and thus capable of being formed into various shapes, most usually through the application, either singly or together, of heat and pressure

Because plastics are closely related to resins, the two are often confused. Resins are gum-like solid or semisolid substances used in making such products as paints, varnishes, and plastics (Richardson 1989, p.2)

A resin is not a plastics unless and until the resin has become a "solid in the finished state". Plastic products are often made from resins that are processed and made solid. Both natural and synthetic resin materials are composed of a series of molecules bonded together with some resins having several thousand molecules.

1.2 Polymer Production

Plastics materials are easily processed. Therefore they have become the perfect substitutes for other materials. On the other hand as an original design material they perform very satisfactory results.

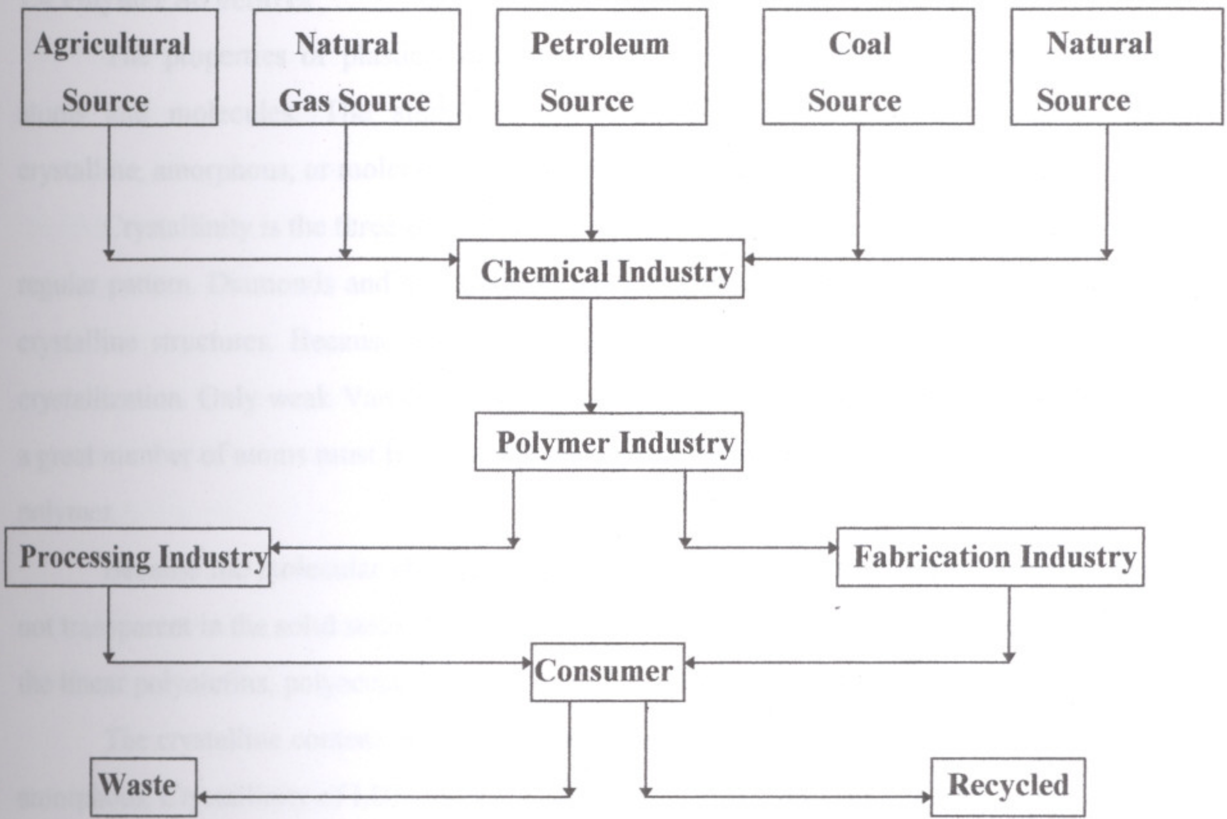


Figure 1.1 Chart of Polymer Production (Richardson 1989, p.10)

1.3 Polymeric Molecules

Molecules of organic materials are composed of carbon as a base element, most commonly joined to hydrogen by covalent bonds. These molecules are referred to as hydrocarbons. As the name suggests, hydrocarbons are composed of hydrogen and carbon. Because of the ability of carbon atoms to link up with other atoms, forming chains, rings, and other complex molecules, thousands of hydrocarbons are known to organic chemist.

At one time, all organic compounds came from plants or animals. Today, coal , oil, and natural gas are good sources of carbon for the chemicals used in making plastics.

Many organic hydrocarbons are obtained directly from plant or animal sources. Oils such as cottonseed, linseed, and soybean oils, lard, and similar products all yield hydrocarbons for plastics production. New techniques in the collection of methane and other gases from sewage sludge may yield additional sources for the chemist.

1.4 Polymer Structures

The properties of plastics are dramatically affected by the arrangement of the atoms and molecules. The atomic arrangement of polymers can be classified as crystalline, amorphous, or molecular.

Crystallinity is the three-dimensional arrangement of atoms, ions, or molecules in a regular pattern. Diamonds and table salt are two common materials with easily observed crystalline structures. Because of the great length of polymer molecules, there is less crystallization. Only weak Van der Waals forces are available to align the molecules, and a great number of atoms must be maneuvered to produce any degree of Crystallinity in the polymer.

Because the molecular chains are only partly ordered, most crystalline plastics are not transparent in the solid state. Partially crystalline (semi-crystalline) polymers, such as the linear polyolefins, polyacetals, and polyamides, are as rule translucent to opaque.

The crystalline content of some polymers may exceed 95%, while the remainder is amorphous. Crystallinity of LDPE is about 65% while HDPE may exceed 95%

The crystallization of bulk polymers is characterized by the forming of large crystalline aggregates called spherulites. The folded-chain molecule alignment is called lamellar (plate like) structure. In ordered polymers, chains are folded back on themselves to produce parallel chains perpendicular to the face of the crystal.

These crystalline structure within the polymers act to scatter light. They give polyethylene and polypropylene a milky appearance. With the use of an electron microscope , X ray defraction, or even the naked eye, it is possible to see these spherulite crystals. With normal processing, a crystalline polymer may begin to form spherulites as it cools. Processing may help align or orient the molecular chains.

The benzene side groups in PS (atactic) normally prevent chain alignment of significant crystal formation. By forcing PS through or around narrow restrictions in molds, some crystalline structures will form. These areas will have a cloudy or milky appearance. Oriented alignment of molecules on one axis may be desirable because this produces greater crystallinity and higher tensile strength . There are hard and fast rules when it comes to crystallinity in polymers. Controlling the crystallization process is a basic consideration in determining the physical properties of the polymer.

Materials that are amorphous meaning, " without form ", have atoms or molecules that are noncrystalline and without ion-range order. Polymers are amorphous in a molten state. A rapid quenching may preserve most of this amorphous state.

Rapid quenching may prevent a large number of the chains from realigning to form crystals. This technique is sometimes used in production of PET and PE to improve transparency.

Amorphous polymers are usually less rigid than crystalline ones. Polymers are transparent if most crystallinity can be prevented. Low-density polyethylene is more transparent if crystallinity is reduced. High density polyethylene is semicrystalline. It has a higher melting point.

Polystyrene is amorphous. It will be clear but more easily attacked by solvents.

The physical size and bonding angle have a significant role in polymer properties. The hydrogen atom is about the same size as carbon.

1.5 Resins

There are number of ingredients of plastics, but resins are the basic organic materials from which plastics are formed. Fillers, solvents, plasticizers, stabilizers, and colorants influence many of the characteristics of plastics. A resin is the polymeric material that helps impart many of the physical characteristics of the solid plastics. It is the molecular arrangement of the resin that determines whether a plastics is thermosetting or thermoplastic.

Thermoplastic materials increase in plasticity with temperature. They become soft when heated and solid when cooled to room temperature. Thermoplastics are easily formed into useful products because weak van der Waals forces allow slippage between the molecules. The molecules themselves are held together by the covalent bonds.

There is a practical limit to the number of times a thermoplastic material may be formed because repeated processing may cause some of the additives to be lost.

Thermosetting plastics are polymeric materials with structural frameworks that do not allow deformation or slip to occur between molecular chains. They are composed of strong, primary covalent bonds and may be thought of as one large molecule.

In thermoplastics, only secondary van der Waals forces, dipoles, and hydrogen bonds exit between chains. In thermosetting materials, heat is commonly used to cause a chemical reaction(polymerization) resulting in crosslinks between chains. While in low molecular mass state, heat and pressure are commonly used to cause the thermosetting material to flow into a mold cavity.

Once solidified, these materials may not be reshaped or formed by applying heat. These plastics have a permanent set once they have been polymerized.

Thermosetting plastics are stronger than thermoplastics, and have a higher product-service temperature. Thermoplastics may hold many process advantages over thermosets, however. A major advantage is that thermoplastics may be ground and recycled into other useful products

1.6 Classification of Polymers

Polymers may be classified by six different systems: source, light penetration, heat reaction, polymerization reactions, molecular structure, and crystal structure (Richardson 1989, p.4)

1.6.1 Source

When classifying polymers by source, there are three principal categories. These are natural, modified natural, and synthetic polymers.

Natural sources of resins include animals, vegetables, and minerals.

Naturally occurring polymers are easily shaped but have little strength. Some common examples are:

Rosin is a byproduct of turpentine distilling. It may be seen oozing out of a pine tree stumps or lumber.

Asphalt, sometimes called pitch, is found in a natural state formed from the decaying remains of plants and animals. Today most asphalt is a by-product of the petroleum industry

Tar is obtained by distilling organic materials. Wood, waste fats, petroleum, coal, and peat are sources.

Amber is a fossilized resin that formed from the oily sap of ancient coniferous trees.

Copal is a resin derived from tropical trees. Copal varies from white to brown in color and it's resins were once used in paints, linoleum, and varnishes.

Lignin is a resinous binder that surrounds each wood cell. The lignin content of wood varies from 35 to 90 percent depending on the species. Today most lignin is used as filler for plastics, or as an adhesive to bind wood chips together under pressure.

Shellac was the first natural resin to be molded. At one time, large quantities of shellac were molded into phonograph records but today, it's primarily used as a filler, wood finish, and electrical insulation.

Modified Natural sources of resins include cellulose and protein.

Modifying natural sources of resins was a natural step toward improving polymeric materials and developing new polymers and product applications. Cellulose is a major part of all plants, thus, it readily available as a raw material for plastics.

One of the purest forms of cellulose is cottonseed oil. These are the short fibers that remain on the cotton seeds after the longer fibers have been separated. Polymers made from cottonseed oil do not yellow and are very transparent. Another major source of cellulose is wood saw.

Other cellulose sources are plant wastes and residues, such as straw, cornstalks, corncobs, grass, and weeds. All of these materials have proved useful, but are difficult to collect and process.

Cellulose is a very complex material and many types of plastics are made from it. There are more than ten basic resins in the cellulose family. The most familiar resins are cellulose acetate, cellulose nitrate, cellulose acetate, acetate butyrate, and cellulose propionate.

Another modified natural resin source is protein, which comes from milk, soybeans, peanuts, coffee beans, and corn. Casein made from skim milk is the only protein-derived plastics that has commercial success.

There are other protein sources including hair, feathers, bones, and similar wastes. There has been little interest in these sources because collection is not easy and there are not many uses for protein-derived plastics. Most are used for adhesives and coatings. Protein plastics absorb moisture and swell , there for items made from them may warp and change shape.

Gelatin is a protein mixture made from bones, hoofs, and animal skins. It is used as an odorless, tasteless, and transparent filler in candies, meats, ice cream, and drugs.

A very important polymer, rubber, is made from a milky juice called latex . When people talk about natural rubber, they are usually referring to elastomers made from latex of the Hevea tree. A mature rubber tree will yield abut 1.8 kilograms of rubber per year. A polymer that is chemically like rubber is gutta percha. Gutta percha trees that yield the milky latex for this polymer are found in Malaya, Borneo, and Sumatra (Richardson 1989, p.3)

Synthetic sources are the most important sources of resins for plastics. Agriculture, petroleum, and coal are the three main sources of chemicals for synthetic plastic materials. The most important of these three is petroleum. As it comes from the earth, petroleum is mainly a mixture of solid, liquid, and gaseous hydrocarbons that are almost useless. In refined forms, petroleum is the largest volume product, other than water, dispensed to people.

Distilling and refining petroleum by a process called fractional distillation yields various crude oil components. These include heavy asphalt and tar, lighter oils, and gaseous portion including propane, butane, and other hydrocarbons.

Residues collected near the bottom of the refining tower include asphalt and thick oils. Lighter fuels (Kerosene, diesel fuel, gasoline, and benzene) are extracted near the top of the distilling tower. Light gases (methane, ethylene, propane, and propylene) are byproducts of further refining.

By varying the portions of hydrocarbons, salt, chlorine, formaldehyde, nitrogen, and other chemicals, chemists create a grate variety of polymers. Hydrocarbons, of course, are the building blocks of polymers. Hydrocarbons also may come from agricultural products, such as cottonseed, linseed, soybean, lard, and safflower. Methane and other gases may come from sewage sludge and crushed coal.

Grain (starch, protein and oil products) has been made into biodegradable plastics, semi-permeable membranes, and protective films. A wide range of plastics are produced from agricultural products. Cornstarch-based plastics film is used as a mulch and protective covering that keeps in moisture and heat. Polyethylene-based resins may be made both photodegradable and biodegradable by incorporating cornstarch into the molecular chain. More than 125 million pounds of petroleum-based plastics film were used as mulch in 1985.

The human race is draining the world's reserves of oil. Soon we will have to use other hydrocarbon sources to produce polymers; as a result, we will need to use more farm and human waste products than we today.

A study of global prospects for energy up to the year 2000 concludes that "oil is essential for just two major uses: transportation and petro-chemical feedstocks."

Plastics technologists are also working on the secrets of photosynthesis. Photosynthesis, the process by which plants convert light and carbon dioxide into sugar, may lead to new ways of producing simple organic chemicals. Bacteria or small plants may ferment sugar to produce alcohol, a raw substance for making many plastics.

1.6.2 Light Penetration

Light is one of the most difficult physical entities to think about. It can be thought of as a ray if lenses are the subject, as a train of electromagnetic waves of varying length if it is the color and as a flow of energy particles if the subject is photoelectric cell.

Optical properties are closely linked with molecular structuring such as chemical bonding and crystallinity. Therefore the electrical, thermal and optical properties of the plastics are interrelated.

Gloss, luster, haze, transparency, color, clarity, and refractive index are only a few of the many optical properties of importance to plastics.

Because many plastics possess unique optical properties they are often classified relative to light penetration. The optical properties summarize this classification.

Opaque-light will not pass through. Cannot be seen through. This means that any light that falls on such a material, will be reflected according to the texture and the color of the plastics.

Transparent-Light will pass through. Can be seen through. This type of plastics have glassy colors. Ethylene vinyl acetate is an example of such a polymer, which is being used in bellows for dolls that can be seen in figure 3.13

Translucent-Light will pass through. Cannot be seen through.

Luminescent has two types; the first one is fluorescent which emits light only when electrons are excited and is usually transparent and the second one is phosphorescent which gives off light energy more slowly than it takes on light. Most of the signs made of plastics are phosphorescent.

Within these specialties, the transparent is the most important type because this kind of plastics replaced a material, the glass. Others appeared with the entrance of polymers in the industry. Plastics, many of which are transparent, arrived on the scene, and not only did they enter into competition with glass in traditional sectors, but they also spread transparency to new marketing areas such as packaging, furniture, and clothing. If a material presents a homogenous structure a light ray can travel through it without disturbance. The medium in this case is perfectly transparent. In general, however, no material exists in this condition; hence, light flow is split up. Radiation with a certain wavelength will pass through, others are blocked, and the quality of flow transmitted is thus changed.

Transparency does not only mean the passage of that range of electromagnetic waves that our eyes are capable of perceiving, but also waves that are outside the field of visible light: ultraviolet (low wavelengths) and infrared (high wavelengths). When a light ray passes from one transparent medium to another, at the moment in which it strikes the surface of the second material, part of it is reflected and part of it is emitted. The quantity and the quality of the light reflected depend on the optical characteristics of the pair of the materials, and on the angle of incidence. The part that penetrates into the second medium may be totally absorbed and transformed into thermal energy. This type of material is called opaque.

The material's transparency depends not only on the quantity and the quality of the energy that passes through it, but also on its ability to transmit images, that is to maintain the order of a beam that of rays. An opalescent material, for instance transmits light with good energy efficiency, but causes the loss of the information carried in the images.

A material, in order to be transparent, need be absolutely homogeneous- it must only be homogeneous with respect to the flow of light. Possible nonhomogeneities do not compromise the transparency if their size is less than the wavelength of the incident light radiation. Therefore, signal crystal and amorphous materials can be considered transparent and semicrystalline plastics are not transparent.

On the other hand, surfaces still play a crucial role. The quality determines the share of energy reflected, and above all- they can cause the loss of that special orderly light flow that is essential to transparency. This depends as much on the intrinsic properties of the material. Among these properties one of the most important, in terms of lasting optical performance, is surface hardness.

Many plastics are transparent- amorphous thermoplastics are transparent, and while semicrystalline thermoplastics are opalescent when used in thin layers, they can also become practically transparent, lastly many thermoset plastics, if they are not filled are also transparent. Plastics therefore, prone to give the chance to create the transparent the entire range of possibilities generated by their remarkable workability.

Finally, it is wiser to consider what is achieved by the transparency. Transparent objects have always possessed three different personalities, often integrated one in another- one is hygienic and functional, one is information related, and the third is esthetic and emotional. Bringing sunlight into a dark space makes it more healthful and improves visibility; seeing through a wall or door means receiving information on what lies on the other side and watching the light's movement is the joy of transparency.

1.6.3 Heat Reaction

All plastics fall into two broad categories with regard to their reaction to heating. They are either thermoplastic or thermosetting.

Thermoplastic materials become soft when heated and solid when cooled to room temperature. This softening and setting may be repeated many times. It is something like melting and cooling wax. When cooled, the plastics become firm.

The most useful members of the thermoplastic group are acrylics, cellulosics, polyamide, polystyrene, polyethylene, fluoroplastics, polyvinyls, polycarbonate, and polysulfone.

Thermosetting materials may not be reheated and softened again. Once the structural framework is set, these plastics cannot be reformed. Useful members of the thermosetting group include aminos, casein, epoxies, phenolics, polyesters, silicones, and polyurethanes.

1.6.4 Polymerization Reaction

Molecules are formed or produced into polymers by two types of reactions: 1) addition polymerization or 2) condensation polymerization.

Most of the polymers are being produced by addition polymerization. In addition polymerization, unsaturated hydrocarbons are caused to form large molecules by using methods such as emulsion, bulk, solution, suspension and the combinations of them. In the condensation polymerization, a polymer different from those produced by the addition method and having varied properties, may be produced. The condensation process is a chemical reaction in which a small molecule, often water, is eliminated from the polymer.

1.6.5 Molecular Structure

Polymers may be composed of different repeating units with different structures. All properties of the polymer are effected by the arrangement of the repeating units. Monomers form five basic molecular structures : 1) linear, 2) branched, 3) cross linked, 4) graft, and 5) interpenetrating

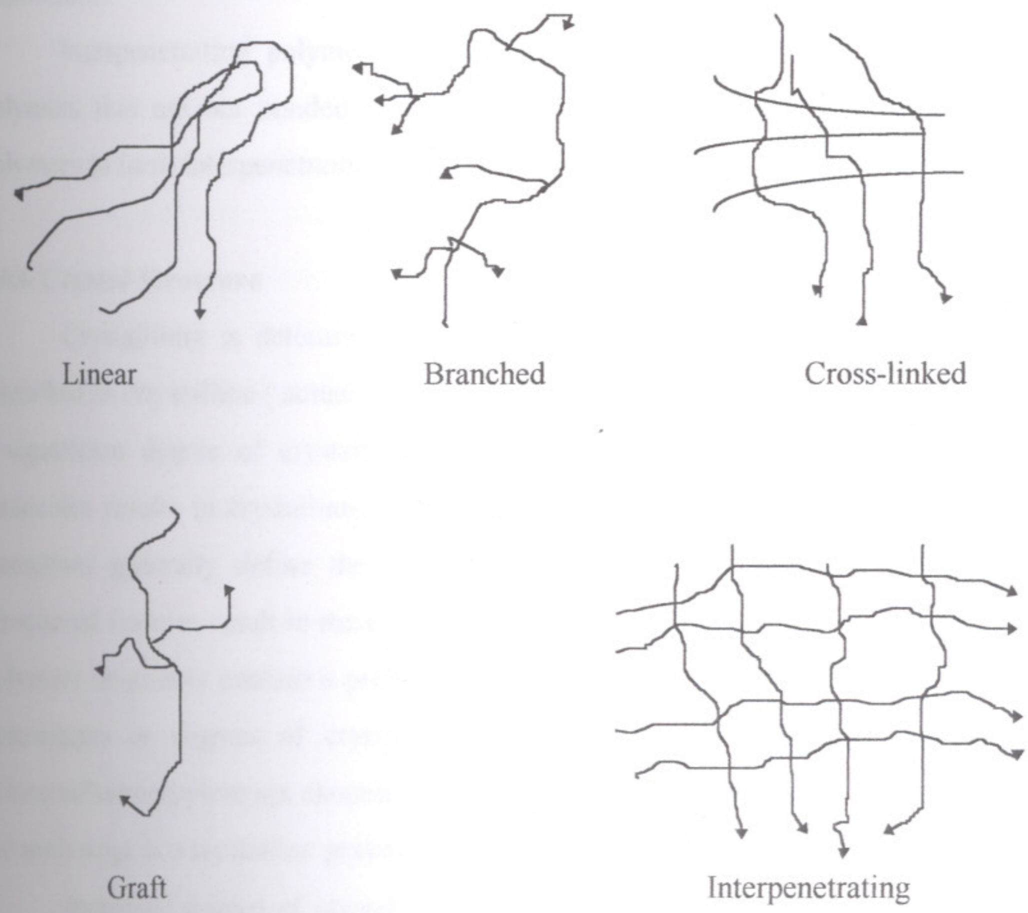


Fig. 1.2. Molecular structure (Richardson 1989, p.28)

Linear structures are long chains of molecules like rope. The primary bonds that hold the monomeric units together within polymers are covalent bonds. In the linear structures there is no branching.

Branched structures represent three-dimensional branching of the linear chain. Low-density polyethylene (LDPE) is a good example of branched polymer as the branches of polyehtylene are irregularly spaced along the chain.

Crosslinked or network structures involve primary, covalent bonds between the molecular chains. For crosslinking there must be number of saturated carbon atoms. This type can be seen in thermosetting plastics.

Graft polymers are similar to the cross-linked and branch-structured copolymers. the side chains permit less movement. As a result the deformation is more difficult- or impossible.

Interpenetrating polymer network is an entangled combination of two cross-linked polymers that are not bonded to each other. The techniques of combining dissimilar polymers to form interpenetrating network results in a plastics alloy.

1.6.6 Crystal Structure

Crystallinity is determined primarily by molecular structure. Polymers may be classified as crtystalline (actual semicrystalline) and amorphous. Many polymers possess a significant degree of crystallinity. The ordered, three dimensional arrangement of molecules results in crystallinity. The skeleton of fibrous aggregates of polymer chains (lamellae) generally define the principal direction of the structure geometry. These directional features result in materials that are generally isotropic. It should be noted that polymers invariably contain a proportion of amorphous material. Polymers have varying percentages or degrees of crystallinity. Polyethylene, polypropylene polyamide, and polytetrafluoroethylene are classed as crystalline or semicrystalline polymers. Only during the melt stage is a crystalline polymer amorphous.

Increased degree of crystallinity raises the melting point, increases density, and generally improves mechanical properties. Increased crystallinity also generally lowers impact strength, solubility, and optical clarity.

Amorphous polymers in contrast lack any internal skeleton or structure. They are generally described as isotropic materials. The random molecular structures of amorphous polymers do not contain crystalline regions. Polystyrene, polymethyl methacrylate, polyester polyurethane, urea-formaldehyde, and epoxy are familiar amorphous polymers.

1.7 History of Plastics

Historians frequently classify the early ages of man according to the materials that he used for making his implements and other basic necessities. The most well known of these periods are the Stone Age, the Iron Age and the Bronze Age. Such a system of classification can not be used to describe subsequent periods for with the passage of time man learnt to use other materials and by the time of the ancient civilizations of Egypt and Babylon he was employing a range of metals, stones, woods, ceramics, glasses, skins, horns and fibers. Until the nineteenth century man's inanimate possessions, his home, his tools, his furniture, were made from varieties of these eight classes of material.

During the last century and half, two new closely related classes of material have been introduced which have not only challenged the older materials for their well-established uses but have also made possible new products which have helped to extend the range of activities of mankind. Without these two groups of materials, rubbers and plastics, it is difficult to conceive how such everyday features of modern life such as the motor car, the telephone and the television set could ever have been developed.

Many people consider only the synthetics as plastics. Actually the plastics industry started with animal horn and hoof, tortoiseshell, bone, ivory, guttapercha, shellac, glue, and other compounds .

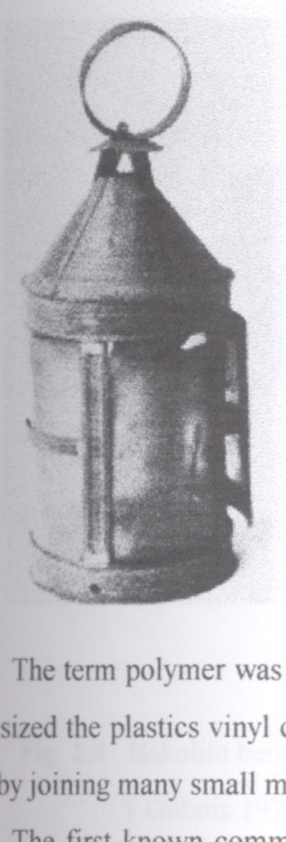


Fig. 1.3 Early use of plastics (Dubois 1972, p.4)

The early use of plastics was in lantern windows in 1740 after the opening of the first glass plant in USA. The window material is keratin, delaminated from natural horn.

Observations by the Swedish chemist J.J. Berzelius led, in 1833, to the production of one of the first synthetic compounds containing several thousand molecules.

The term polymer was first used by the chemist H.V: Regnault, when, in 1835, he synthesized the plastics vinyl chloride. A polymer is a substance that has large molecules made by joining many small molecules of one or several substances.

The first known commercial use of polymeric material occurred in 1843, by Dr. George IV William Montgomerie, a malayan surgeon. He noted that the malayans used a natural polymer material, gutta percha, to make knife handles and whips. Resins collected from gutta percha trees were sent to England to interested scientists and manufacturers.

Michael Faraday, a pioneer in electricity, found that gutta percha was a good electrical insulator in water and so it was used as insulation for the first transatlantic cable. Modern undersea cables still use plastics for bases, housing, shields, and cores.

In 1862, Alexander Parks of Birmingham, England, displayed a new plastics at the international Exhibition in London. Called Parkesine, this plastics was made from nitrocellulose containing less than 12 percent nitrogen. When nitrogen content of nitrocellulose, a combination of nitric acid and cellulose, is more than 13 percent, the material is known as guncotton, an explosive used in the Civil War and World War I.

John W. Hyatt, a New York printer, began synthetic plastics production in the United States. In 1868, Hyatt responded to an advertisement to find a substitute for the ivory used for billiard balls. There is no record that Hyatt ever received the reward, but he did succeed in producing a new plastics. Hyatt accidentally mixed camphor with some pyroxylin (a nitrocellulose with low nitrogen content), and Celluloid resulted. This new, easily molded material was less explosive than previous nitrocellulose plastics.

Fig. 1.4 Bakelite being used for billiard balls instead of Gutta-percha by Hyatt
(Dubois 1972, p.99)

At the end of Civil War, there were huge quantities of surplus nitrocellulose. Hyatt and his brother bought a large amount of this surplus to use as raw material and they were granted over 75 United States patents for the production of plastics.

In 1897, W. Krische found that protein from milk could be used to make a new plastic material called casein. A Bavarian, Adolf Spittler, found that treating the compressed protein sheets with formaldehyde improved their water- resistance. Casein plastics were then mostly used as adhesives.

Based on the earlier work of a German chemist Adolf von Baeyer, Leo Hendrik Baekland of United States produced a new resin, phenolformaldehyde, that advanced the commercial use and acceptance of plastics. In 1909, Baekland secured patents to and began producing plastics products using the trade name Bakelite.

In 1920's celluloid replaced ivory and was used for the natural keys on pianos until 1950. Another usage area of celluloid was in the automotive industry. Some parts of these new machines were replaced by this new material or it's derivatives due to it's high performance characteristics. As an example, 1920 model Ford T had rain curtains made of cloth coated with cellulose nitrate, and the windows were of celluloid

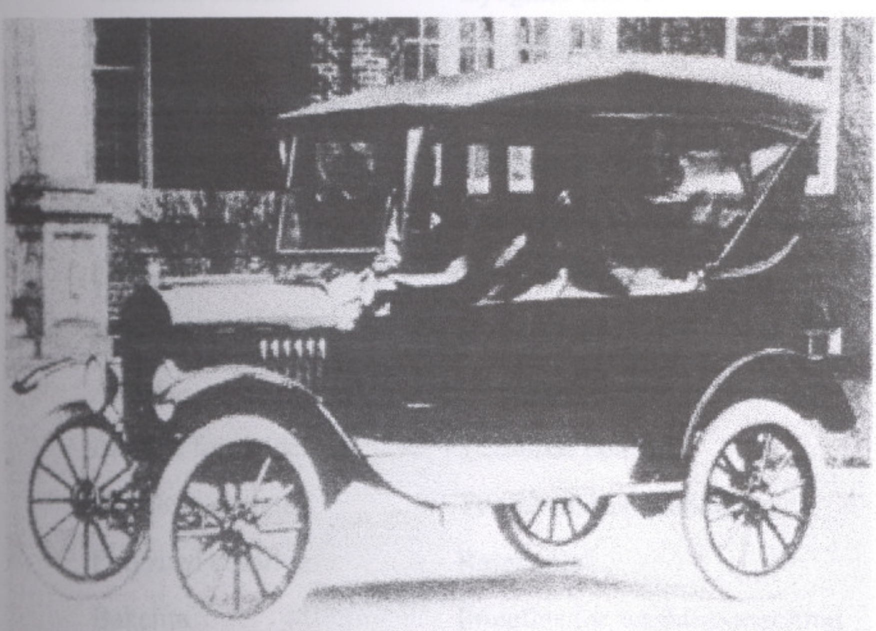


Fig. 1.5 1920 Model T Ford (Dubois 1972, p.48)

Plastics technology developed as new polymers were discovered and new methods of forming and shaping them were devised. New steels for use in molding plastics had to be made. Machinery builders, engineers, educators, salespeople, and others had to learn about this new technology. This education process continues today.

It might be said that the plastics industry was in the bronze age of plastics development during the 1970's. Most development during this time was directed toward discovering new monomers or homopolymers.

Today 30000 different polymer is known to exist and polymer chemists and engineers are combining and assembling many synthetic polymers to improve properties, improve processing, or lower costs. The idea of combining or assembling two or more different material is much older than modifying the polymer chain. Many of the demands made upon modern materials are so severe that individual materials no longer perform or have the desired properties.

Table 1.1 The chronology of Plastics

Date	Material	Example
1868	Cellulose Nitrate	Eyeglass frames
1881	Celluloid	Artificial teeth
1909	Phenol-formaldehyde	Telephone handset
1909	Cold molded	Knobs and handles
1914	Bakelite	End panels of Kodak special camera
1919	Casein	Knitting needles
1923	Reinforced phenolic	Carburetor
1926	Alkyd	Electrical Bases
1926	Analine formaldehyde	Terminal boards
1927	Cellulose acetate	Toothbrushes, packaging
1927	Polyvinyl chloride	Raincoats
1927	Bakelite	Impeller for washing-machine
1929	Urea-formaldehyde	Lighting fixtures
1929	Red phenolic	Electric shaver, Schick Model A
1935	Ethyl cellulose	Flashlight cases

1936	Acrylic	Brush backs, displays
1936	Polyvinyl acetate	Flash bulb lining
1938	Cellulose acetate butyrate	Irrigation pipe
1938	Polystyrene or styrene	Kitchen Housewares
1938	Nylon (polyamide)	Gears
1938	Polyvinyl acetal	Safety glass interlayer
1939	Polyvinylidene chloride	Auto seat covers
1939	Melamine-formaldehyde	Tableware
1942	Polyester	Boat hulls
1942	Polyethylene	Squeezable bottles (Stoppette)
1943	Fluorocarbon	Industrial gaskets
1943	Silicone	Motor insulation
1945	Cellulose propionate	Automatic pens and pencils
1947	Epoxy	Tools and jigs
1948	Acrylonitrile-butadiene-styrene	luggage
1949	Allylic	Electrical connectors
1954	Polyurethane or urethane	Foam cushions
1955	Polyester Resin/ glass fibers	Automotive Body, 1955 corvette
1956	Acetal	Automative parts
1957	Polypropylene	Safety helmets
1957	Polycarbonate	Appliance parts
1957	Polyethylene (linear)	Hoola Hoop
1959	Chlorinated polyether	Valves and fittings
1962	Phenoxy	Bottles
1962	Polyallomer	Typewriter cases
1964	Ionemer	Skin packages
1964	Polyphenylene oxide	Battery cases
1964	Polyimide	Bearings
1964	Ethylene-Vinyl acetate	Heavy-gauge flexible sheeting
1965	Parylene	Insulating coatings
1965	Polysulfone	Electrical and electronic parts

1965	Polymethylpentene	Food bags
1970	Poly(amide-imide)	Films
1970	Thermoplastic polyester	Electrical and electronic parts
1972	Thermoplastic Polyimides	Valve seats
1972	Perfluoroalkoxy	Coatings
1972	Polyaryly ether	Recreation helmets
1973	Polyethersulfone	Oven Windows
1974	Aromatic polyesters	Circuit boards
1974	Polybutylene	Pipes
1975	Nitrile barrier resins	Packaging
1976	Poyphenylsulfone	Aerospace components
1978	Bismaleimide	Circuit boards
1982	Polyetherimide	Ovenable containers
1983	Polyetheretherketone	Wire coating
1983	Interpenetrating Networks (IPN)	Shower stalls
1983	Polyarylsulfone	lamp housings
1984	Polyimidesulfone	Convey links
1985	Polyketone	Automative engine parts
1985	Polyether sulfonamide	Cams
1985	Liquid-crystal polymers	Electronic components
1989	RIM Polyurethane	Door panels of cars
1990	Thermoset Polyester (SMC)	Chevrolet Lumina

Some examples of the mentioned products can be viewed in below figures.

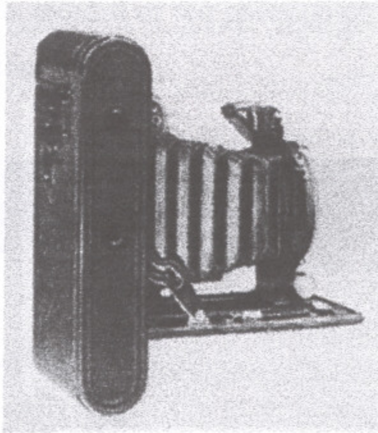


Fig. 1.6 The Kodak special Kamera (Dubois 1972, p.98)

Kodak special camera was the first to use plastics. The end panels were molded from Bakelite in 1914.

Fig. 1.7 The linear polyehtylene usage in Hoola Hoop (Dubois 1972, p.306)

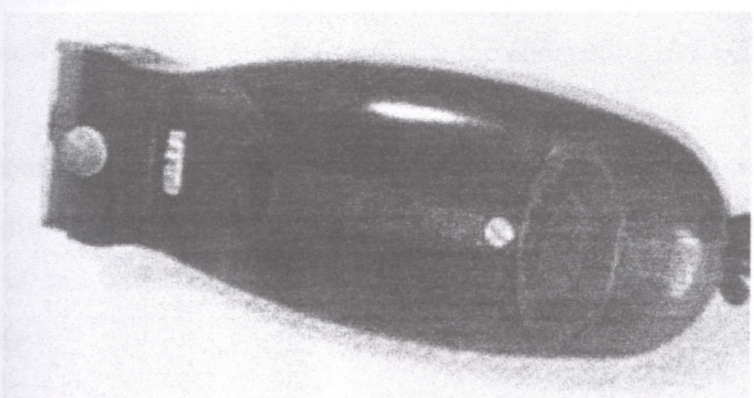


Fig. 1.8 The world's first electric shaver, Schick Model A (Dubois 1972, p.185)

Schick Model A, was molded of red phenolic by Norton Labrotories in 1930. The mold cost 400,000 US$ at that time.

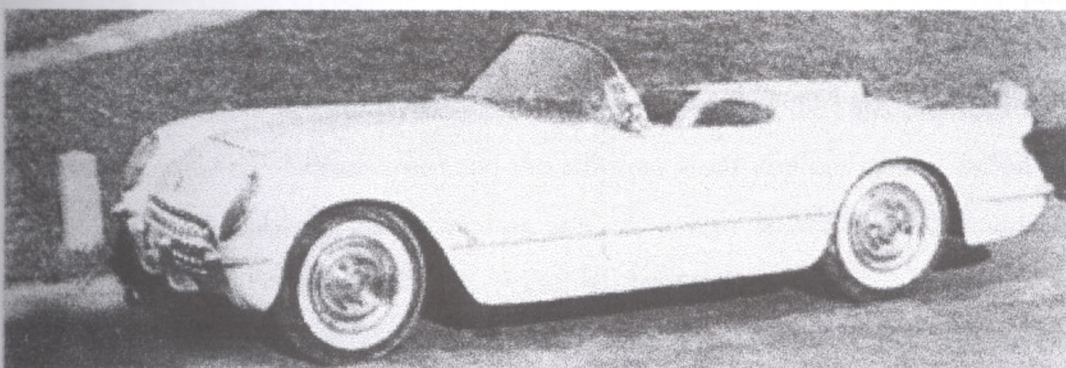


Fig. 1.9 The first production automobile body, 1955 Corvette (Dubois 1972, p.300)

1.8 Bonding In Plastics

Most elements are combinations of two or more atoms bonded together to form molecules. Molecules in crystals assume specific geometric patterns. Attractive forces form invisible bonds between atoms and influence the properties of all materials. The fundamental principles of bonding must be studied and understood.

Bonds (ionic, covalent and van der waals) are all important considerations in the study of plastics. These bonds determine many of the physical characteristics of the plastics products.

All bonds between atoms and between molecules are electrical in nature. Individual atoms are held together by the electrical forces of their individual particles (protons and electrons). It is these forces, either negative or positive, that bond atoms into molecules as well. The valence electrons provide the connecting link or bond that creates a molecule.

Most elements constantly try to reach a stable state. They become stable only by: a) receiving extra electrons , b) releasing electrons, or c) sharing electrons. In doing this they make use of two basic bond systems which may be classified as ; Primary bonds and secondary bonds.

1.8.1 Primary Bonds

Ionic and covalent bonding forces are known as primary bonds. The simplest bond to understand is the ionic bond. In ionic bonding, there is an actual lending of one ore more electrons from one another. For example sodium has one electron in its outermost shell. Chlorine has only seven electrons in its outer shell, but tends to become stable with eight. Since less energy is required to lend one electron than seven , the electron jumps to the outer shell of the chlorine atom. This converts these two previously neutral atoms to opposite charged ions. A strong electrical attraction between the ions provides the bond that holds together the sodium atom and the chlorine atom in a compound called sodium chloride (NaCl) molecule. Ionic bonding can occur only between the elements on the opposite sides of the periodic table, the IA and VIIA groups.

The major requirement in an ionically bonded material is that the number of positive charges equal the number of negative charges.

Another primary force of attraction is the covalent bond. In covalent bonding, electrons are shared and the valence orbitals between adjacent atoms overlap. Covalent bonding makes it possible for elements adjacent to each other on the periodic table or two atoms of the same element to bond together.

The simplest example of shared electrons is found in the hydrogen molecule, H_2. The element hydrogen has only one electron in its K shell. Hydrogen rarely occurs this way in nature because the K shell level seeks completion. In all the atoms the first shell requires two electrons and can not hold more than two.

When two hydrogen atoms combine, each shares an electron and a single covalent bond is formed. Unlike sodium and chlorine, which are opposite charged when combined, hydrogen atoms remain electrically neutral after joining force to make a molecule. The atoms draw closely enough together so that their electrons begin orbiting around both nuclei. The strong bond resulting from this sharing of electrons is that holds giant molecules together. When two electrons from each other are shared, a double bond is formed. An even closer bond is produced when more electrons are shared.

1.8.2 The Metallic Bond

A third primary type of atomic bonding is metallic bonding which occurs in solid metals. In metals in the solid state, atoms are packed relatively close together in a systematic pattern or crystal structure. For example in the arrangement of copper, atoms are so close together that their outer valence electrons are attracted to the nuclei of their numerous neighbors. In the case of solid copper, each atom is surrounded by 12 nearest neighbors. The valence electrons are Therefore not closely associated with any particular nucleus and are thus spread out among the atoms in the form a low density electron charge cloud, or "electron gas."

Atoms in a solid metal bond themselves together by metallic bonding to achieve a lower energy (or more stable) state. For metallic bonding there are no electron pair restrictions as for the covalent bond or charge neutrality restrictions as for the ionic bond. In metallic bonding the outer valence electrons of the atoms are shared by many surrounding atoms, and, so, in general metallic bounding is non-directional.

1.8.3 Secondary Bonds

Secondary bonding forces, or van der waals forces are much weaker than the primary bonds. These are the forces that bind the atoms of inert gases together to form a liquid or solid.

Secondary bonds that hold molecules together are related to the electrical forces that hold atoms together. Ionic and covalent bonds occur between atoms to make molecules. Van der walls forces are the bonds between the molecules or between the atoms in different molecules. Most van der waals forces of attraction arise from three sources:

1. Dipole bonds
2. Dispersion bonds
3. Hydrogen bonds

When hydrogen and fluorine atoms combine, they are left electrically imbalance. This occurs even though the K shell of the hydrogen atom and the L shell of the fluorine nucleus completely surrounded by electrons, while the covalently shared electrons are off-center. This leaves the positive hydrogen nucleus exposed at the end of the bond. This imbalance is called an electric dipole. It is these electrical imbalances, or secondary forces of attraction, that cause many molecules to join .

Fig. 1.10 Electrical Dipole effect in HF molecule

An important bonding force between molecules of many organic solid is dispersion bond .As the electrons orbit around the nucleus of each atom, a momentary dipole effect (polarization) is established . With an atom of hydrogen, it is easy to see how one side of the atom can become more positive for a moment.

A weak secondary van der Waals force similar to the dipole bond, is the hydrogen bond. This force is produced by the exposed nucleus (proton) of the hydrogen atom attracting the unshared electrons of nearby molecules.

Because all van der Waals forces form relatively weak bonds, plastics and other materials involving these forces are comparatively soft and have low melting points.

1.8.4 Mixed Bonding

Mixed bonding commonly occurs between atoms and in molecules. For example, metals such as titanium and iron have mixed metállic-covalent bonds; covalently bonded compounds such as GaAs and ZnSe have a certain amount of ionic character; some intermetallic compounds such as $NaZn_{13}$ have some ionic bonding mixed with metallic bonding In general, bonding occurs between atoms or molecules because their energies are lowered by the bonding process.

1.9 Industrial Plastics

The first commercial plastics, Celluloid, was developed about 100 years ago, but in recent decades, explosive growth have occurred in the industry. Since the World War II, the plastic industry has been growing at a rate double that of other industries.

Plastics are widely used in everyday living-at home, on the job, and even at the frontiers of space. From housewares to exotic aerospace applications, plastics are replacing more traditional materials. The volume of plastics consumed, has exceeded the volume of metals consumed, in 1983. On the other hand although most people think that plastics are being used in the mentioned areas the main area is elsewhere. The construction industry is using plastics more than others despite limited acceptance by labor unions and the public.

The estimated consumption of plastics through the year 2000 in thousands of metric tones by miscellaneous industries is as follows; The building Ind., 7000, the packaging Ind. 6000, the automotive Ind. 5000, the electronics-electrical Ind. 3000.

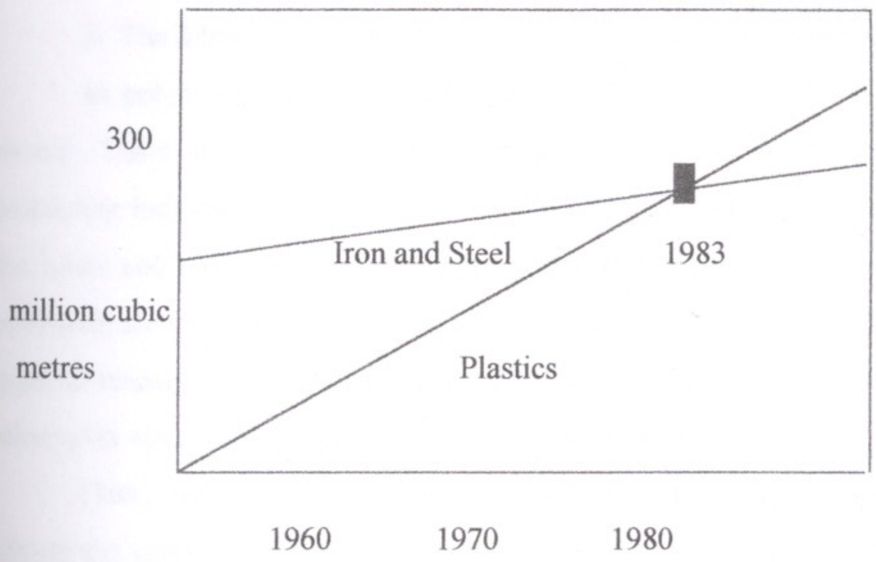


Fig. 1.11 Word consumption of iron and steel and of plastics (Richardson 1989, p.9)

Electronics used about 1 000 000 tons of plastics ,worth more than billion dollars, in the manufacture of components. The growing use of plastics in all modes of transportation is most evident in the automobile industry. The packaging industry has long been high volume user of plastics and that trend continues to grow.

1.9.1 Extent Of The Plastics Industry

The extent of the plastics industry with each passing day is becoming increasingly difficult to define plastics as a discrete industry. Plastics are products of companies in practically every industry including steel, paper, chemicals, petroleum, electronics, construction, electric, transportation and etc.

Plastics are known by many names, some of which are hard to pronounce. For this reason, manufacturers use trade names for their brands of resin, knowing these names are easier for consumers to pronounce and remember. For example, Acrylite, Lucite, and Plexiglas are trade names for polymethyl methacrylate, plastics manufactured by three different companies. Acrylic is used as the common name.

The plastics industry may be divided into three large categories that sometimes overlap:

1. The material manufacturer who produces the basic plastics resins from chemical sources.

2. The processor who converts the basic plastics into solid shapes.

3. The fabricator and the finisher who further fashions and decorates the plastics.

In polymer production part, a simple flow chart of the polymer industry was shown. There may be additional connecting lines between the polymer industry, processing industry, and fabrication industry. Also, a connecting line could be drawn to the waste and recycle stage.. There are waste products in all stages. Plastics and other chemicals are recycled in each stage. Recycling is more economical by saving energy and material resources. This can be achieved by better consumer strategies instead of thinking what to do with so many waste plastics after producing

Odor, noise, and, in processing, radiation pollution are among problems that affects the plastics industry. Pollutants have been given increased attention because of their effect on people and the environment. These effects can involve a remarkable range of problems including chemical, physical, social, psychological, and even psychological damage. The plastics industry must apply the knowledge and technology at hand to solve these problems (Richardson 1989, p.11).

1.9.2 Recycling

The ultimate problem to pollution and solid waste problem is reclamation or recycling. The largest single obstacle to reclamation of plastics is the need for a practical, low cost method of separating plastics from wastes.

Plastics recycling is an infant industry. Metals and papers have long established reclamation technologies, industries, and associations interested in recovery. The Center for Plastics Recycling Research (CPRR), SPI, the Society of Plastic Engineers (SPE), and other agencies and industries recognize the importance of reclaiming and reusing materials.

There are four general classifications for recycling plastics waste. 1)Primary recycling is the processing of scrap plastics into the same product or one similar to that from which it was generated, using standard plastics processing methods. Only thermoplastics waste can be directly recycled and reprocessed, and the material must be clean. Primary recycling causes general reduction of mechanical properties through a general thermoexodative degradation or, in some cases, branching and crosslinking. The aspect ratio of reinforcements, chain length, and matrix interface are generally lower. Up to 100 % reprocessed material may be used for less critical applications. An industry source estimates that 75% of plastics waste generated during fabrication is reused. 2) Secondary recycling involves reprocessing plastics into products with less demanding properties and quality. The waste may be obtained from postconsumer waste or industrial plastics waste sources. There may be a mixture of different types of plastics and small amount of nonplastic materials. Drain pipes, cargo skids, flower pots, posts, and cable reels are familiar products formed by intrusion (flow) molding, compression molding and extrusion. 3) Tertiary recycling involves a pyrolysis process in which simple chemical compounds are made of mixtures of waste. The process does not cause air pollution, reduces the volume of waste by 90%, and results in valuable chemicals (tar, gases, light oils, and other organic compounds). 4) Quaternary recycling is the recovery of energy from waste plastics by incineration, hydrogenation, or anaerobic digestion.

1.10 Advantages and Disadvantages

It is included to show positive and negative aspects of plastics in general. For example not all plastics are effected by moist or all change shape easily. Therefor plastics have their unique characteristics but cost factors may be considered an advantage in many plastics products.

Advantages of Plastics

1. Corrosion and chemical resistance
2. Good thermal and electrical insulating properties.
3. May be made isotropic or anisotropic
4. Good strength-to -mass production
5. Light(mass) weight
6. Ease of processing
7. Available in variety of forms
8. Capable of being foamed or made flexible
9. Available as transparent, translucent, or opaque
10. Available in wide range of colors

Disadvantages of Plastics

1.Dimensional instability

2. Limited useful thermal range
3. Fragility (may break, crack, or scratch easily)
4. Flammability (many burn easily)
5. Absorb moisture
6. Non-degradability (some do not decompose)
7. Subject to attack by chemicals (deteriorate)
8. Odors or chemical fumes in processing
9. Difficulty of repair (thermosets)
10. Cost (vary by family)

1.11 Designing With Plastics

Plastics have helped produce new designs in automobiles, trucks, buses, rapid transit vehicles, aircraft, boats, trains, musical instruments, furniture, appliance housings, biocompatible implants, and other applications. Aerospace and military research in composite designs have changed our concept of design and traditional construction techniques. Lightweight composites have allowed dramatic advances in aerospace technology. New world-records are being set with the aid of composite bicycles, sleds, canoes, tennis rackets, and other athletic equipment.

Many plastics are stronger and lighter than the metallic parts they replace.

It is frequently necessary to combine several materials into a composite. A composite is formed when two or more materials are combined, usually with the intention of achieving better results than can be obtained with a single, homogenous material.

Some thermoplastic polymers are combinations of more than one polymeric resin system. Alloying and blending techniques are used to improve physical properties, lower cost, or improve processing. These alloys and blends generally have a synergistic effect. The resulting combination may produce a polymer with attributes better than those of either component.

With increasing demands for emission control and fuel economy, plastics are an important automotive design element. Reducing mass is one of the most efficient ways of increasing fuel economy.

Researchers have estimated that every 100 pounds reduce from a 2500 pound automobile produces fuel savings of 0.3 miles per gallon. The energy resource requirements per pound of most plastics are only half that of aluminum or steel.

Because plastic materials are easily processed, they have become the perfect substitutes for other materials. Often better results may be gained by using plastics as the original design material rather than as a substitute material. Some of the early uses of plastics were failures because plastics products were designed wit little regard for the properties and limitations of the material. A lack of structural design knowledge is a problem even today, because plastics are not sufficiently understood by some designers, engineers, and technicians.

1.12 Polymer Technology in Turkey

The polymer industry in the world, has the production capacity more than 100 million tons per day . The variety of implementations and the increase in the requirements is leading a continuos increase in the capacity of production. The polymer production in Turkey is only the 1% of the world's production. The polymer consumption per person in Turkey and in other countries, is as follows;

Turkey: 5.63 units kg, Finland: 118 units kg, USA: 72 units kg, Japan: 53 units kg, Italy: 44 units kg and, Spain: 29 units kg.

This comparison is emphasizing that our production will increase at least five times more by the year 2000 relatively (Yedinci Beş yıllık Kalkınma Raporu, Plastik).

CHAPTER 2

CHILDREN

2.1 Playing Games

Adults have found it convenient to amuse their children with toys from the earliest times, and examples of bronze miniature furniture, earthenware dolls and animals with simple articulation have survived from the ancient civilizations (King 1978, p.7)

During the last century, psychologists and educators conducted thousands of studies to determine when and how young children learn. The results of the researches seemed to confirm what parents, grandparents and wise observers of youngsters have long known: that learning occurs spontaneously, naturally, and constantly during play. Play is a prerequisite to later intellectual activity, and numerous skills and abilities are developed and refined within the context of play (Boehm 1986, p.1)

It is through play, that a child develops a sense not merely of freedom, expression and creativity too, but, ironically, a need to be obliged, or at least have his expressions defined. Play therefore, is one of the first steps of personal and social evolution (Cottle 1976, p.28)

Children are using play as a vehicle, as a medium to travel the boundaries of reality and fantasy. In pretend play they are not only using their imagination and creative energies but also learn to understand themselves, their feelings, and other intrinsic talents. One can observe that it is through play that children translate the world to child size and manageable proportions, where they are in control. At the heart of play there are no fixed rules save those made by the player (Oppenheim 1987, p.xx). When children play they exercise their problem solving skills to solve intellectual puzzle and also social emotional and physical ones.

By observing the multiple modes, we can see that play means many things to children. In a play a child is always eager to alter the possibilities of the game in order to enrich the limits of life. So the play is the main medium for transforming the dull life into a life of rich variations.

On the other hand playing is more than a way of developing the talents and enriching creativity. It is the frontier of socialization. Whether they are rolling a ball back and forth in a game of roly-poly or playing house, during play children learn the language of give and take, of communication, cooperation, and even negotiation. What begins as a duet between parent and child gradually grows into an orchestra that includes playmates, school mates and team mates. (Oppenheim 1987, p.xx)

When a child is playing, the main thing that convinces him about the plays' imaginative reality or strengthen the belief , is the toy that is being hold in the hand. In other words toys are like devices that are always ready to get them into any life structure they can imagine.

Toys are fun, the main source of entertainment every child is fond of . But, here lies a problem that every family has to find an answer. What kind of a toy is the right toy? As a matter of fact there is no "right" set of toys for every child, but rather a need for variety. Capability of variation is the criteria that determines whether a toy is the best toy, a better toy or the worst toy. For years specialists have been advising parents to look for "open ended" toys. In other words, toys that can be used again and again in multiple ways. A set of blocks may become a skyscraper today, a zoo tomorrow, and a space station the next day. Compared to a plastic castle that always looks like a castle, the unstructured nature of blocks allows children to shape as many new settings as their imagination can invest. In short transformation is the basic tool a child makes use of when playing with a toy. Anyone who has watched a child pick up a pencil and buzz it through the air like a plane is witnessing a true transformation. The ability to make one thing stand for another is no small intellectual feat. In making such transformations children begin to "play" with symbols-an ability that will eventually be needed to make symbols like c-a-t stand for the four legged furry creature we call cat. Very young children need realistic toys for their symbolic play: for a toddler a toy phone must look like a real phone. The preschooler, on the other hand, can pick up a phone out of thin air and carry on a conservation.

By now, toy companies are sharing or bearing the cost of creating cartoons and movies featuring toys in their product lines. This has opened the door to a new kind of TV-toy connection. This connection is consisted of television stations, film animators, and toy makers which all determine what the children will play with, setting aside the mentioned transformation talent.

Children do not learn about feelings from toy's name or label. They learn about their own feelings and others from the people in their lives and the way they treat each other. A toy may come to represent comfort and security. In times of need it will be a nonjudgmental listener a confidant, and a dependable friend. A teddy bear or monkey may be treated as if he's naughty, happy, silly, quiet, lovable, angry, shy, noisy, or whatever else the child wants or needs it to be at the moment. The point is, the toy doesn't have feelings but the child does.

2.2 Toys

Toys are not only the helpers of the families in emergencies. They are in fact the game styles of children through which they develop their learning capabilities, socialization rules, family ties in short everything that they can build up in their games and so be prepared for the coming years.

2.2.1 Toys For Infants (the first year)

A child, in his first years of life, is extremely bright. Through lacking in intrinsic knowledge, he acquires the concept of space and language in a few months, from when he is 5 months old up to 12 (Mari, stileindustria, 1995).

Researchers have claimed that infants respond to a stimulating environment, and toy makers have dutifully translated these findings into an abundance of products to dangle from crib, carriage, changing board, high chair and car seat.

The notion of constant artificial stimulation is being sold as a valuable way to communicate with and comfort babies. As a result, any newborns begin life in an atmosphere that can only be described as wild.

It is not toys to comfort or stimulate or of no value. Not at all. But there are no things more interesting , stimulating, or important during a child's early months than a real live person. People are the most versatile and fascinating playthings in a baby's world. Objects are not a substitute for people, and a young baby can't interact with objects without the assistance of people.

Infants against the belief of not being able to see, come into world with a full set of sensory equipment. Not only can they see, they can hear, smell, taste, and touch. It's through their sense that babies learn about people, things, and themselves.

Even before babies can reach out and take hold of things, they begin to explore the world with their eyes and ears. But until they are about three months old, infants can focus their eyes only within a limited range. Objects that move slowly and produce gentle sound will capture their attention more than a fixed object. A musical mobile on the crib rail will attract more attention than a static picture on the wall. Studies indicate that infants under three months look to the right 80% of the time (Oppenheim 1987, p.63). Infants are more attracted to bright primary colors, objects with sharp contrasts and clear but simple features.

Squeak toys, rattles, teethers and soft cloth toys all offer new sounds and sights that will attract the baby's attention. Toys that are brightly colored and have interesting sound and visual effects will be more interesting for baby than a solid colored object with no sound. These early toys will eventually be played with independently, examined from every angle, tasted, passed from one hand to the other, banged, twisted, and turned. But such attitudes will eventually remove parts that may be hazardous, as it is the first thing to do, when having the chance; to put into the mouth. Therefore toys with plastic eyes and snouts are potential choking dangers to infants. Indeed, any frills or features such as bells, buttons, flowers, whiskers, ribbons, and yarn wigs should be considered what lawyers call an "attractive nuisance." Such parts are the very things a baby will mouth and possibility choke on.

Once baby begins sitting up, he has a new view of the world and develops a fascination with manipulating objects. He explores toys from every angle with eyes, fingers, and mouth. Using two hands he will bang two toys together or spend a long time passing a toy from one hand to the other. Until about 24 months, a toddler usually turns a spoon upside down when bringing it to her mouth (Fisher 1987, p.31)

Activity toys with doors to open, buttons to push, wheels that spin, and knobs to turn offer babies the opportunity to practice fine motor activities with payoffs they can see and hear.

Out of the crib and seated on a blanket on the floor, babies enjoy slightly different types of toys. In fact, multiple toys are generally of more interest than activity boards at this stage. Most of the ornamented toys are more decorative than entertaining. With a young baby they are just a excess baggage and for the older baby they are boring.

As babies themselves become more mobile and begin crawling, toys that move hold new interest. A small but simple toy car with sturdy wheels is fun to push back and forth. Balls at this stage of life, seems to be best match that a baby can have for the entertainment.

2.2.2 Toys For Young Toddlers (The second Year)

The second year is the state of standing up for most of the toddlers. With his new found mobility anything that is within reach is worthy investigation. Toys are by no means the most interesting objects to be explored, although in a sense, they may be a safer and more reasonable substitute for the multitude of real things he'd love to grab, turn, twist, bang, carry, throw, taste, and test.

As he makes the transition from wobbly first steps to sure-footed walking, and ultimately to running, the toddler is a study in motion. Few toys can compete with this challenge of mobility. A child at this age is very fond of investigating his surroundings. Observation and inspection of how things work is of particular interest to the child between two and three (Boehm 1986, p1)

Few toys or activities will hold your toddler's interest for long. Variety is important. Action is the name of the game, and toys that match the toddler's new mobility are the most appropriate. For instance a wagon may be a good choice both for this age as a helper for walking and for the coming years as a carriage. Doll carriage, wagons, and light weight push toys are not suitable, as the less sure-footed beginner needs a toy with mass to keep him steady. Toddlers do enjoy features like storage compartments so they can carry along small toys; and they love ride-on with sound effects like horns, or ratchets on wheels.

Both boys and girls enjoy toy cars, trucks, and planes that they can roll along the floor. As toddlers become more sure-footed, push-along toys with a stiff rod make taking a walk into a game. But because looking back over the shoulder is difficult for inexperienced walkers, pull toys are for the slightly older toddler who really has her land legs, Therefore instead of pulling, push toys are better. Again motion and sound effects have great appeal. Although some of the most useful pull toys are wooden works of art, they are also terribly costly for the short term use.

For safety's sake there has to be no bead handles that can be mouthed and no more than a 25-30 cm cord for pulling.

On the other hand, balls are still the most popular toys the child can play with. Also this kind of a toy introduces the child to give and take. Indeed it is the first cooperative game children learn. But not all the toys are of the same value such as Ping-Pong balls which are small enough to be mouthed or balls that can bounce higher than a controllable height.

Because there are few toys more fascinating to active toddlers than steps, families who live in split-level or two story houses really need to protect young toddlers from dangerous falls. Some experts advocate no gates but rather suggest parents teach babies early how to climb up and down. Taking into consideration such a will of a child, it is wiser to design a climbing tool which will neither require a too hard effort nor supervision due to low height. This kind of indoor climbing toys are good for toddlers who are over eighteen months

Both boys and girls enjoy a doll to lug and hug even if they don't have a carriage. Soft uncomplicated dolls are easiest to hold and play with. Most toddlers become especially fond of one particular doll or animal, and that this attachment frequently continues for a long time. So it is a good idea to design a doll or stuffed animal that is durable and easy to clean. But it is still required to pay attention to the safety standards mentioned above as because many toddlers are still apt to chew button eyes, bells and others. They may fall asleep on top of a doll ór roll over on it. Dolls with zippers, whiskers, or wire under the plush-are still potential hazards.

For infants, simply holding, twisting, or tasting a toy offers enough manipulative play value, but toddlers like their manipulations to lead to some kind of outcome. In other words, a toy should not just have an action but reactions too. At this age the toddler has considerably more eye hand coordination than he did a few short months before. It is easy for the child to pull pop beads apart but still difficult to put them together. Most toys with interlocking pieces will be better for later in the year. A set of nesting cups or ring-and-post toys can be used as multiple objects to roll, chew, bang, toss, or carry about

For the most part, young toddlers are more interested in motion and big muscle action than in prolonged play periods with toys that demand fine motor control. They like both small and oversized objects to carry about with them. Clutching two small dolls-one of each hand- seems to give some young walkers another way of "holding on". Soft clutchables are safer better than hard objects that might hurt them when they trip.

By the middle of their second year , toddlers do enjoy fitting objects- the hide and seek aspect of putting toys into containers and emptying them. A shape sorter consisted of three shapes offers enough challenge for a starter. Blocks are mostly big and, are made of soft material which means they don't have any visual balance. Building up with blocks may also be very interesting since children are eager to see things being scattered when they kick. It gives them the satisfaction of having the strength to move things away with their power. Lugging large objects from one place to another is an appealing motor activity

Water, by its very nature, is fascinating to splash, pour, sprinkle, and taste. With an assortment of toys, toddlers can make a duck swim, propel a boat, or bathe a doll. Water with its intrinsic capabilities is enough fascinating to provide hours of entertainment and is prone to be used of with accessories as a stationary toy because water related play sets encourage bath time fantasy play (Fisher 1987, p.85).

The manufacturers of educational toys often praise the importance of particular toys for language development, it is not the toys but how they are used that enhances a child's learning. A toddler with a roomful of toys but no one to talk with will not learn more than a child with relatively few toys who is surrounded by people who interact talk, read, and, respond to him.

From their earliest days infants enjoy the rhythm, motion and sound of music. Toddlers who have been sung to will be singing alone toward the end of their second year. A child Therefore will always be attracted by the sound of music that is played in the toy. Toys as mentioned earlier are the life of a child and every child is fond of a rich life which means to have all of the senses satisfied. The satisfaction is very much related with a complete achievement of taste with five senses. Therefore with music one of these five senses is satisfied and having it supported with others, the best toy is designed.

During the latter half of the second year, children begin their earliest games of pretend. At this stage making believe is more imitative than inventive. Toddlers begin by doing what they see adults doing. The child will enjoy a toy telephone almost as much as a real one or will wish to sit on the driver's seat of the car and pretend as driving, girls will be very fond of their mother's high heels or make up accessories.

Some toddlers may be interested in drawing with crayons. This art exploration may of course effect other children. But the children who are still eager to chew play things should be paid more attention. So the non-poisonous pencils, crayons, watercolors, markers might be a good sample of design area for such consumers. Also in order to prevent them from rolling away it is better to design a cornered or chamfered pens.

At eighteen months, children enjoy pounding, pinching, and poking at dough or home made variation. They will be much less interested in making something than exploring the way this plastic material responds in their hands.

As toddlers approach their second birthday, their repertoire of play is growing rapidly. They no longer wait for someone to initiate a game or offer a plaything. With both language and locomotion they are able to engage themselves and others in play. Increasingly they have preferences and a style of playing that reflects their individuality.

2.2.3 Toys For Older Toddlers (Two To Three Years)

Walking is now an old talent. Now they can run, jump, climb and slide. Though more sure-footed than before, they are still not very well balanced. The child does not always look before making a mad dash and ends up tripping on the toy it has just discarded. As he climbs to the top of the slide, he makes it clear he wants no help or interference; a few minutes later he needs help getting down (Oppenheim 1987, p.111)

This tug of war between the desire for independence and the continuing need for dependence is what makes children of this age a trouble. In fact they are more testy than being a trouble. What they are testing are their own limitations and parents. They neither want nor can they handle the total independence they keep asserting.

At play, he provides inanimate objects with lively sound effects. He does not yet fully understand that an electronic teddy bear that talks and moves is not alive. He believes that objects, especially those that can move, can also see, feel, and think just as he does. In fact, he believes everybody thinks, feels, and sees what he does. Being the center of the universe, he can not imagine any other point of view but his own. He still has so much to learn about what is real and not real, what is possible and impossible, what is right and what is wrong.

By two and a half, toddlers begin to use familiar toys in original ways. She puts the doughnut from her ring-and- post toy on her wrist and calls it a bracelet. She eats cookie and offers a bite to her teddy. They are still very literal, and more imaginative flights of fancy are yet to come. Even so, the ability to use one thing to stand for another marks the beginning of symbolic play; it is another signal of a new and more advanced level of intellectual development.

This is an age of transition when the skills that began to emerge earlier are refined and expanded. Though few toys will hold their interest for prolonged periods, they are ready for new kinds of playthings to match their growing physical intellectual, and social skills.

Through their active play, children develop a sense of their own physical competence. They are keenly interested in testing their capacities for climbing, running, and walking under, over and through a variety of spaces. This active kind of play not only helps them develop their gross motor coordination, it strengthens their new sense of selfhood and proves a good outlet for their seemingly endless energy.

A low climbing device with a few steps up to a platform to stand on and a small slide down is a good choice for indoors or out. Also, most of the ride-on toys suggested for the younger toddler will still be appropriate, as the children of this age are eager to carry things on their toy vehicles. When designing such a toy, a designer has to be very careful with the wheels. Wheels have to be inset so that they are not in the way of the child's foot action.

Indoors and out there are few play materials better loved by twos than sand and water. Rich with sensory experiences, both change, move and respond to the touch. Such hands on experiments provide the meaningful underpinning for expressive language. Abstract words like wet, rough, drippy, smooth, and soft become meaningful when coupled with real experience. With the addition of tools, both sand and water can be poured, patted, pounded, poked, and otherwise enjoyed. Plastic toys may be the best convenient for such sand and water games.

Young children begin their games of make-believe by playing out familiar roles and events. Since home and the family are the world they know best, this is the logical place for pretending to begin.

Since imitation is what they like the best, housekeeping equipment and dolls are enjoyed by both boys and girls at this age. Most of the dishes and pots in toylands these days are undersized, unattractive, and made of flimsy plastic that snaps easily. So this section may be appropriate for a design with better plastic characteristics and form. While a real vacuum cleaner may be too noisy for twos a child size version may help diminish such fears. In playing out roles children are often able to gain sense of control over objects and situations that produce anxiety.

A good many of the everyday things children use in the course of a day challenge their eye-hand coordination. Dressing and undressing themselves and their dolls, opening and closing boxes, doors, and faucets all require different kinds of fine motor running. In many respects everyday tasks are more interesting than toys specifically designed for repetitive skill building. The plastic construction sets that snap, screw, link, or simply stick to each other all invite young builders to use their hands and eyes work together.

Forming a group, when playing is not very common at this age, one-on-one socializing usually works best. In other words, with twos, a duo is more apt to play together happily than a trio or a quartet. Taking such a criteria into consideration, it is more convenient not to design toys that needs more children than two to play with.

It is always wiser to design toys that will not do the playing on their own. It is better if the child can communicate and realize what he can do with it. So that a family may expect their child to make up stories and pass his time in this world of dreams.

2.2.4 Toys For Preschoolers (Three To Five Years)

For preschoolers, play is not merely fun. It's through their play that young children continue to learn about things, people, and most especially, about themselves. At this age there are several development changes in the nature of play.

The preschoolers do not just imitate the adults in their lives. They also invent games of make-believe that are complex and dramatic, embellished not just with action, but with a story line as well. Indeed, through dramatic play the child can transform himself into a growling tiger, a daring super hero or a helpless kitten. These flights of fancy offer children a way of dealing with feelings and fears. They are an outlet for tension, for fulfilling impossible wishes, and for rehearsing a broad range of emotions.

Although the preschoolers are egocentric and find it difficult to see things from another person's point of view, through play they begin being more socialized. So they learn that there is a "yours" as well as "mine" and a "we" as well as "me". So play becomes a vehicle for social growth.

In the company of other children the preschooler gradually learns about sharing and taking turns. In fact, the desire to play with age mates comes to outweigh the need to have everything his own way and helps him accept the necessity of giving as well as taking.

If you leave a four year old to pick up her Legos, she may start building a new or become totally immersed in sorting the pieces by size or color. By five she will be able to sort and match using more than one attribute. Preschoolers are not just more imaginative, they are more inventive and playful. They play with objects, ideas, and words-anything that comes their way. This is the age when imaginary play mates appear, or a teddy bear takes on the role of scapegoat.

Unlike toddlers, who tend to go from one activity to the next, preschoolers have more staying power. They are able to plan ahead, to combine ideas, and think of new ways of using familiar objects. Once they start playing with a toy and feel that one object is missing in the play, they try to get it without having their attention diverted by whatever may attract. In short there is a new kind of seriousness and purposefulness to his play.

Although many of the so-called "educational preschool toys" put heavy emphasis on school related skills, the young child's learning style can not be limited to such compartmentalized lessons Because half an hour in the sand box is no less educational than moving a set of magnetic letters and numerals around on the refrigerator door. Nor is fitting a complex puzzle together more important than riding a trike, playing house, or building a tower of blocks.

2.2.4.1 Violence

We know that children's behavior is more aggressive after viewing shows with violent themes. Although researchers can only speculate on the long term effects, there is no question about here and now; shows and toys that feature violence lead to games of violence.

Although no research has shown that violent play in the childhood leads to a life of crime or criminal tendencies, children's immediate reactions to violent programming can not be ignored.

One of the most detailed studies of preschoolers indicated that children who viewed violent cartoons played more violently than children who watched Roger Rabbit or Captain Kangaroo. In more than two dozen other studies, researchers found that cartoon violence increased in children behavior as hitting, kicking, choking, throwing, pushing, holding, other children down, hurting animals, and selfishness (Oppenheim, 1987, P.160)

The problem is that every child admires the characters in the TV series and what ever they do is very much approved by the family. Therefore the child does not hesitate to do the things that the characters do, as it makes people laugh and admire . The children wants to be as powerful as the heroes are. But the main point is that they believe every thing is real and they won't hurt anybody if they pretend to play the game like the heroes they watched on TV.

Considering the research , it is hard not to conclude that the logical answer for parents is to ban both TV programs and toys. Yet that may be the least effective way of helping children handle the issues of violence, aggression, and consumerism. Indeed, banning has a way of making things even more desirable. When dealing with children, it is important to use absolute prohibitions only on a limited basis. Even if a parent decides not to give his child a toy gun, this can not prevent his child from pointing his fingers and pretend that they are the barrel of a gun.

The best thing to do is to establish firm limits on the amount of TV watched and number of TV toys bought, talk about what is happening on screen, provide alternative forms of entertainment, or limiting own viewing habits. The main point is to prevent children from long continuos TV watching. So the child may realize what is on TV and what is in the real life without having mixed the mentioned two.

2.2.4.2 Kinds of Toys

As it is explained the children at this age are eager to imitate the grown up people. Therefore the toys that they want to play with are the representations of the real life. A doctor's set, a dashboard with steering wheel, a vacuum cleaner, a workman kit with many tools, cooking and feeding sets and many others are some of the sources of entertainment

Preschoolers are fond of baby dolls that drink and wet, have eyes that open and close, hair to brush, and clothes to change. Boys are no exceptions for such tendencies. But boys are mostly fond of powerful ones other than ones like Barbie.

Increasingly, toy makers are also acknowledging that we live in a multi-ethic world and that children enjoy dolls that reflect themselves. Therefore dolls of different color, different nation are now better accepted by the children which makes their reflections easier. As doll play becomes more elaborate, so does the need for doll accessories. A carriage or stroller, a bed or cradle, and a high chair are all useful additions.

Plush animals are also favorite childhood companions. Teddy bears, monkeys, kittens, and other creatures comes in all shapes and sizes. These toys are privy to secrets and subject to severe scolding and hugs and kisses. This very special toy may need to be patched up and accepted, no matter how ratty it becomes (Oppenheim 1987, p.171)

Although parents may wish to extend the play possibilities for their sons and daughters, preschoolers are already often very much cued into sorting the world by gender.

In doing so, the preschooler may have more conservative views than parents would wish of what boys and girls should wear, play with and do.

On the other hand, many children enjoy dressing up in clothes of the opposite gender and trying on both male and female roles. Through pretend play, children can safely transform themselves without risk, since they know it's just a game.

Through puppets children can say things they would never say in reality. They can ask questions, give answers, and clarify their feelings. The reason is that children mostly do not feel free to talk about subjects that they may be scolded for. This way they are more comfortable as they have something ready to put the blame on. Unlike role playing in which they transform themselves, in puppet play the child is once more removed. Rather than using his own body, the child projects his feelings, ideas, and story on to the puppet through action and words. The child at this age likes to replay familiar stories or to play out stories from their inner lives. Hence it is still the best choice to design toys from the real life other than TV heroes. Such designs are better appreciated by both the families and the children them selves.

Preschoolers have fascination with wheeled toys they can use for dramatic play, indoors and out. Realistic trucks with details and moving parts are most interesting for the sand box or to use along with blocks (Oppenheim 1987, p.172). These are mostly made of plastics

The plastic or wooden building blocks are preschooler's raw material for more imaginative play. When designing blocks , the designer has to be careful with supplying sufficient quantity and variety of shapes. Another vital point is that, the child has to be able to dream his own style of building other then the drawn picture on the cover of the toy box. In other words unlike a toy garage or farm that comes with a preset structure, blocks must be able to "become" whatever the child wishes. The variety of the themes and scenes children construct has to come from the child's imagination rather than the toy maker's. As with sand, clay, paint, and other unstructured materials, blocks put the child in center of the play. They invite the child into to invest himself in creating his own symbols-his own bridge, tower, airport, or playground. This ability to make one thing stand for another takes the child a step closer to dealing with more abstract symbol systems like words and numbers. The role of the designer is to design toys that may be easily derived out of the module in many directions.

Whether children are playing alone or with others, block play is rich with many layers of active learning experiences. In playing with others, there is a need for social dialogue and for cooperative planning. Blocks have a way of stimulating both doing and thinking, while letting the child experience the triangles, squares, rectangles and others in one structure which is to exist. They begin to grasp meaningful concepts that are the foundations of mathematics. That is why blocks are really effective in children plays. The designs of these blocks have so far, many advanced typologies that offer the child many variations of play. Most of the standard blocks come in multiple sizes and have a logic that children discover and use with amazing ease and skill. The coming step in such designs should be to design a system of blocks without having them scattered around, when trying to build up an object. If they are linked to each other in some way and still form the desired objects this design might save the parents collecting the parts of the Lego type toys when scattered or preventing the child loose some important parts of his toy during or after the play. Such a design is also important, for children who have not yet got rid of the habit of putting things in mouth.

Studies with preschoolers show that children are better problem solvers after they have time to explore materials than if someone demonstrates what to do and how to do it. On the other hand to meet divergent needs a toy should not exactly matched to an age but rather to an individual child (Boehm 1986, p.81). Therefore the studies mostly indicate the probabilities of play manners

2.2.4.3 Toys for Active Play

Running, jumping, climbing, swinging, chasing a ball, or walking a balance beam- what whirlwinds of activity preschoolers. Even if they are watching TV or listening to a story, the preschooler rarely sits still voluntarily for long. It is through their bodies that children first gain an inner sense of themselves as able and competent doers. But the enthusiasm may not last as long as the play. Therefore the children still needs the support of a grown up family member. They may climb up the monkey bars and just at the top of the bars he may ask for your help to get down. The only point is to show the parents how powerful he is. Any toy design related with such an idea may be appropriate for children at this age. Children are not only eager to show their strength but also how fast they can run, drive bicycle and etc. When designing a pedal toys which will give the children a dangerous mobility, the height of the bicycle or three-wheelers, the body material, the weight, the reliance of the brakes and the ease of use are some of the critical points the designer has to be very careful with. If the designer designs a three-wheeler low to the ground so that they are harder for cars to spot, or too heavy bicycle to carry out of the elevators

Fours and fives also enjoy highly realistic and detailed toy cars, fire engines, and tractors with horns, steering wheels and plenty of potential for dramatic play. A toy designed for preschooler children must meet rigorous standards: it's size must be tested to ensure that it is too large to be swallowed by a three year old and it's material must be strong enough to withstand a simulated bite (Wiencek 1987, p.78). The children of this age have a solidly developed sense of their own bodies. When the children are eager to find about the realities of life, they do not hesitate to take the risks. Any toy that is designed for these ages must be able to stand for hard investigations to prove it self in the toy industry.

Physical play is mostly held outside the house. Under the supervision of a parent the child is now on slides, swings, seesaws. But for parents who are willing to restrain their children from the steel toys of the playground, the toy industry is very helpful. The toy slides must have side rails and all equipment should be checked for rough edges and protruding nuts and bolts that could cut or catch small fingers. The swings has to be able to carry the load easily with a security constant of at least 3. Because even if the children are pre-told not to use it with others at the same time, they may forget the reasons of such a prohibition with the enthusiasm of the game.

Active preschoolers also need some sit-down toys for a change of pace. Puzzles, board games, manipulative, books, tapes, and talking toys are all kinds that children play with when they are tired of physical plays. Also children are surprisingly eager to learn about complicated mechanical principles when they can build examples with their own hands (Wiencek 1987, p.90).

Computers are the machines of their age. Therefore they are almost becoming acquainted with them when they are four or five. The children likes playing video games because yet, that is all they can do with computers and children are very well aware of the variety of games they can experience. Another thing that children are fond of is the computer's never ending energy of being a playmate. They know that when ever they wish they can play together unless there is any kind of energy shortage. If a parent has a computer in the house, there is no doubt that that the preschooler will try to get his hands on. Young children love to push buttons and make things happen, and any piece of equipment parents use is bound to have special appeal.

2.2.5 Toys for Six and Sevens

A school age child still learns best from active doing. But more often the toys that are sold focuses on the drill and practice of math and reading materials. On the other hand making the top reading or having the beast scores in the lessons may be of great value and please the parents, it is of the same importance to make it to the top of the jungle gym.

The children of this age are too much influenced by each other. Therefore if the action in the school yard or back yard centers on roller skates, then skating will take on an importance that needs supporting. The same may be true of riding a two wheeler, jumping rope, or playing football.

Unfortunately many schoolage children have little opportunity for active play. Best toys for this age group may be the ones that focus on such a gap in children's life when such activities are of great value. On the other hand there are some classical toys that are always valuable in child's life. Among these we can count bikes which appear to be more than a toy by having scaled models being used by the parents.

Bikes offer children the mobility which under any other circumstances no other toy can offer. But with such an offer the children are entering a dangerous world that they are not familiar with. Therefore when designing a bike there are some spots to be paid attention to in the first place. Of course the security is the main criterion, but in the design, the cost and durability are also, other points of careful consumption. For safety, bikes should have reflector stripes on the body and fenders. At this age children won't be riding at night but evening can set in early or the weather may be cloudy enough to darken the sky. Bikes have to be of enough height in order to obtain security when riding on the road both for the child and for the drivers. Another point is the mechanical parts that may be ruined easily due to usage in time. A good design has to offer enough life span for every designed object both on behalf of the consumer and on the producer.

Although highly realistic motor driven vehicles have great appeal to children, as well as to tolerant parents. The fact of the matter is that they have more value as accessories to pretend play than as aids to physical development. Therefore the pretend play has more to offer to children as children creates a world of their own when playing .

That makes the children to think of many details that comes alive during the play and so helps them to develop their thinking ability.

On the other hand children of this age has to be prepared for the coming school years. The child will be among many others and a place of challenge will be build in a very short time. Therefore socialization is very important in these years for preschooler.

The motor driven vehicles are not easy for every parent to buy. For that reason children when playing with such toys are not offering the medium of socialization unless they are ready to share their belongings with others. But skates are not so highly priced. The medium is created on it's own when children do the skiing at the same place and at the same time. These are often more basic equipment for socializing with agemates.

Although schoolage children love to be among other children, they also need time for being on their own, and play their own games. Dolls, stuffed animals, art materials, and other entertainment sources are all enough time taking for any child to take them beyond the borders of the house. Of course bikes and jump ropes are the main toys for solo play. For the children, a solo play might be a coming reprieve after a long day in the school.

By this, children learn to enjoy their own company in contrast to their school life where they have to be social, during the day. Solo play provides children to gather their thoughts and feelings and so help them advance their talent of judgment. When playing on their own, children prepares them selves for socialization. They create their images for play and life so learn about the coming relations. Pretending is still an active form of play for schoolage children. Some prefer playing games with using action figures, vehicles, and blocks to create their own theaters with which they use as a medium of transformation and create better stories. Any toy that helps them create a story and so provides them a play is a nice story creation source. Like a magician, trying to make magic he needs a special tool for making him powerful, children needs toys for making themselves believe in such dramas. So that their stories become more realistic and worth playing.

Six and seven years old children enjoy making up more complex stories like war stories, space stories, or stories that they have watched on TV night before, by adding parts that will make them the super hero. A stick may become the sword of magic or a tool which even doesn't have wings may become the fastest plane of the world. But of course these are all of the materials that TV provides. That is what makes the toy companies design toys that are very much related with TV. But of course it is designer's duty to think of the probability of taking the ability of creating stories from the hand of the children when providing them a prepared one.

2.2.5.1 TV and Playing

Children of the past and the grown up people of the future might all very well be informed about their lives of the past individually. But the children of today seems to have something in common to build up memories of games and toys as they have all been influenced with one thing the most, TV. Therefore setting aside the idea of diminishing the children's power of story creation, TV seems to play an active roll on the way of providing them a common source of play which makes them more social. In this sense, a child playing outside, with other children does not hesitate to start making up a story, related with yesterday night's cartoon show, which he is very sure that he and others have watched. So this provides them another medium of socialization.

On the other hand comparing the play of the previous generations and the play of children today, one must admit that the plays and toys of children today contains more science and is likely to offer more privileged child life due to the source.

For most children, the interest in TV related toys is generally short lived. This is true because most of the stories watched on TV have to be replaced in time by the new ones. And the children who were not totally satisfied with the previous story do not hesitate to shift to the character of this new story in his plays. When playing, the child absolutely needs to create a story by making use of the toys available.

Both boys and girls still enjoy pressing their plush dolls against their chests and play together with them as they are always available. These toys continue to supply comfort as children when they are left on their own still needs a friend.

By the early school years, the distinction between boys and girls is clearly defined . The choice of toys are made more sharply and every detail in the game reflects the life of one sex, the sex of the players. This as if becoming a member of the same sex group helps them not get in contact with the other sex which is thought to be source of shame. They believe in belonging to a group with which they can entertain them selves and feel more powerful. Due to their game habits the children chose their toys according to the idea of "who may use it ?" other than "do I like it ?". This reason made the toy producers to put both boy and girl pictures on the toy box. So that they thought to convince them that the product is not for only girls or boys. (Wiencek 1987, p.60)

In the pretend play to serve as a medium the puppets offer opportunities to act in a way that they can give voice to their feelings that are sometimes hard to express directly. They also sharpen the story telling ability and hand-brain correlation. Because, when playing with puppets a child pays attention both to the manners and to the words in order to keep them related with each other. Mostly they replay a passage or a show they watched on TV or a story they read, by the use of the puppets.

2.2.5.2 Art Supplies and Puzzles

Both sexes of children are ready to experience watercolors, crayons, colored pencils and other art materials. Most often the children are fond of drawing pictures which means not much to parents but a lot to them selves.

During the early school years, children enjoy showing their creations. They take pride in their art and like doing things mostly related with relatives.

Crafts work is also entertaining for preschool children , sewing hand puppets, needlepoint, some simple wood work and others are children's play source. But the main point in designing such tools for children is to be able to prevent the possible hazards of these tools without disregarding any part. A designer has to always design the tools as if they are to be used by someone totally illiterate. Therefore a toy designer has to be twice careful with the toy he designs as the children needs supervision most of the times.

School age children are fond of solving problems with which they believe to be evaluated. Therefore every children is eager to show his talents and so be able to appreciate the best regards of parents. Beginners may welcome some assistance at the very start but they surely wish to be left on their own. These children like to cope with others in proving how he manages the toy. Especially some computer games and pocket games are of this kind. These games offer the required socialization. On the other hand toys that are based on such criteria are fundamentals of school life where the children will be among others.

Multi-sided cube puzzles with pictures and others provide different kind of problem that a child has to solve. Because the time needed in such a game is related with how fast you can work it out, other than requiring time for entertaining the child. In other words a child who is eager to solve a cubic puzzle tries his best to solve it as fast as he can and meanwhile postpones the joy of the play until he manages to finish the game. But in the other games such as pocket games the child enjoys him self while handling the game.

These games stretches the time for play and so helps the children spend their time in developing their capacity of problem solving.

2.2.5.3 Electronic Playthings

At this stage the children must be able to match the reading and the drawing printed on the page so as to be able to keep in mind the matched attitudes of what is said. These kind of books gives the readers good experience at scanning phrases and using the voice expressively. Computer games offer the children the chance to play while learning about the most advanced technology of their time. In order to be able to use such a chance the parents must be ready for any question about the technology they have at home. The understanding of play by now has shifted to a less physical power need and more brain work which may cause unhealthy body structure due to long sit down plays. Therefore a toy must provide the children both entertainment and development in physical structure.

The variety of games and adventures being offered by computer games is far beyond the imagination capacity of children. The reason is the structural figures and their talents are the sources of variety. Children in each play meets another hero or story that he enjoys to be a part of. But the parents must be very careful in explaining their children explicitly that these are only games and the success is not easy to achieve in every game.

In looking at the variety of toys and playthings for children of this age, no TV based toys are of too much value but the ones with which they can make their own stories are better appreciated. Toys must provide enough brain exercise and understanding of the world that they have just entered. Such a criteria in the toy design helps the designer to design toys that satisfies the children on the bases of entertainment and success. Therefore toys must offer some challenge and socialization while paying attention not to create a source of quarrel.

2.2.6 Toys For Middle Years (Eight to Eleven Years)

These years are the last years of children for having toys. Their interest is mostly shifted to what is being advised or seen at school by their school mates and also teachers. The school tools they have to use are now the new challenge for children of this age. Of course they still enjoy the toys of their ages. By now they become to be influenced by the heroes not as much as their early years. On the other hand what influences them is now the stories that is created or some special phrases that are used in this story.

Sports and games with rules become very important for the children of this age (Oppenheim 1987, p.260). Being a member of a team or any special group is required not only because they need to be a group but also because they need to exclude others and feel having privilege.

The children of this period like to collect things such as pencils, stamps, chewing gum cards, postcards and etc. The reason of such collection is to have the chance of being able to compare their gatherings with friends as a part of socialization.

The toys that might be appreciated as collect toys do not provide children enough entertainment as the entertainment lies in the interest that has to be created spontaneously by the children. But such a toy might be a good design if it offers the children variety of products that are easily collected. On the other hand sea shells, rocks, coins, and other found or obtained objects might all be interesting for collection.

Many children continue collecting mini cars and trucks. But the children also enjoys playing with remote control cars, trains, or racing cars. On the other hand assembling vehicles are also entertaining and at the same time satisfying event for the children at this age. These assemblies offer the children the taste of building up their own toy and watching it move. While assemblage of these vehicles the children appreciates the help of a parent or do it all together from the beginning with which they learn "work together rules". In building a complex model by following the instructions, a child learns to think methodically and to tackle difficult tasks one step at a time(Wiencek 1987, p.81).

These years are important for children to learn about their friends, attitudes, likes and dislikes, entertainment reasons and emerging talents by being able to reason many sources they face during their lives. They learn about the value of play and cooperation as well as competition. In pretend play they step outside their childish world and become the heroes of the world which can be interpreted as a therapy they go through when playing. Therefore any toy design that is believed to be long lasting must be able to provide enough socialization, therapy, and strength the children requires. The children do not know about what is to come and what kind of problems may arise during their lives. Therefore the parents must always keep in mind that although their children may seem not to have any problems, in their own little world ,like every human they have their own problems, stresses and reasons of unhappiness they have to live with.

For many adults play and toys are not something to be taken seriously. And so they may think that any kind of toy will do. For some others toys and play can be educational and serious. But there is one thing that is solid ; the children from their debut to their latest formation of thinking systems and capacities, they are always interacting with tools that people offer them which are under the responsibility of parents to welcome or not to welcome.

2.3.Designing For Children

When designing a product for children the main point is to think of parameters which exist due to the number of consumer groups. Because when designing for children the designer is designing also for mom, dad, grandfather, grandmother and other family members. That is what makes the design for children a real challenge.

Color is an important factor in children's design. Ages up to nine months respond to bright, hot, fluorescent colors. Children nine months to three years of age respond to basic colors. After the age of three children start to pick a color that happens to be their favorite. On the other hand although, designer strictly obeys such criteria, the design may fail just because mom dislikes the color of design.

Simplicity in design is another point that flourishes buying motives. Most of the parents are reluctant to buy their children toys that are consisted of many parts. The exceptions are of course play sets with storage areas.

Another major factor is safety. Sharp edges, easily burned clothing, pinch points and toxicity are among some of specialties that must be avoided when designing. On the other hand, safety when put in mouth, durability and fire resistance are good design points. For instance the wheel well on a toy truck, should be at least 7 mm away from the tire. Any contrary situation can cause a bad pinch to a little finger. Safety standards that governments are responsible for the establishment, are the limitations of the design parameters that can never be set aside. Although it is believed that the age groups for which the toy is designed, defines the strictness of obedience, a perfect design should always require a true obedience of product standards for a safe toy design.

Besides safety, ease of use is also an important factor. The best example for that characteristic is, Velcro on clothing. It has become a best way for children to learn to dress themselves without facing the old shoe lace problem or button problem (Mosberg 1988, Foreword).

When designing for children another criterion that must be strictly obeyed is governmental standards and regulations. Understanding these guide lines enables the designer to create a more successful product and consumer to make a better choice.

The reason of standardization is to lesser the probability of risks for users as much as possible. On the other hand the standardization does not include the hazards of the toys that are related with their intrinsic specialties (i.e. the unbalance of bikes or pins in a needle set).

Mechanical and physical properties of toys, flammability, experiment sets for chemistry and related functions, chemical toys excluding experiment sets and the transportation of specific elements are that consists the safety of toys according to the TSE (Turkish Standards Institution) which refers to EN, ISO, IEC standards.

2.4. Toy Design

A modular toy is called an open-ended toy which means it provides a medium of an endless imagination. This imagination is only under the control of children and another individual who is to interfere, has to strictly obey every rule.

The basic aspect of playing is never to suggest ready-made solutions but only a hint at what can be done (Munari, 1995 p.30). Otherwise it is someone else's world of imagination the child has to interfere and obey the rules of, where he can be the only ruler, in a contrary condition.

In the design of LIBRA, it was firstly aimed to design an open-ended toy which will provide various mediums for various children. One child when building a castle with it, another one may try to make a giraffe. The point is to try to see what they build with their children eyes. Everyone must have watched a child drawing himself, a cat, a tree or another kind of form. In most of the cases, what they come up with is mostly a different form that hardly resembles the object. The aim of any similar activity such as drawing, building, describing and e.t.c, is to develop the child's pure imagination into a better structured formation. As a Einstein remarked, " imagination is better than knowledge ".

The idea was to build up a form that would be simple, but when brought together would be able to resemble a familiar form. That is why the starting point of the design is simple lines. As it is known two points makes a line and three points makes an area. The second step was then to draw an area and for that another point was required.

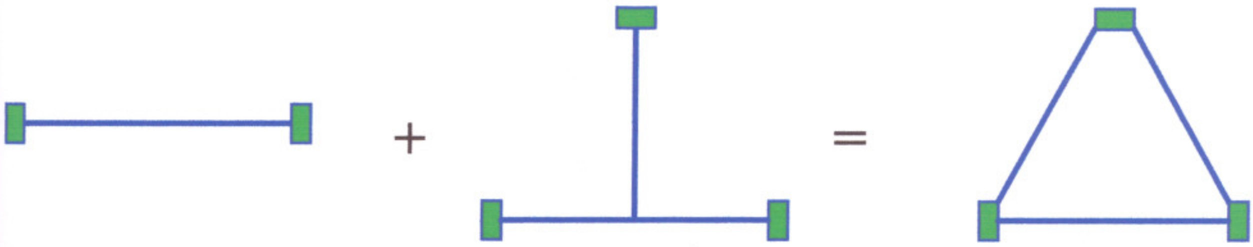


Fig. 2.1 Formation of an area

There are types of modular designs, in which the aim differs from an other. In LEGO type designs the player is mostly pre-decided or is conditioned to build up a form that is drawn on the cover of the box or on the illustration paper. In such kinds of play systems the parts of the toy are different from an other, but still each part needs one another to form the structure. In another type of a modular design, the parts of the toy are slightly different form another and are more open ended. Both of the systems need a talented eye-hand coordination or are ready to provide a teaching medium for the achievement of this goal.

In the second type of modular design, three end points are not very adequate for structural formation, because it always better with a fourth point not to limit the imagination , on the contrary you are left with four ends waiting to be connected.

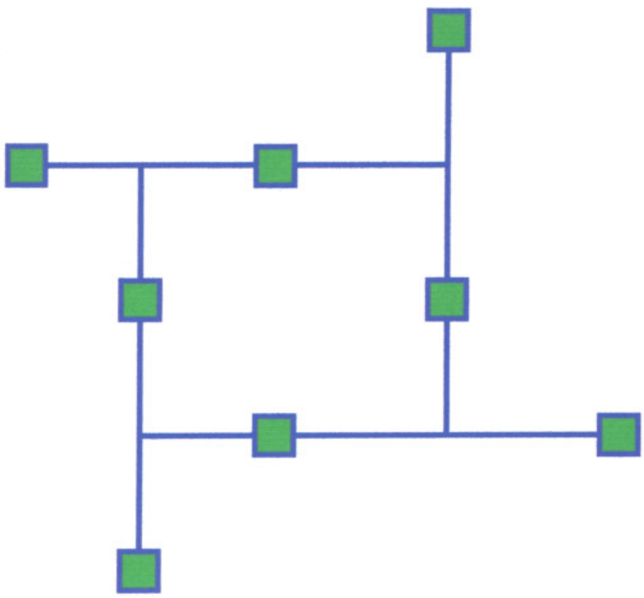


Fig. 2.2 Four ends to be connected.

On the other hand when the end points are doubled the player, would be more free to build up the form in any direction which would enable better forms to be built . That is why eight end points are preferred in the design.

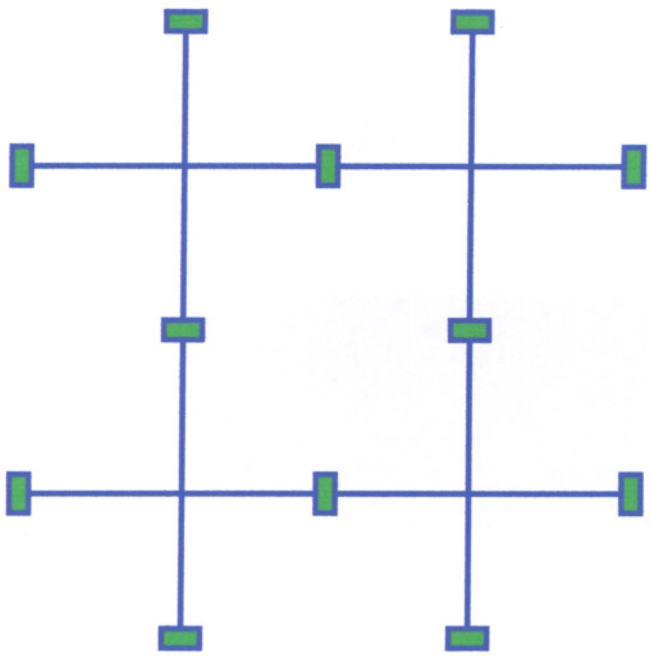


Fig. 2.3 Eight ends to be connected

This system offers the player a planar system. So the third step of the design was to put this planar system into the third dimension. First, it was thought to give this structure, the third dimension, by means of an another line system that would be structured in the crossing point of the other second lines.

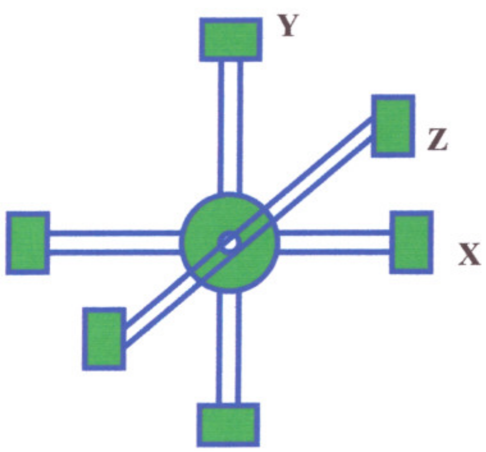


Fig. 2.4 3D Formation study

This binding system would undoubtedly give the structure the third dimension, but the more there are parts of the system, the more they are likely to get lost. Therefore another structure was required in which the modules would be consisted of a single form.

In the LIBRA system, there are four different forms which are the same on the basis of manufacturing. The point that makes four individual parts differ from one another is the positioning of the eight C-like figures on the structure.

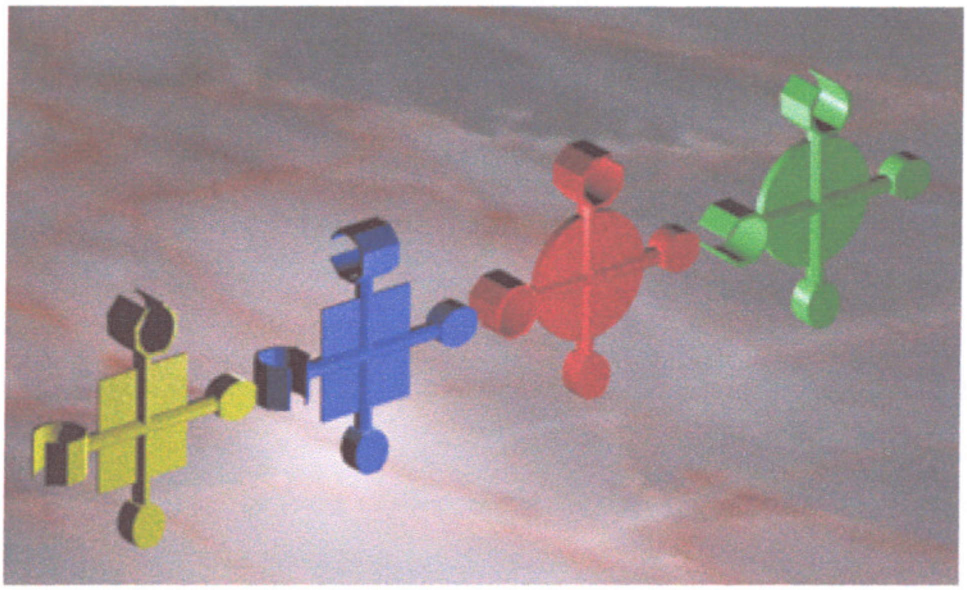


Fig. 2.5 The LIBRA modules

By the achievement of the 3rd dimension, the play system is satisfied not to be planar any more.

These four figures are easily attached to each other and for a better visual perception, square and circle forms are structured on the intersection point of the axes. By that, it was aimed to give the play system a full form look. The base module which is the only totally different shaped form is a heavier unit and is to be used when building the LIBRA system. The weight of the module is focused on the top of the cone and is designed to keep the system balanced for an amount of time from the beginning.

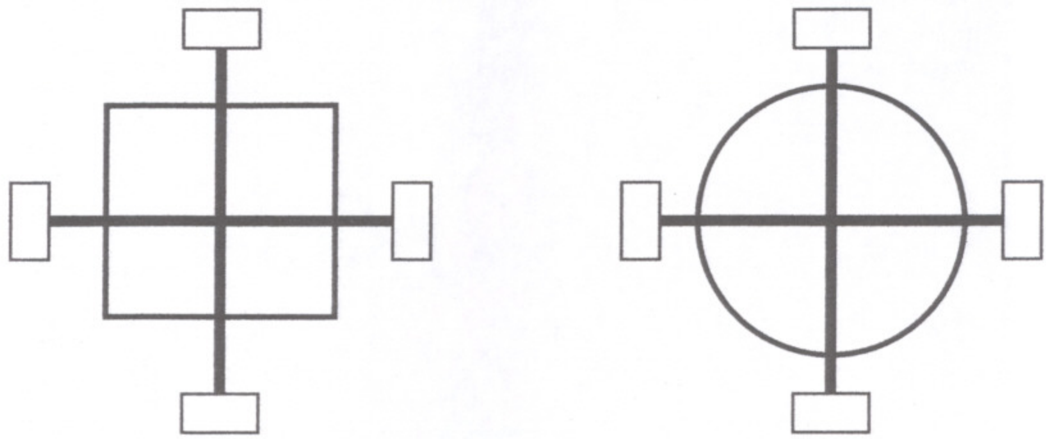


Fig. 2.6 The filled forms

The game is intended to give the children enough socialization, and eye-hand coordination before entering a social world where they have to make use of their logic and intelligence. Therefore this system is designed as an over-table game system which may require a company or two for a challenge. On the other hand this system still allows children to structure forms alone or structure the LIBRA in their solo plays.

The magic of this system is the challenge being offered by the rule of the game which is to keep it stand still after mounting up a single module on the already structured system. The game is not required to be completed in a day, on the contrary it is aimed to make it a long term play medium that will be kept at a corner of the child's room and provide a statue-like form, with which the child will be able to test his patience, competence and interpretation.

The production of this system is very easy and therefore very cheap. There are only four different module systems which will be derived from one another by a simple variation of the head unit (C-like figures).

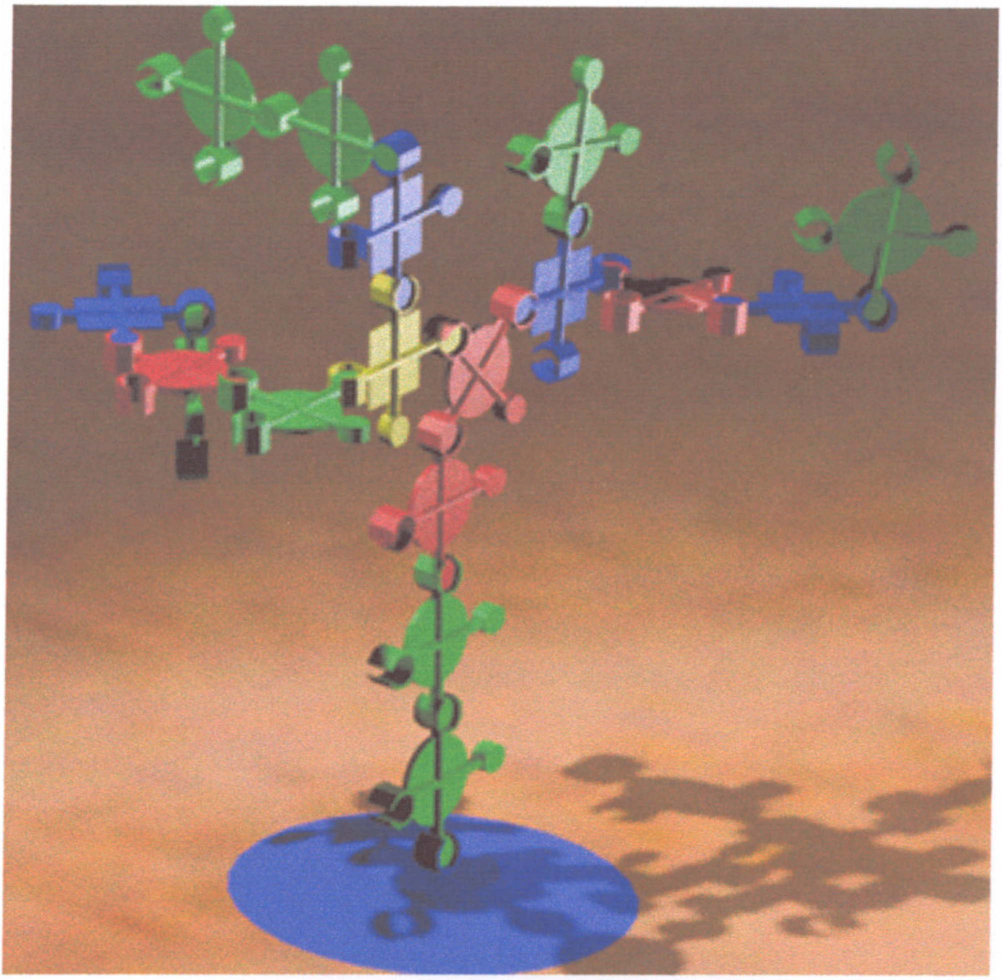


Fig. 2.7 The LIBRA

The production material is preferred to be ABS, with the adequate characteristics. Although there is a study about a new material called CELCON M270 which is said to be the future material of such play systems, the availability of the material is a characteristic that effects the material selection. The production system is chosen to be injection molding which is mostly preferred for production in groups.

The below figures are some of the examples that can be structured with the modules (Please do not consider the color difference with the modules on top and the primitive structure).

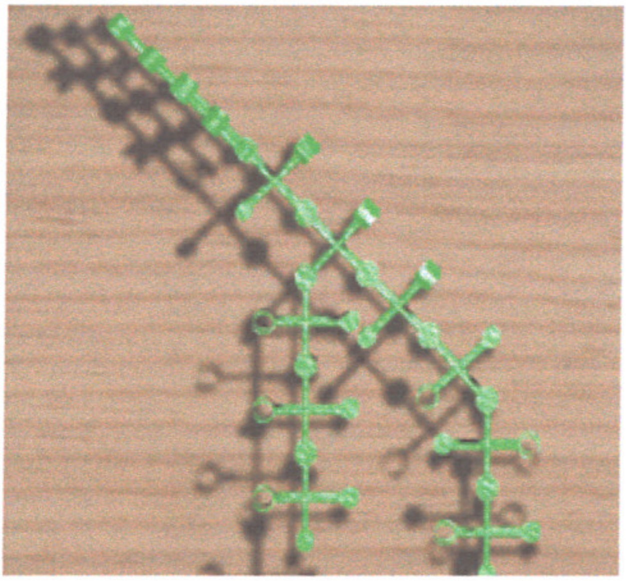


Fig. 2.8 The Giraffe

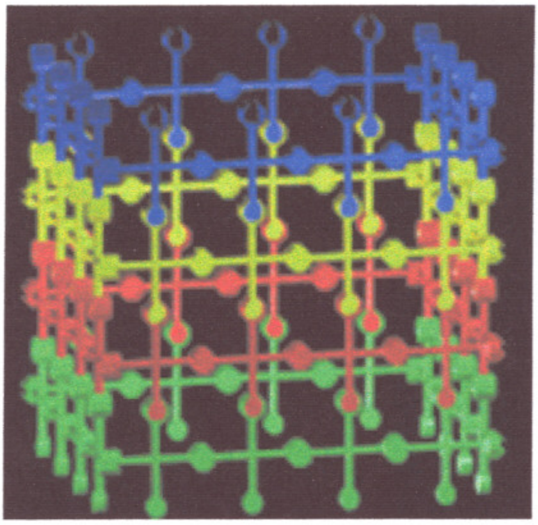


Fig. 2.9 The Box

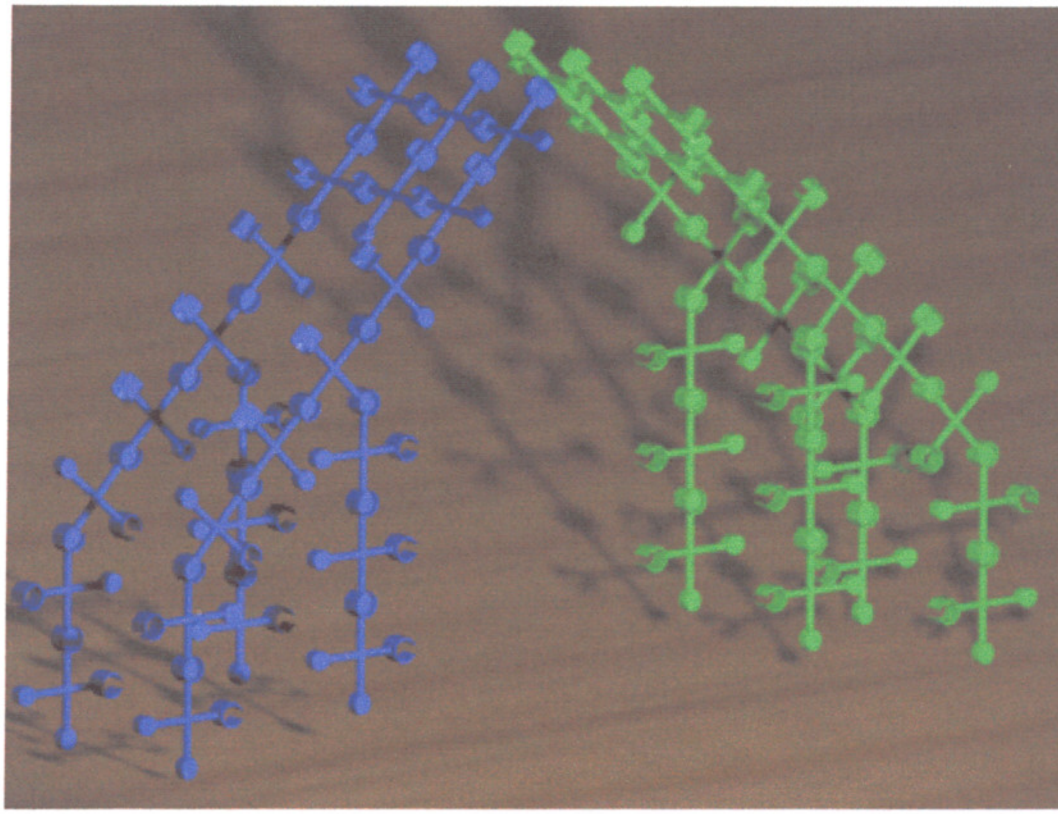
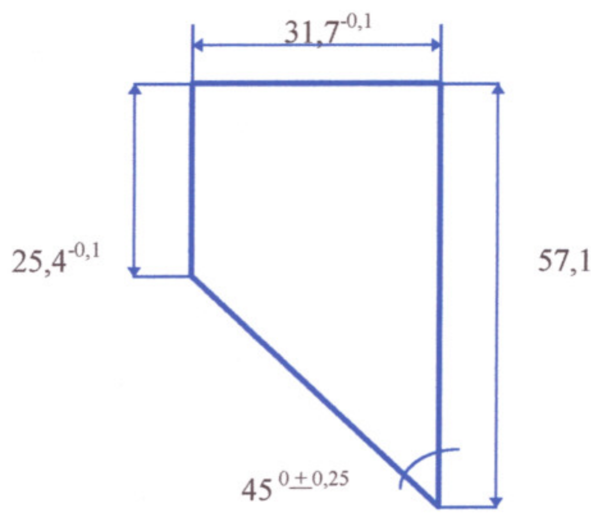


Fig. 2.10 Formation of a house

The dimensioning of the modules are calculated according to Turkish Standards Institution (TSE). According to TSE any part which may be a toy or a piece that may be dismantled from the main structure must not get through or cause a full closure in the test cylinder.

Fig. 2.11 The test cylinder



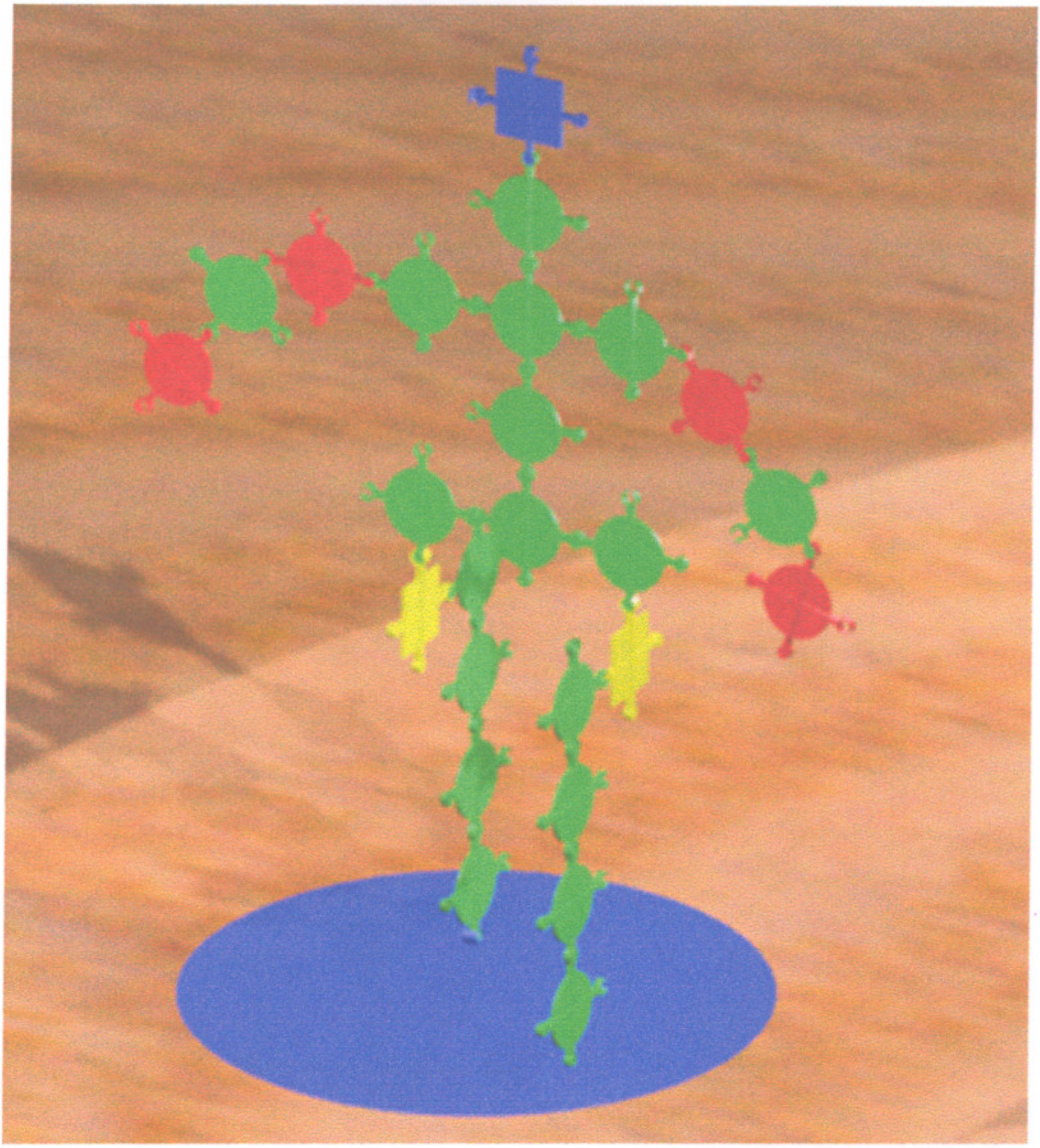


Fig 2.12 The LIBRAMAN

Taking into consideration the TS 5217 prEN 71-1/ Nisan 1996 (Safety of Toys- Part 1: Mechanical and Physical Properties) standardization, the dimensions are calculated to be minimum 50 millimeters. Another standard which is flammability (TS 5218 EN 71-2 Aralik 1996) was also inspected and no contrary argument about the use of ABS was found.

2.4.1 Technical Drawings of the Modules

All drawings are in millimeters and scale is 1:1

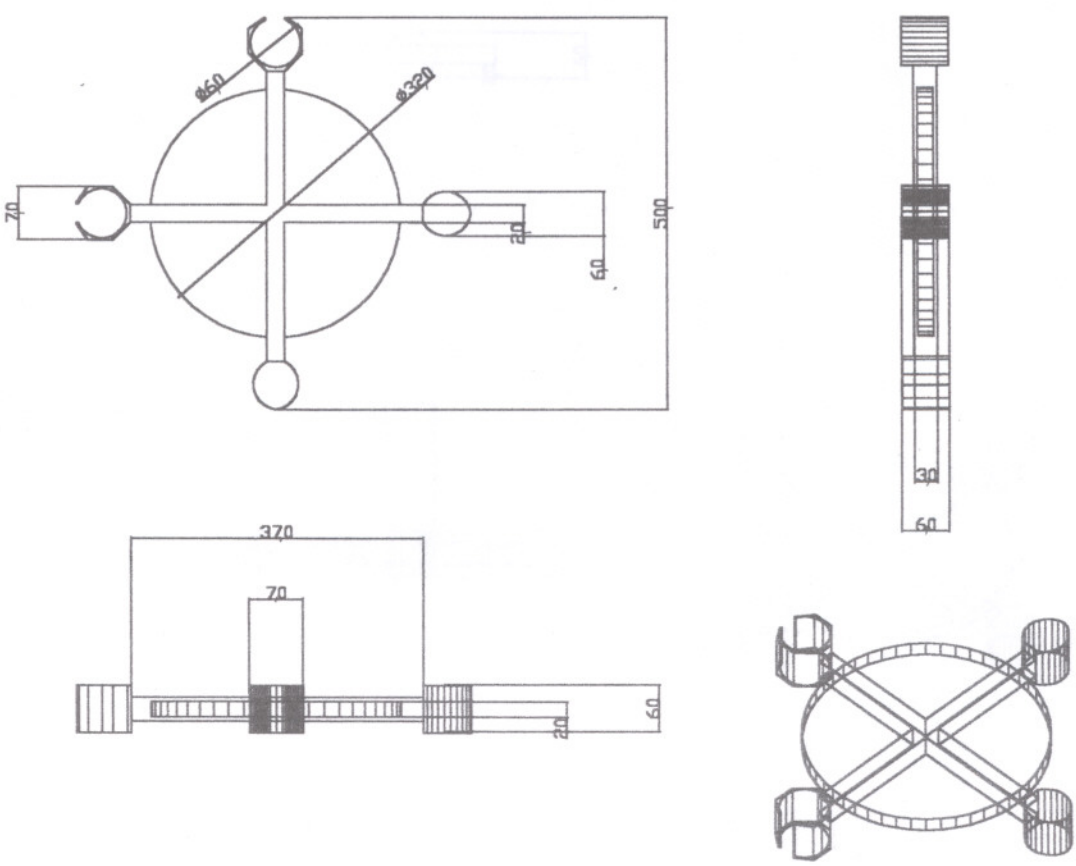


Fig. 2.13 The First Module

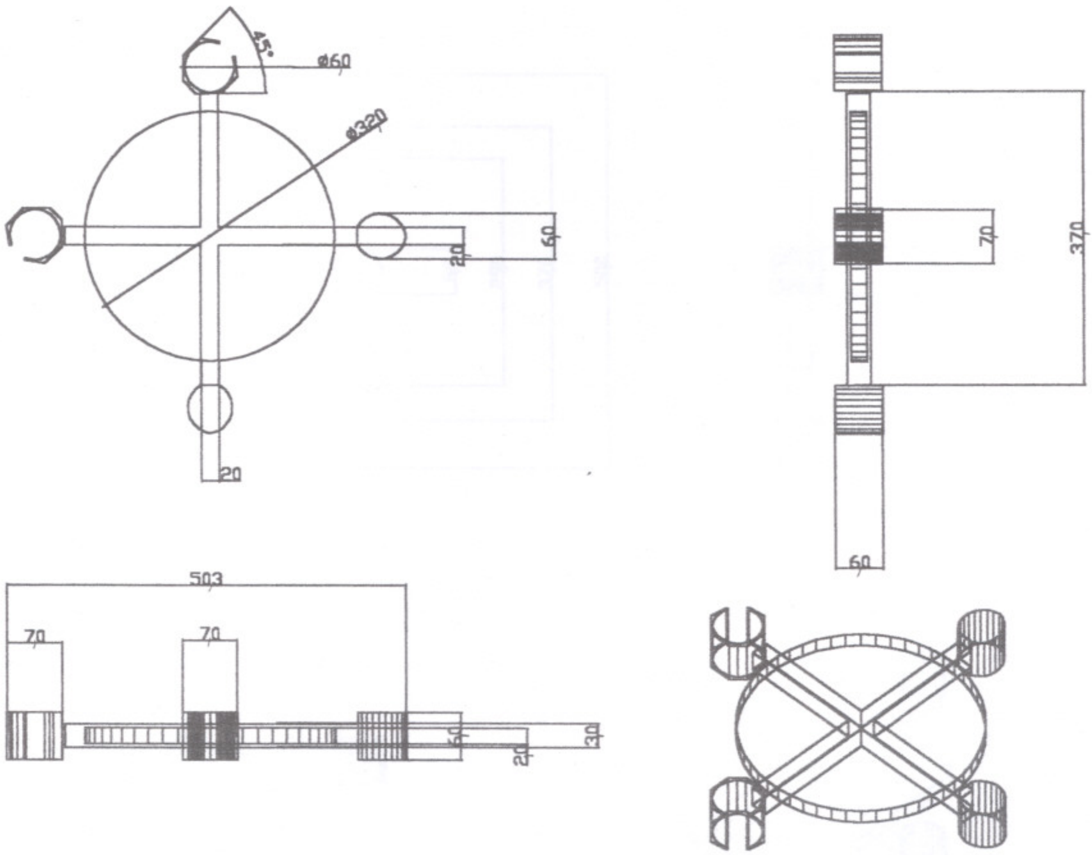


Fig. 2.14 The Second Module

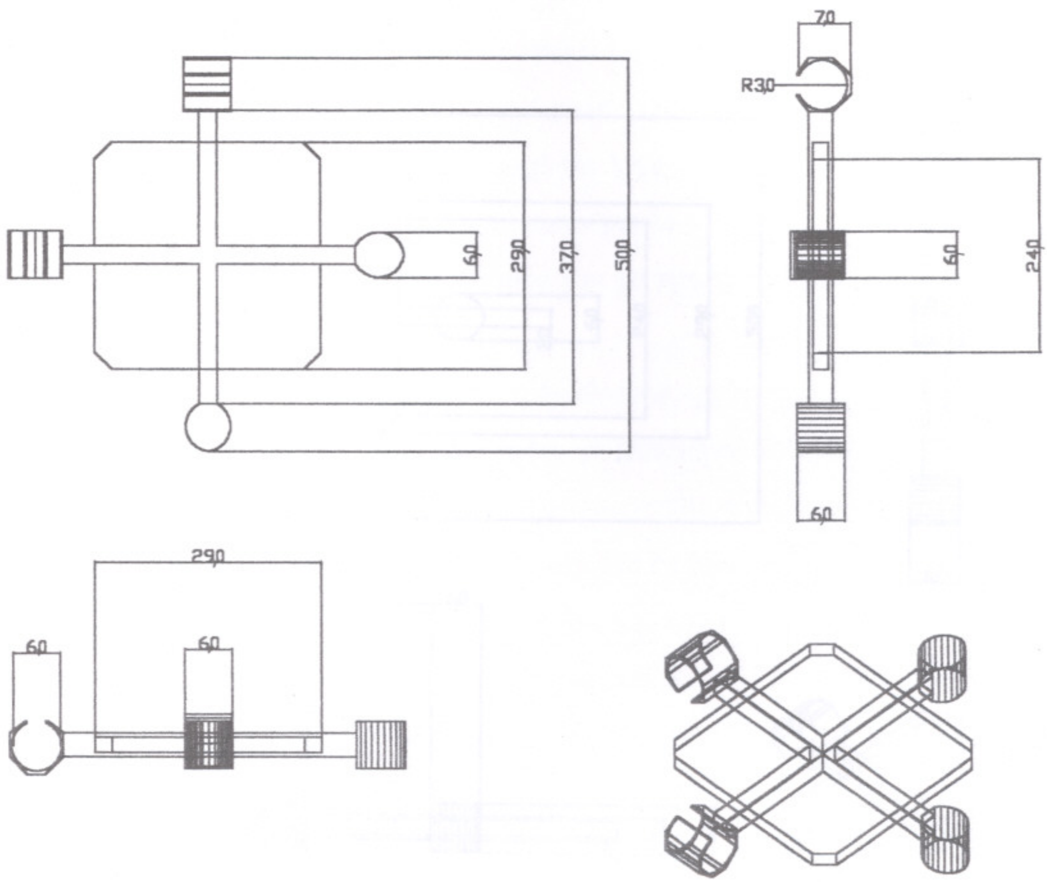


Fig. 2.15 The Third Module

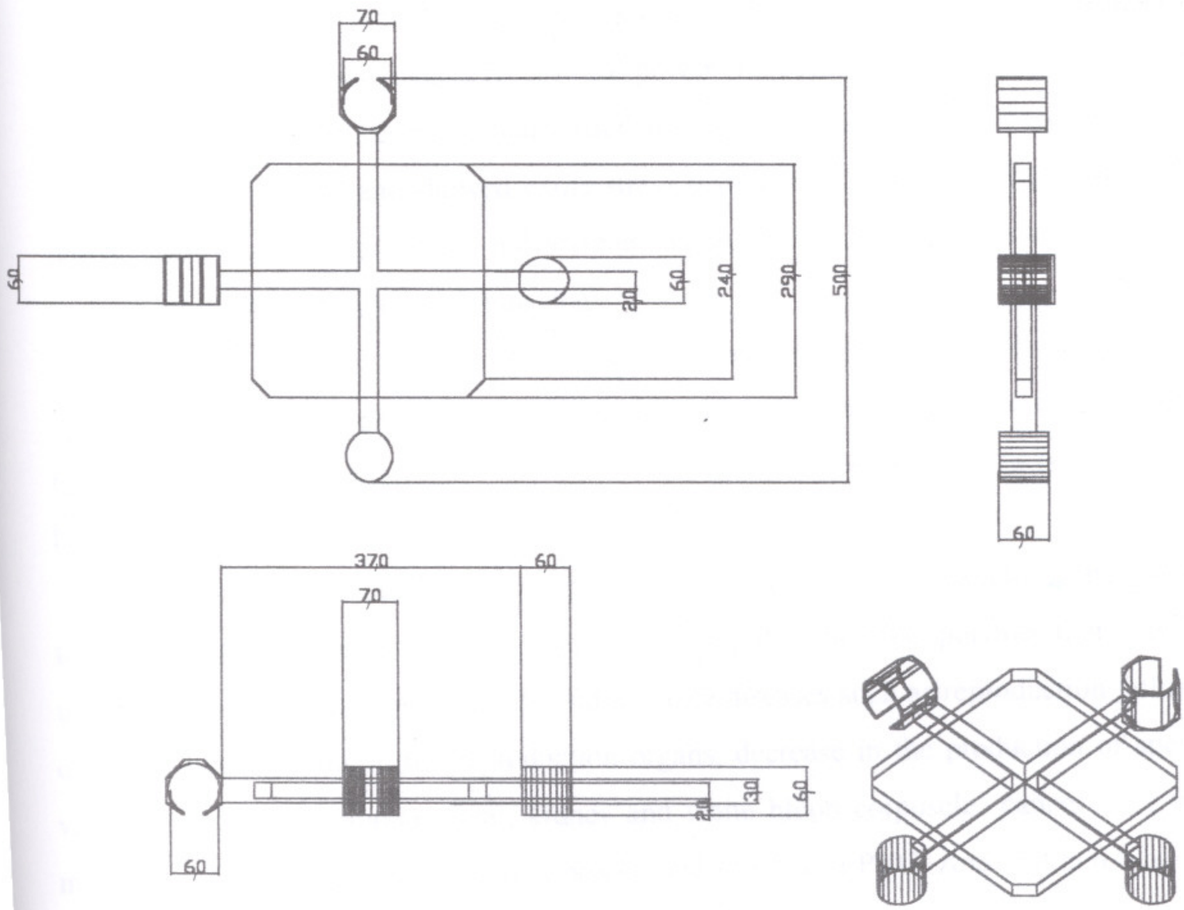


Fig. 2.16 The Fourth Module

CHAPTER 3

MATERIALS AND PRODUCTION TECHNIQUES

3.1 Materials

Children's toys can have complex performance requirements and contain some valuable lessons about materials selection issues (Fletcher, 1996 p.395). Toys must be able to withstand a certain degree of physical power and continue to perform for a number of years. The polymers, conventionally used for toys can not withstand repeated abuse. Polyethylene elongated and showed white stress marks at weak spots. Polypropylene can not retain its shape. High impact polystyrene has no springy flex. The actual copolymer, both flexes readily and goes back into shape.

As can be seen, polymers like polyethylene, polyvinyl chloride, acrylonitrile-butadiene-styrene, polypropylene, polystyrene, polyurethane and polyisoprene are mainly being used. The latest researches on one of these materials revealed some facts that can not be ignored until the contrary arguments are proved to be true.

The research made by the Greenpeace organization which is said to be announced to the toy producers all around the world, explained that the PVC polymer that is being used in the production of soft dolls is said to cause diseases such as reproduction failures, different developments in the reproduction organs, decrease in the production of sperm, variations of cell membrane, liver, kidney and white blood corpuscle cancer due to a material called "Phthalates" which is proclaimed to exist in PVC. And children who are likely to put everything that they can find into their mouth and squeeze, bite or lick, can easily get the so called material out of PVC.

This research which lasted for one year is prepared by scientists Dr. David Santillo, Ruth Stringer, Irina Labounskaia, Dr. Paul Johnston, John Siddorn and Angela Stephenson from the Exeter University in England and proved that among the 71 toys tested, 63 of them had parts made of PVC. Many other researches made by companies such as Aristech in 1995, Europe Chemicals Bureau IUCLID research in 1996, Swiss National Chemicals research and USEPA researches based on rats in 1992 seem to support the Greenpeace arguments.

Another study that supported the Greenpeace organization is made by Environmental Health Perspective (EHP). In the report prepared in 1997, phthalates material is proclaimed to cause decrease in the estrogen hormone which effects the development of the children .

As a result of these researches it is believed that the children who are to get involved with such material in their growth period are prone to have diseases that can not be cured.

A new material, the Celcon M270 which is selected for a toy is a high mould flow material with a tensile strength of 60 MN/m^2 at room temperature. A toy called "Links" proved that the acetal copolymer satisfied the stringent toxicity standards demanded of a teething toy and provided the right combination of mechanical properties. ASTM load to failure standards call for toys to take 65 N of stress without breaking, and this new material slipped of text figures. On the other hand colorants which matched the designers' bright color specifications without lead, cadmium or other toxic heavy metals are formulated, in this new material. ABS was also studied and was found to be convenient for making rod segments with stiff, strong ends for a snap fit.

Under the light of these arguments although Celcon M270 seems to be the best material that matches toy requirements, on the other hand ABS is still being preferred in the construction toys and most of the companies try changing the inner structure according to their requirements.

3.1.1 Polyvinyl Chloride (PVC)

The basic raw material for polyvinyl chloride is acethylene or ethylene gas. During it's manufacture, polymerization may start by peroxides, persulfates, ultraviolet light, or radioactive sources. For addition polymerization the double bonds of the monomers must be broken by the use of heat, light , pressure, or a catalyst system to quicken the polymerization.

The use area of polyvinyl chloride may be increasred by using plasticizers, fillers, reinforcements, lubricants, and stabilizers. By this the formation of different structures such as flexible, rigid, elastomeric, or foamed compounds is achieved.

PVC is mostly used in flexible films and sheet forms. Washable wallpapers, handbags, rain coats and such dresses are so me of the products that can be produced by making use of polyvinyl chloride (Richardson 1989, p.197). They are easily fabricated by welding, heatsealing, or solvent cementing with mixtures of ketons or aromatic hydrocarbons.

Slush and rotational casting of polyvinyls are used to produce hollow materials such as dolls, balls, large containers. In the toy industry polyvinyl chloride is heavily used due to it's ease of manufacture and preferable availability. Generally materials in the vinyl group are flame, water, chemical, electrical, and abrasion resistant. They have good wheterability and may be transparent. To aid processing and provide various properties, polyvinyls are commonly plasticized.

Polyvinyl chloride is the most popular in the vinyl family. Other homopolymer and copolymer polyvinyls are finding increasing use due to the variation of requires from the industry for different characteristics.

The reason why polyvinyl chloride is mainly being used may be described by it's advantages which are; the processability by thermoplastic methods, wide range of flexibility, nonflammable, dimensional stability, comparatively low cost , and good resistance to weathering. On the other hand the disadvantages may be counted as; being subject to attack by several solvents, limited thermal capability , may be stained by sulfur compounds and has higher density than many plastics.

3.1.2 Polyethylene (PE)

Ethylene gas is a member of an important group of unsaturated, aliphatic hydrocarbons called olefins, or alkenes. The word olefins mean oil forming. This name is given to PE because oil is formed when ethylene is treated with chlorine.

Polyethylene has many different kinds which vary in the molecular mass and so are called as, very low density polyethylene (VLDPE), linear low density polyethylene (LLDPE), high molecular weight-high density polyethylene (HMW-HDPE), ultrahigh molecular weight polyethylene (UHMWPE). With increasing density, the properties of stiffness, softening point, tensile strength, crystallinity, and creep resistance are increased. And so impact strength, elongation, flexibility and transparency are reduced.

Because of it's low price, processing ease and a broad range of properties PE is the most used plastics. Polyethylene is mostly used in the food sector as it is oxygen permeable (For instance oxygen keeps the meat looking red and prevents moisture from condensing on packages.) and is also used in containers where beverages are kept. Also injection molded toys, small appliance housings, garbage cans, freezer containers are all made of polyethylene plastics.

They are among the light weight plastics with a density range of 0.91 gr/cm^3 to 0.965 gr/cm^3. It can be twisted in very thin sections but is quiet rigid when it is thick. The surface of the PE is like it is waxed and resists water sticking and also has good characteristics when cooled.

Advantages of PE are low cost (except UHMWPE), excellent dielectric properties, moisture resistance, very good chemical resistance, availability in food grades, process ability by all thermoplastic method (except HMWHPE and UHMWPE). On the other hand high thermal expansion, poor weathering resistance, subjection to stress cracking (except UHMWPE), flammability and difficulty in bonding are the disadvantages of PE.

Addition of fillers, additives or other monomers may also change properties of polyethylene. These additions result in the above mentioned polyethylene types which are all used in many parts of industrial products.

3.1.3 Acrylonitrile Butadiene Styrene (ABS)

ABS is a thermoplastic material and belongs to the group of acrylics.

Thermoplastic plastics are the group of plastics which softens when heated and hardens when cooled. With twice or thrice repetition of this heating and cooling process a new form of thermoplastic is achieved due to it is capability of being poured when heated.

On the other hand acrylics is a sub-group of thermoplastics and Therefore have all the properties mentioned above. Acrylics are slow burning and releasing little or no smoke materials and have wide range of colors. With their outstanding optical clarity, ease of fabrication, excellent dimensional stability and low mold shrinkage, perfect electrical properties and rigidity with good impact strength, they represent the feasible material type. Their resistance to weather conditions and ultraviolet rays provides them the external use. They are unaffected by food and human tissues. On the other hand due to their rigidity they have poor flexibility and are limited with continuos service temperature of 93^0 C. They have poor solvent resistance and can be cracked due to stress.

ABS polymers are opaque thermoplastic resins that are composed of acrylonitrile butadiene and styrene monomers. Acrylonitrile, provides chemically resistance while styrene provides ease of manufacture, hardness and shininess and butadiene provides shock protection and durability in room temperature and in cold weather. Therefore, ABS can be called as terpolymer (“ter” meaning three) consisted of three monomers.

This polymer was developed during and after World war II and researches were made on ABS which lead thermoformed ABS to be used for an experimental car body in 1970 designed by Borg-Warner's Centaur Engineering facility.

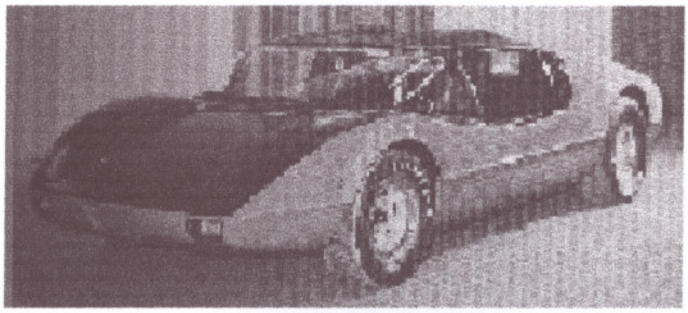


Fig. 3.1 Thermoformed ABS usage in an experimental car in 1970 (Dubois 1972, p.253)

Due to ease of extrusion and injection molding, ABS has an easy manufacturing process. But ABS is hygroscopic material Therefore it needs drying in order to reduce surface errors. ABS can be used in domestic wares such as food and home as it is resistance to cold and chemicals. Ease of production offers the ABS to be used in hundreds of injection molding processes. Due to efficiency in good looking and durability ABS is used in homewares, small tools, the pipe fittings of the telephone and other complex molding implementations. It's high resistance to heat and decoration coherence (lamination, coating, coloring and etc.) are key features.

ABS can be used in manufacturing of inner parts of planes with addition of flame proof additives.

Opaque ABS, is used in, inner parts of refrigerators and toys. ABS, when used in unstable and unprotected mediums, has little UV resistance. ABS can be used at outside conditions but for the parts exposed to sun light for long periods, a protection is required. This protection may be provided by coating a protective acrylic leather strata on extruded ABS plate.

Some examples of toys and the polymers they are made of can be seen in the below figures.

Fig. 3.2 Toys made of polyisoprene

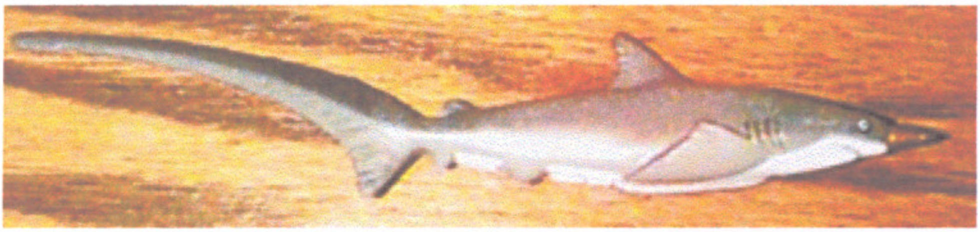


Fig.3.3 Shark pen

This shark pen is produced from polyethylene, which is both a toy and a writing utensil

Fig.3.4 A toy periscope

This periscope is another example of polyethylene, a material that is commonly used in the toy industry

Fig.3.5 The toy car made of polymer

The body of the car is made of polystyrene, tires made of polyisoprene

Fig.3.6 Different kinds of polymer usage in a toy

The robot is made of polystyrene. The insulated wires are made of polyethylene. The circuit boards inside are made of epoxy resins.

Fig.3.7 Group of toy animals

These puppets are stuffed with polyurethane foam. On the outside their fur, be they mammals, is made of things like polyacrylonitrile and their scales, be they fish, are made of nylon.

3.2 Production Techniques

The primitive production techniques mostly contained a muscular power generation unit and a press unit with which mostly a comb or jacket buttons were produced.

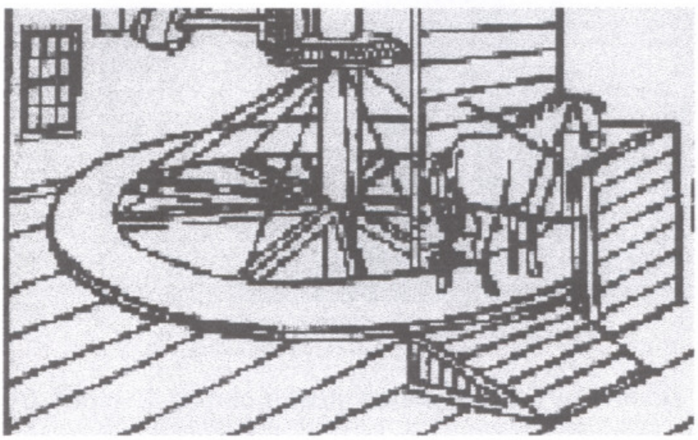


Fig. 3.8 The primitive production technology (Dubois 1972, p.12)

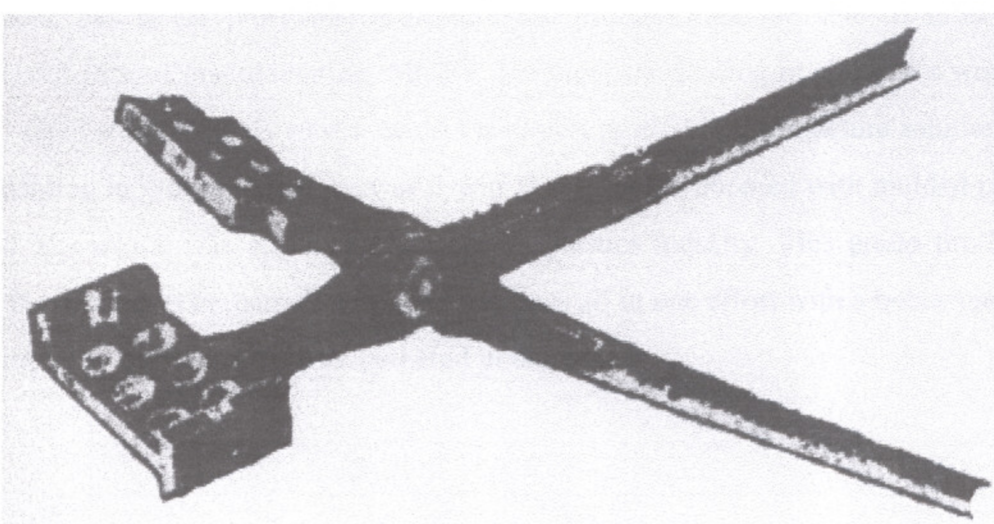


Fig. 3.9 The early mold technology (Dubois 1972, p.6)

Since then many developments occurred and production became more feasible. By the end of 19th century the technology became efficient enough to produce intricate details which can be seen at below doll-like figures. These were among the first plastic products to be made by the Hyatt-blow molding technology.

Fig. 3.10 Molded celluloid baby rattles in 1890 (Dubois 1972, p.44)

The techniques employed in the toy Production industry, like other industrial productions has to be profitable. Therefore the process must be able to offer many variations of ease of manufacturing. Most of the products existing in children's world are of small sized scaled objects which causes the easiest profitable manufacture solution to be the production in groups. After the world War II the market boomed with molded plastics toys and kits which was an other milestone in plastics industry. This group production offered the producers to manufacture their products all in one effort with a better precision as everything to be controlled was gathered in one unit.

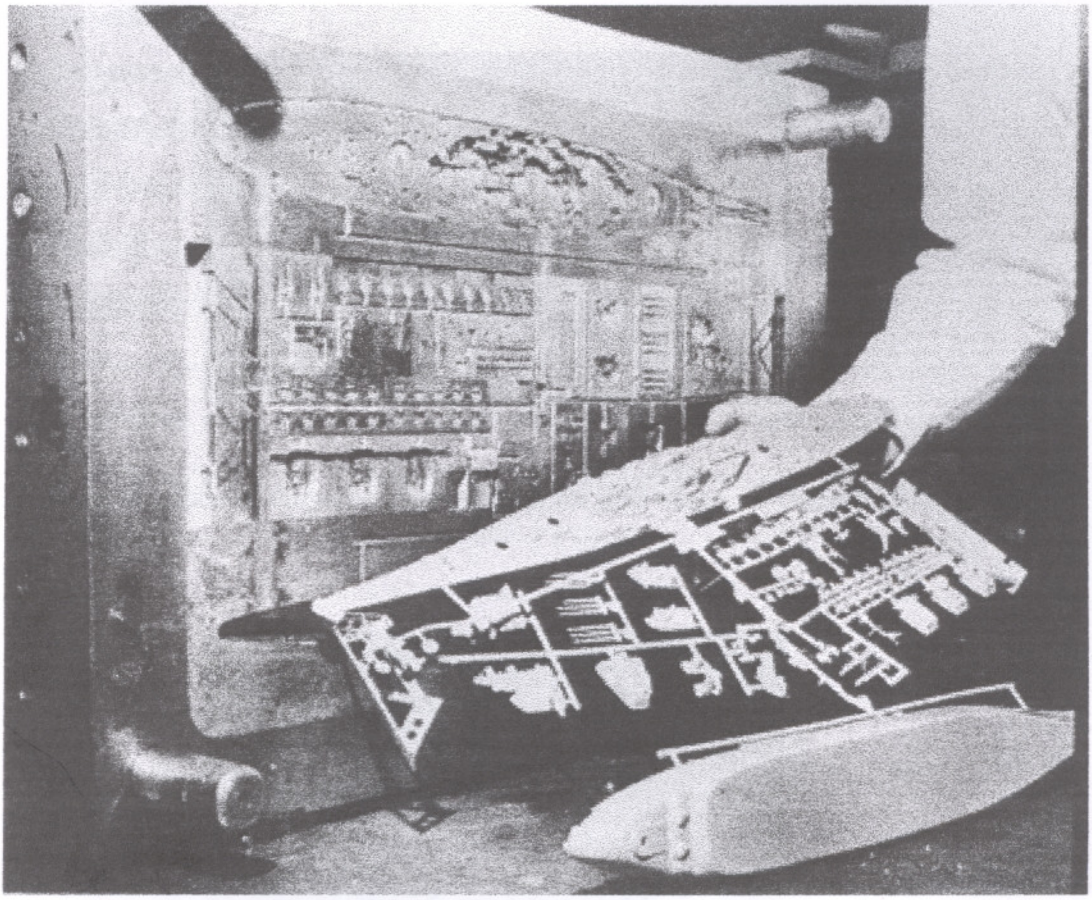


Fig.3.11 A plastic warship produced after the world war (Dubois 1972, p.296)

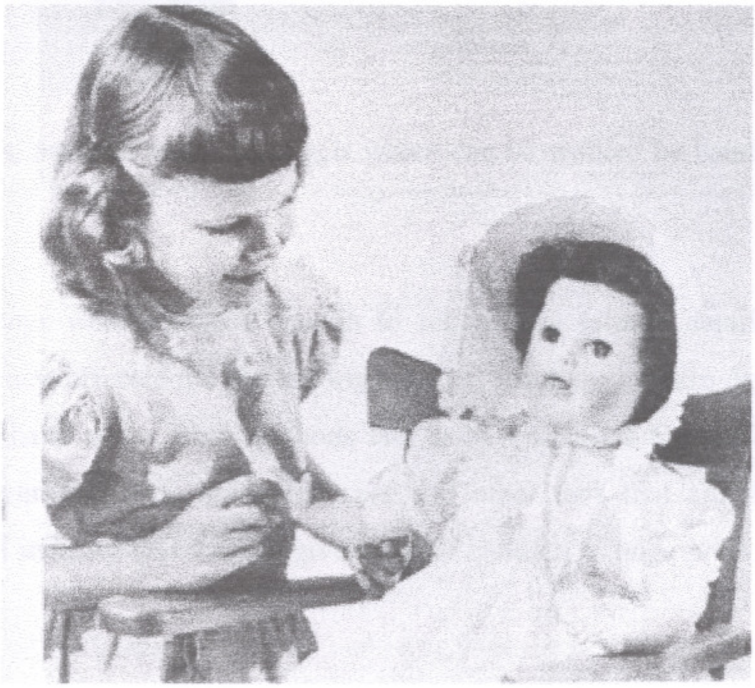


Fig. 3.12 The plastisols were used to make realistic dolls (Dubois 1972, p.287)

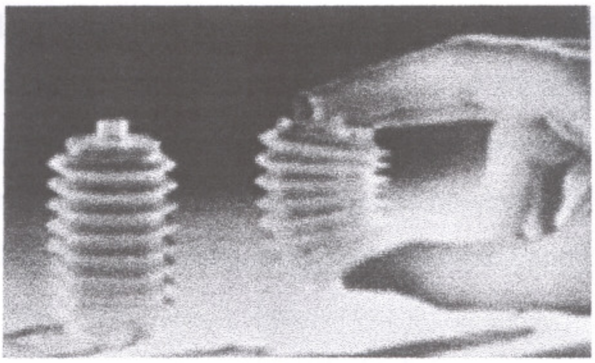


Fig. 3.13 Bellows made of ethylene vinyl acetate for doll voice (Dubois 1972, p.99)

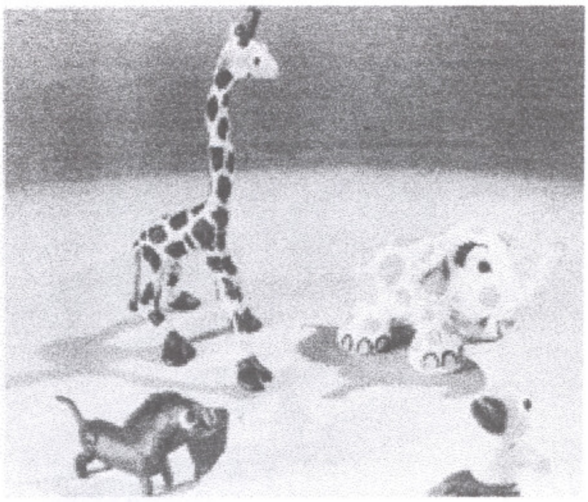


Fig. 3.14 Toys, made of vinyl plastigels which can be worked by hand (Dubois 1972, p.287)

All of these toys were efficient enough to retain very minute details without distortion. This efficiency, effected the plastics toy industry, reach the modern days.

On the other hand some other methods has to be employed for some specific products such as playground toys, motorized cars and other toys that are the plastic reflections of the steel industry that used to give form to children's huge products in the past.

3.2.1 Injection Molding

Injection molding machines for thermoplastics are derived from metal molding or die-casting machines.

The first such machines were developed in USA in 1870. The first machine to produce thermoplastics parts by injection molding was however built in Germany in 1920. It was an entirely hand operated machine. Both mold clamping and injection were actuated by the operator.

As a product, combs played a great role both in the plastics industry and in the injection molding technology by being among the first products to be injection molded and produced with plastics.

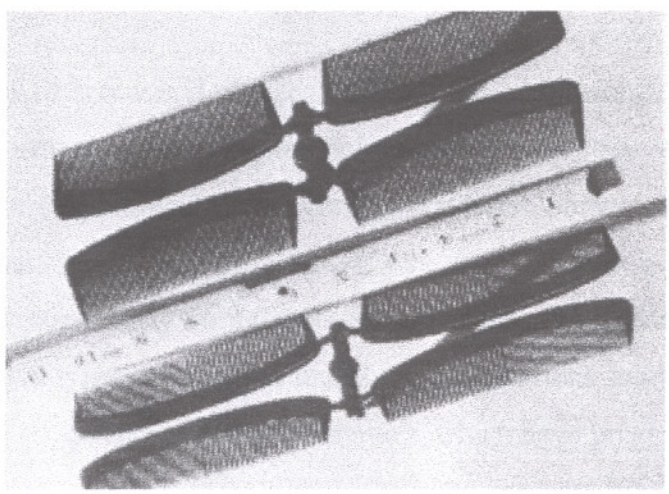


Fig. 3.15 Combs produced by injection molding technology (Dubois 1972, p.273)

Italy was one of the first European Countries to begin building self hydraulic injection molding machines. The earliest machines of this type appeared in Italy in 1947. They were small machines, with shot capacity limited to approximately 30 gr. polystyrene.

Since then development has gone forward rapidly, Fully automated machines are now available that require no intervention whatever by the operator. There are new industrial plants where banks of machines are installed with 50 or more units operating entirely automatically. Even hopper feeding as well as ejection and removal of parts as the cycle is completed are performed automatically.

This method is used in the production of many objects made from many thermosetting compounds and from all thermoplastics except PTFE fluoroplastics, polyimides, some aromatic polyesters and special engineering grades.

The injection molding process consists essentially of, heating the thermoplastic material, which comes in powder or granule form, so as to make it " plastic " in a cylinder known as a "plasticizing barrel" and then injection it into the cavities of a mold, from which it will take its shape. The mold is kept at a temperature below the material's melting point, so that once injected material quickly solidifies. At this stage, the processing cycle is completed, and the molded part ejected.

In other words in every injection molding process there are five steps;

1.The mold is prepared, closed and moved against the nozzle.

2.The screw or screw and plunger plasticize the material and force it forward into the mold cavity.

3.The screw or screw and plunger maintain pressure through the nozzle until the plastics is cooled (heat is removed by water circulation).

4.The pressure is removed as the screw or screw and plunger receive fresh material from the feed hopper.

5.The mold moves away from the nozzle and opens. The molded part is removed.

There are two types of injection machines, with various modifications. These are the plunger and the reciprocating screw techniques, which have preplasticizer sections and can be combined.

The major difference between the two methods is in the way that the molten mass is forced through the heating cylinders and injection chamber. In plunger machines, the material is forced around the torpedo and then into the mold cavity. In the other technique, granular material is quickly made molten by the heated barrel and screw action. This screw acts like a plunger when stopped turning. The hot melt is then forced into the mold cavity. This machine is capable of mixing and blending colors and other materials faster due to the action of the screw.

Injection molding is used more because material inserts may be employed output rates high surface finish can be controlled to produce any desired texture and dimensional accuracy is good. For thermoplastics, gates runners and rejected parts may be reused.

The injection capacity of machines is measured by the amount of material they can eject per cycle and for standardization, polystyrene is used. This capacity is between 0.7 Oz (20 grams) and 19.8 lb. (9000 grams).

There are other kinds of injection molding among which we can count coinjection molding, reaction injection molding (RIM), and reinforced reaction injection molding (RRIM). In the coinjection molding process, two or more materials are injected into the mold cavity. This usually produces a skin of material on the mold surface and a cellular center core. In the reaction injection molding several reactive chemical systems are mixed and forced into the cavity where the polymerization reaction occurs. The automotive and furniture industries are the major users of RIM. When short fibbers or flakes (particulates) are used to produce a more isotropic product, the process is called reinforced reaction injection molding (RRIM). The application areas of this method is automobile fenders, panels, bumpers, shields, appliance housings and furniture components.

Every injection method has some basic steṕs in common in a time cycle. These are:

Injection time: The time required for the plastic materials to be forced into the mold cavity.

Dwell time: The time that force or pressure is kept on the material in the cavity.

Freeze time: The time required for the material to cool or set enough for safe removal from the mold cavity.

Dead time: The time required to open the mold, remove the molded part and close the mold.

A plastic material ready for molding or for other process may be defined as "compound". Incorporating the base resin called "binder", and various chemical additives as well as reinforcements or fillers varying types.

In the group of thermoplastic resins, the base resins widely used for producing molding compounds, and generally supplied as granules or powder are cellulose resins, vinyl resins, acetal resins, styrene resins, polyphenylenes, thermoplastic polyesters and polyurethanes.

Since the very early stages of the development of the plastics industry, it was realized that better products could be obtained if the base polymer were mixed with additives or fillers that are inorganic powders, platelets or short fibbers included into the polymer composition to reduce the coefficient of the thermal expansion.

Additives on the other hand can be conveniently classified according to their function into various classes and subdivided according to their more specific function. The main classification includes; processing additives, flexibilisers, anti-aging additives, surface properties modifiers, optical properties modifiers fire retardant and foaming additives.

As a result we can count the advantages of injection molding as (Richardson 1987, p.261):

1.High output rates

2.Fillers and inserts may be used.

3.Small complex parts with close dimensional tolerances can be molded.

4.More than one material may be injected into the mold (coinjection molding).

5.Parts require little or no finishing.

6.Thermoplastics scrap may be ground and reused.

7.Self skinning structural foams may be molded (RIM).

8.Process may be highly automated.

And disadvantages as:

1.High mold costs

2.High equipment costs.

3.Quality may be affected by workmanship, process control, and other variables.

The injection molding is a convenient production type for toy systems as it offers many positive characteristics as mentioned above. Also the toy systems especially the ones which are over table design are mostly produced in groups, which injection molding provides.

3.2.2 Rotational Molding

The tooling for rotational molding can be compared to the split cavity techniques of blow molding; their molds are similar except that no cooling areas are required. The machines provides the means of holding the tooling and rotation causes the powdered material that was loaded into the mold, before it was clamped into the machine, to solidify and cling to the wall of the mold. The thickness of the deposit depends on the time allowed for rotation and the amount of material placed in the mold.

Rotational casting rotates on two planes, while centrifugal casting rotates on one plane. Large pipes and tubes are sometimes centrifugal cast. It may be used for hollow, completely closed objects such as balls, toys, containers, and industrial parts including armrests, sun-visors, fuel tanks, and floats.

Plastics powders, monomers, or dispersions are measured and placed in multi-piece aluminum molds. The mold is then placed in an oven and rotated in two planes (axes) at the same time. This action spreads the material evenly on the walls of the hot mold. The plastics melts and fuses as it touches the hot mold surfaces, making a one-piece coating. The heating cycle is completed when all powders or dispersions have melted and fused together, but the mold continues to rotate as it enters a cooling chamber. Finally, the cooled plastics is removed.

Nearly all thermoplastic powders may be used in rotational casting. By programming of rotation speed the wall thickness in different areas may be controlled. If it is desired to have a thick wall section around the parting line of a ball, the minor axis can be programmed to turn faster than the speed of the major axis.

Rotational-mold parts may be produced as large commercial containers, tubing with ends cut open, ice chests, pans, boxes, and especially children playground toys. Luggage may be cast as one piece which is then cut at the seam to form two perfectly fitting halves. Foam filled and double walled items, including true composites, can be produced.

3.3 Design Considerations

Most composites change their characteristics with time, due to environmental factors, such as heat, moisture, fabrication method and stock types. These composites therefore may be designed to be isotropic, quasi-isotropic, or anisotropic depending upon design requirements. These requirements are mostly identified by the manufacturer. The manufacturer may wish to have a material that will last for a long period of time or for a short time depending upon the company's sale strategies.

Materials must be selected with the right properties to meet design, economic, and service conditions. On the other hand plastics materials must be chosen with care keeping the final product use in mind. Plastics are more sensitive to changes in the environment, that is why many plastics are limited in use.

Cost is an other major factor in the design concept. The most appropriate material has to be chosen in order to lower the cost and obtain a share in the market. The choice of strength to mass ratio, or chemical, electrical, and moisture resistance, may form the products price. Economics must also include the method of production (R&D), capital investment for new tooling, for new employers, mold making, technical drawing of the items, stocks, tool maintenance, scrap loses and the employed computer programs which may be CAD (computer assisted design), CAM (computer assisted manufacturing) and CAMM (computer assisted mold making) that are very expensive. On the other hand there are some specific problem solving computer programs, such as "control of heat distribution in the mold". It is calculated beforehand how much money must be spent for the mold making paying attention to the cost for each part individually. It is wiser to inspect design considerations under three major group. The first one is material. As it is mentioned earlier the plastics material are effected by the environment more than any other. Therefore the manufacturer has to be very well informed about the standards of the material he is to employ. There may be a vital compromise required to make between the rightist and the cheapest. The second group is the factors determined by the environment. Environmental factors do not only include factors that are related with climate, but also include interactions with chemicals or physical environment. Therefore in this group, heat, humidity , other chemicals and plastics usage area is important. As by now, plastics is being used in human body as reinforcement for some organs such as arteries, heart regulators. These criteria are the same for every industry, only changing case with industrial production types. In the toy industry the material has to be paid attention for, starting from the material in-factory step to the product out-factory step. But again where and how it is going to be used determines the compromise.

In the toy industry the criteria may vary due to the miscellaneous age groups as the play habits are not the same for all. Ages between one and three mostly prefer licking the materials that they find therefore the products have to be safe when mouthed and must not cause any disease while being the cheapest. Ages between four and eight plays with toys with using more strength and so the durability of the product must be achieved for a longer periods. In short play habits identifies the materials inner structure and the money to be spent.

The child Protection and Toy Safety Acts of 1969 and 1976 govern the manufacture and distribution of children's toys in USA. Toys that may cause an electrical, mechanical, toxic or thermal hazard are banned from sale. In addition to extremes of temperature, humidity, radiation, abrasives, and other environmental factors, the designer must consider fire resistance and how he can control the material's characteristics.

CONCLUSION

When designing for children there are several important points to be carefully examined, the first one is that whatever the design is, it must never be a source of injury, it must fulfill the regulations of the legal standardization offices, it must be appropriate for a specific age group, and the designer must never forget that the product is being designed for a different interpretation system owning user. This evaluation means that it must not always be taken for granted that the product, prone to be highly appreciated by the elders will also be as highly appreciated by the children. Because the buying motives of the parents, in most of the cases, is to start the education of the child or to be able to offer him an entertaining reason to be busy with, or to prove to themselves and to other relatives that they can afford to buy their children every thing available. It is true that children do not have the physical power to buy the products but they always have their own physiological persuasions ready for use. Under these circumstances, the marketing strategy of children products, should be to design the packaging for parents and toys for the children as it became easier for the producers, with the help of plastics.

On the basis of marketing, there are of course other things to consider. No matter how high the first implementation of the system price is, the criteria under control helps the producer to get profit out of it in a short time. For instance, in most of the cases the exact control of the life span of the product enables the producers better, to make long term and short term plans about the usage of the product. On the other hand as can be seen in LEGO, a toy designed for a year old child, might easily be adaptive on the LEGO system to be played with, when the child is over five. These strategies are too much related with the marketing concept of the firm. One firm might be remarking that their products will grow the children up, an another might be claiming that they are ready to offer a vast variety of products from the birth until the growth. In such decisions, the boundaries of plastics of course plays a great role. The producers, taking into consideration the unsurpassed characteristics of this material, rely on their products better on the basis of consumerism.

With the new findings, the plastics manufacturers can easily be able to manufacture any form any characteristic any color, in short everything to startle a child. In the figures at the top which enlightens the production standards of a century ago, the superiority of the plastics can easily be seen. The very hard details, the range of colors, the lightness of the product, the taste of the touch, transparency and the variety of texture are specialties, very hard to compete with.

On the other hand the number of production in just one action gives the producers the chance to lower the price of the product. Since the, debut of plastics in the industry, not much of the minds were changed for the better about the use of any other alternatives. On the contrary, the new findings of the scientists and researchers about polymers and especially about plastics, revealed other facts that supported the past. It is believed that every day there is a new polymer group being introduced to the industry with new improved intrinsic characteristics. The toy industry is no exception to accept these new polymers worked on by their researchers and others. As being the most easily influenced group of consumers, children are a rich vein to produce for. To be able to serve this required richness of product and production type, plastics are the most appropriate material. The mentioned criteria at the top indicating the superiority of plastics is the main cause of this situation. On the other hand, as the first material that children taste, hear or touch is their rattles, made of plastics, the importance of these materials is once more approved.

Plastics are still prone to development due to daily identifications made by the researchers. With their unique reasons, what is being produced today is also being a step for the future. Every plastics is being produced for a specific characteristic and once this is achieved it becomes a material to be worked on for the formation of a new characteristic. But what is in common in every step is that every plastics being designed, is produced just to make people's lives as comfortable as possible. And the achieved rate of this criterion is determining the success of the product.

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