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Study of Roles of Plastic for Electrical and Electronic Appliances towards Cost Effectiveness

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Abstract: Along with the rapid progress of office appliances in the world, there has been a drive towards miniaturization and weight reduction. Engineering plastics that are able to replace metal, play an important role in achieving those requirements. Since these engineering plastics are available in a variety of chemical compositions and can, in additions, be modified by reinforcement with a variety of fiber materials as well as fillers or by forming polymer alloys, it is easy to design a suitable plastic material for a given appliance. Furthermore, Super-engineering plastics, which are characterized by combining much higher heat distortion temperature with excellent mechanical strength are being applied to mechanical and structural components and parts of appliances as well as to electronic components and parts. In this paper, the engineering plastics and super-engineering plastics being applied to office appliances in country are outlined by each plastic type.

1. Introduction

There is a demand everywhere to down size and miniaturize office appliances, as well as to reduce their cost. Personal office appliances are becoming more popular, highly efficient desk-top workstations and multiple use office parts are becoming more common, and networking a variety of appliances for more efficient utilization of information and effectiveness of operation is rapidly progressing. It is certain that more and more office appliances are going to be used in future.

Although, the major improvement of appliances will be by speeding up the processor and increasing the capacity of the memory, there are also improvements to be made in making them lighter, thinner, shorter and smaller. These latter improvements are especially important in order to be able to utilize more effectively in limited office space. The most important contribution toward size reduction will be made by the use of engineering plastics.

The considerations in applying engineering plastics to offices appliances are as follows[1].

- Reduction of weight. Utilization of plastics for structural materials, such as housing and chassis and making mechanical components such as gears, pulleys, etc. by using plastics.
- Miniaturization and thin patterns. The production of multiple laminations and thin pattern, e.g. printed circuit boards and electronic components for surface mounting technology.

Video cameras have been reduced in size with further miniaturization in process. CD players are being made more portable and thin patterns are being developed for headphone stereos. As with office equipment, the application of plastics is playing an important role in the miniaturization and reduction in weight of audio-visual parts. Metallic parts are being replaced with plastic and the cost reduced by use of by incorporated moulding [1].

2. Overview of Recent Engineering Plastics

Engineering plastics have an advantage in that they are able to replace metals. Engineering plastics such as polyamide (abbreviated as (PA), polycarbonate (PC), polybutylene terephthalate(PBT), polyethylene terephthalate (PET), and modified polyphenylene oxide (Mod. PPO) are mass produced and have year by year become more important as industrial materials.

In the development of engineering plastics it was natural that much attention was given to the improvement of their heat resistance so that they would be able to replace metal. As a result, the so-called super engineering plastics viz., polyphenylene sulfide (PPS), polysulfone (PSO), polyethersulfone (PES), polyetheretherketone (PEEK), polyetherketone (PEK), polyarylate (PAR), liquid crystal polymers (LCP), polyimide(PI), polyamideimide (PAI) and polyetherimide (PEI).

There were also composite engineering plastics materials that became competitive with metals by means of reinforcement by glass fiber (GF) and carbon fiber (CF) [2,3]. This is because the tensile strength, rigidity, HDT and dimensional stability were markedly improved by the reinforcement. Fig 1 shows the HDT versus tensile strength relationship in GF-reinforced engineering plastics [2]. It is clear from this figure that the reinforcement effect by

GF is outstanding for both properties, particularly in the crystalline engineering plastics. The reinforcement by CF for both properties is better than that by GF [3]. There is also another type of reinforcement by use of metallic fibers and inorganic fillers [4].

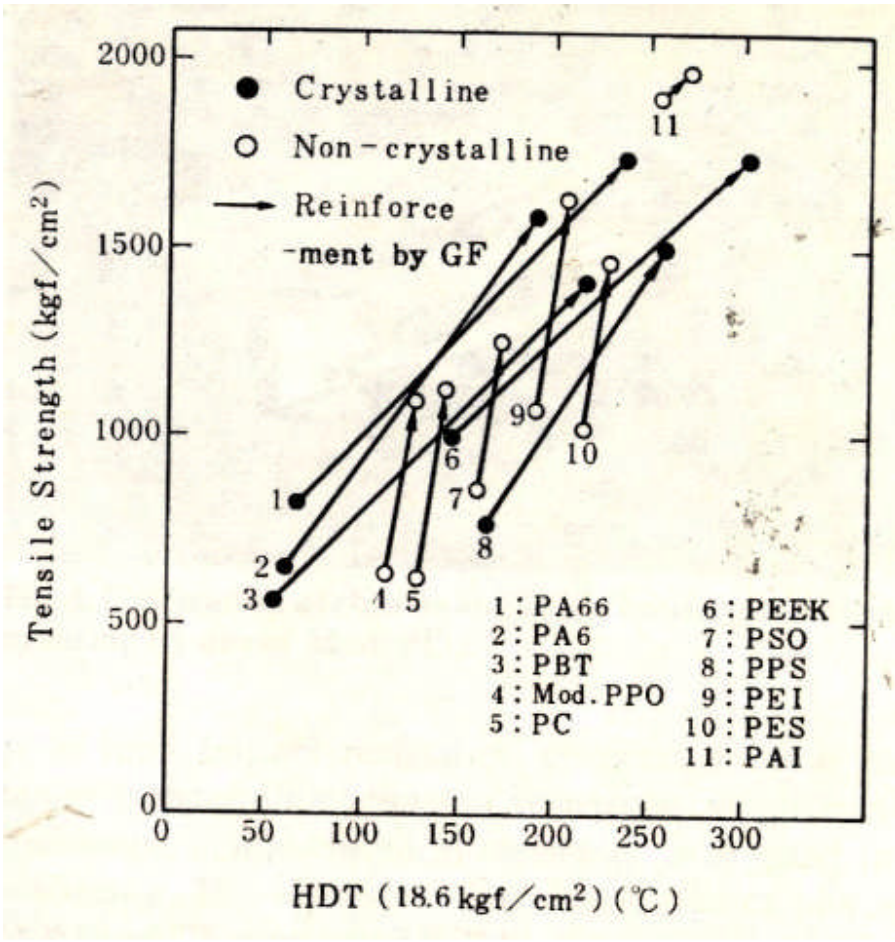

Fig:1 HDT vs. Tensile strength relationship for single and GF reinforced engineering Plastics

The technology of making a polymer alloy is progressing and it has become possible to mix different polymers homogenously in order to produce a number of modified plastics (polymer alloys) that have a wide spectrum of improved properties, for instance, improvement of impact resistance. The pioneering ex-

ample of a polymer alloy used as an engineering plastic was Mod. PPO (a mixture of PPO and polystyrene).Today, a number of polymer alloys have been developed and are applied for office and audio-visual appliances.

3. Polyamide

Polyamide (PA) has many advantages, such as low cost, tenacity, heat-resistance, mouldability, and ease of formation of composite materials, while it has a disadvantage of large water absorption, which result in a reduction of precision in the shape of products. Single PA and GF-reinforced PA are very popular as engineering plastics**.** As stated previously , reinforcement by GF,CF and Aramid fiber bring about improved rigidity, heat-resistance ,and

appearance of the moulded products .Further heat-resistant PA, for example, High melting point Nylon and a high impact-resistant polymer alloy consisting of Nylon and modified olefin polymer, are attractive to users.

Accordingly, in office parts, GF reinforced PA and CF-reinforced aromatic PA are used for housing, including one for a notebook –type personal computer. Stainless steel fiber-filled PA is applied as EMI shielding material [4],and various kinds gears and connectors made of PA are widely applied [1].In audio- visual appliances , gears and levers made of PA are applied to video tap recorders(VTR)[1].

4. Polycarbonate

Polycarbonate (PC) is one of the most versatile engineering plastics for office application and audio-visuals appliances. Due to its small moulding shrinkage, it is suitable for parts and components that are required to have high shaping precision. PC is modified by formation of a polymer alloy, reinforcements by various fibers and mixing with inorganic ingredients in order to meet more diverse requirements, for instance, PC/ABS and PC /PBT alloys, GF – reinforced grade, CF reinforced grade, aluminum flakes filling grade for EMI shielding etc. Further, the high purity high fluidity grade was developed for making a CD substrate [5].

In office application appliances, GF-reinforced PC is used for the chassis of laser printers and the housing of lap-top personal computers. PC/ABS alloy is used for the housing of large computers. Further, the reinforced PC is applied for the inner structural parts of facsimile machine and plain paper copiers. It is well known that reinforced PC is a very popular material for optical parts and components [1].

5. Modified polyphenylene oxide

Modified polyphenylene oxide (Mod. PPO) is a well –known polymer alloy of polyphenylene oxide (PPO) with high impact polystyrene (HI-PS)that is characterized by heat-resistance, self –extinguishing property, dimensional stability, and moludability. Because of its excellentmouldability and small moulding shrinkage, it is applied for making the large housing for office use and audio-visual appliances. Mod .PPO is re-modified by means of polymer alloy formulation, reinforcements by various fibers, and mixing with inorganic ingredients in order to improve its properties still further. Examples are PPO/NYLON and PPO/PTFE alloys, GF/inorganic filler-reinforced grade, CF/conductive carbon black mixed conductive grad, and EMI shielding grade .Further, important characteristics of Mod. PPO such as heat-stability, self extinguishing property and dimensional stability are further improved.

A Typical Example produced by GE plastics Co. Ltd [6]. EMI Shielding grade **resin** is applied for the housing of a lap-top personal computer. Single MOD.PPO and GF/inorganic filler-reinforced grade are used for the inner mechanical parts and components of a plain paper copier and facsimile machine. In particulars, Mod. PPO is suitable for the insulation of the charging parts of a plain paper copier because of its excellent corona resistance[1]. In audio visual appliances, Mod. PPO and the improved grades are applied for TV yoke coils, mirror tube of projection TVs, chassis of CD players, and turntable of CD players[1].

6. Polybutylene terephthalate

Polybutylene terephthalate (PBT) is suitable for injection moulding, because its rate of crystallization is much larger than that of polyethylene terephthalate (PET). It is characterized by a good balance between mechanical strength, heat-resistance, excellent electrical property, low water absorption, superiour chemical resistance and large abrasion resistance coupled with small friction resistance [2].

PBT is modified by formation of a polymer alloy and reinforcements by various fibers. Some examples of the polymer improved by modification are: PBT

/ABS. PBT/PC, and PBT/PET alloys, GF reinforced grade, EMI shielding grades (CF – Reinforced grade, Stainless steel fiber mixed grade and aluminum flakes mixed grades) hydrolysis suppressing grade, contact corrosion suppressing grade, and warp reducing grade.

In office component, PBT/ABS alloy is used in mechanical chassis of a printer in which the ABS contributes to the reduction of the cost. The EMI shielding grades are applicable for appliances. Further, PBT is applied for the keytop of personal computer. This takes advantage of its property of being easily dyed [1].

7. Polyethylene Terephthalate

Polyethylene terephthalate (PET) is not extensively used as an engineering plastic, because it is inferior to PBT in many respects. Only the GF-reinforced PET can be used as an engineering plastic. It has advantages in terms of mechanical strength, heat-resistance and surface hardness, whereas it has a disadvantage in the necessity for high – temperature moulding due to its small rate of crystallization and low impact resistance.

8. Polyphenylene Sulfide

Polyphenylene sulfide (PPS) is currently ranked sixth as an engineering plastic. This is due to its excellent heat resistance, superior mechanical property, out standing chemical resistance, good electrical property, and good mouldability [7]. PPS is classified into two species; one is a linear, high molecular weight PPS that is suitable for making a film, the other is a thermosetting-type PPS that is cross-linked by heating in air, resulting in a higher rigidity and larger creep resistance [8]. PPS is modified to expand its applications as an engineering plastic. This is done by forming a Polymer alloy, with reinforcements by GF, CF and inorganic fillers (for instance, GF/inorganic filler reinforced grade, PPS/Nylon alloy, high tenacity, cross linked type grade, less protrusion, less warp type grade).

At the moment, PPS is principally applied in electronic fields, such as encapsulation of electronic parts and components, injection moulding for PCBs/PWBs for surface mounting technology (SMT), and injection moulding of connectors, switches, coil bobbins etc. The improvement of its impact strength and expansion of the PPS family are on-going.

PPS is applied for the mechanical chassis of a digital audio tape recorder (DAT), which is then unified with the other parts by moulding.[1]

9. Polysulfone, Polyethersulfone

Polysulfone (PSO) is one of the super-engineering plastics along with polyethersulfone (PES). PSO is characterized by heat resistance, transparency and water resistance, but its mouldability is not good [7]. PES is characterized by heat resistance , transparency, mechanical property and water resistance, and its mouldability is relatively good [7]. PSO is modified to improve its mouldability by formation of a polymer alloy and by reinforcement by GF or inorganic fillers. Examples are PSO/ABS and PSO/PBT/GF alloys, and mineral filler reinforced grade. PES is applied in electronic fields such as injection moulding for PCBs/PWBs, common parts and components, including switches, cases, sockets etc., and electronic parts and components including IC sockets, frames, coils, etc.

PES is applied for the gears, bearings, roller sleeves, separating claws of a copier, a printer and facsimile machines [1].

10. Polyetheretherketone, Polyetherketone

Polytheretherketone (PEEK) is one of the super engineering plastics along with polyetherketone (PEK). PEEK is characterized by outstanding heat resistance superior mechanical property, excellent chemical resistance, and outstanding irradiation resistance, and PEK has almost the same characteristics as PEEK [7]. PEEK is modified by reinforcements by use of GF and CF. Recently, Aramid fiber reinforced grade and potassium titanate whiskers reinforced grade came into the market. Further, a mouldability – improved, highly fluid grade has been developed for electronic purposes.

At the moment, the applications for PEEK are confined to the common parts and components such as coil bobbins, sockets, etc., [9].

11. Polyarylate, Liquid Crystal Polymers

Polyarylate (PAR) and liquid crystal polymers (LCP) are numbered among super-engineering plastics, and the latter are the plastics of current interest. PAR is a

non crystalline, all aromatic type polyester and is characterized by heat resistance, flame resistance, and weathering resistance. Its disadvantage is weak resistance against solvents and chemical [7]. PAR is modified to improve its characteristics by means of a polymer alloy and reinforcements by GF, inorganic fillers, etc., for instance, PAR/PA alloy, chemical resistance improved grade, heat – resistant, reciprocating grade, etc.

LCP is applied for the gears and separating claws of copiers for the parts and components of printers[1]. Also making the common parts and components of electrical and electronic appiances including coil bobbins, connectors cases, sockets etc,.

12. Polyimide, Polyamideimide, Polyetherimide

Polyimide (PI) is the super engineering plastic with the highest heat-resistance. Along with the advantages of heat – resistance, there is the disadvantage that it is extremely difficult to mould because of its thermosetting nature.

Some modified PI resins have been developed that are capable of being injection moulded. These, such as polyamideimide (PAI) and polyetherimide (PEI), sacrifice some of the heat resistance. PAI is characterized by the best balance between heat resistance and mechanical property, while PEI is characterized by good heat – resistance [7].

Recently thermoplastic PI capable of being injection molded has been developed in India [2]. PI films are being employed particularly in electronic fields [9]. Further low thermal expansion type PI was also developed [2]. In office application and audio visual appliances, since it is important to balance heat resistance, mechanical properties mouldability and the cost of the plastic materials, a modified PI that could satisfy both mouldability and low cost.

Thermoplastic PI is applied for the gears and separating claws of the fixing roll of a copier[1]. PAI is applied for the gears of the fixing roll and the separating claws of a plain paper copier [1], whereas PEI is applied for an endblock supporting a charger in an imaging system of a plain paper copier[1].

PEI is applied for the parts and components of an opto-pick-up of a laser disk (LD) [1].

Incidentally, both PAI and PEI are applied for the common parts and components of electrical and electronic appliances, such as coil bobbins (PEI), switches (PEI), IC sockets (PAI) substrates (PEI), connectors (PEI), chip carriers (PEI), etc.

13. Conclusions

A state of the art review of the applications engineering plastics materials for office application in our country has been presented . It is clear that engineering plastics will play a major role in reducing the size, weight and cost of these appliances. The theory of polymers alloys and its application to practical problems has led to solutions to complicated requirements. It is projected that the applications of engineering plastics for electrical and electronic appliances will be further accelerated.

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