

We could be all bottled up

DR. NIZAMUDDIN AHMED

Presently we are overwhelmed in many sectors by factors that had initially appeared useful, harmless and negligible.

Take the instance of the motorcar. It began its journey as a provider of comfort to city commuters but over the years it has emerged as a serious urban problem.

The list could be lengthened if gramophone, talking movie, telephone, television, and scores of other modern amenities are included. The mobile phone is queuing up to be enlisted.

The convenient plastic bottle turned up as a means of yet another bit of comfort for the increasingly fussy modern man. Harmless at first, it has now become a major concern because of the material from which they are made - non-biodegradable plastics, a hazard to the environment.

There is an increasing global concern for solid waste management or lack of it, and again the type of solid waste. By producing millions of plastic bottles, PET as the authors of today's main piece explains, we are creating a situation from which there may be no return unless appropriate measures are adopted now.

The situation is alarming for every part of the world and ours is no different. In referring to environmental issues I prefer not to speak in terms of politically divided countries because the impact of any wide-ranging ecological cause will be comprehensive, not necessarily restricted along the political borders.

Prof. Dr. M. Anwarul Azim and Faiz Ahmed of the Department of Industrial and Production Engineering, BUET makes a timely appeal to all concerned to implement plans to arrest the menace in its infancy. Their proposals of motivation for reuse, looking for alternate use and environmental taxation should be considered with seriousness not only because of their merit, but because they have been tested in other parts of the world. A country like Bangladesh can save millions by avoiding the

course of trial-and-error.

The paper is one of the many that will be presented at the three-day International Conference on Manufacturing (ICM), organised by the Department of Industrial and Production Engineering, BUET. This publication coincides with the inauguration today of the conference at BUET.

In order to develop the economic base of any country, it is important to improve and strengthen the manufacturing sector and its management, while simultaneously taking into account the growing environmental and other global concerns.

For Bangladesh it is also essential to keep in stride with the developments taking place in other parts of the world such as to benefit from contemporary international understanding of management and production elements of manufacturing.

To meet that end the second ICM is being organised with encouraging participation from abroad, both in terms of paper contributions and delegates. The first was held in year 2000.

It is incredible that when almost every sector seems lost in a country riddled with natural and manmade calamities, there shines a bright ray of hope because some dedicated souls are striving silently to prepare for the worst. We can allay the fear of the experts if we, more importantly politicians and bureaucrats, wake up to their alarm bell and act accordingly.

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PET BOTTLES DESIGN FOR RECYCLING

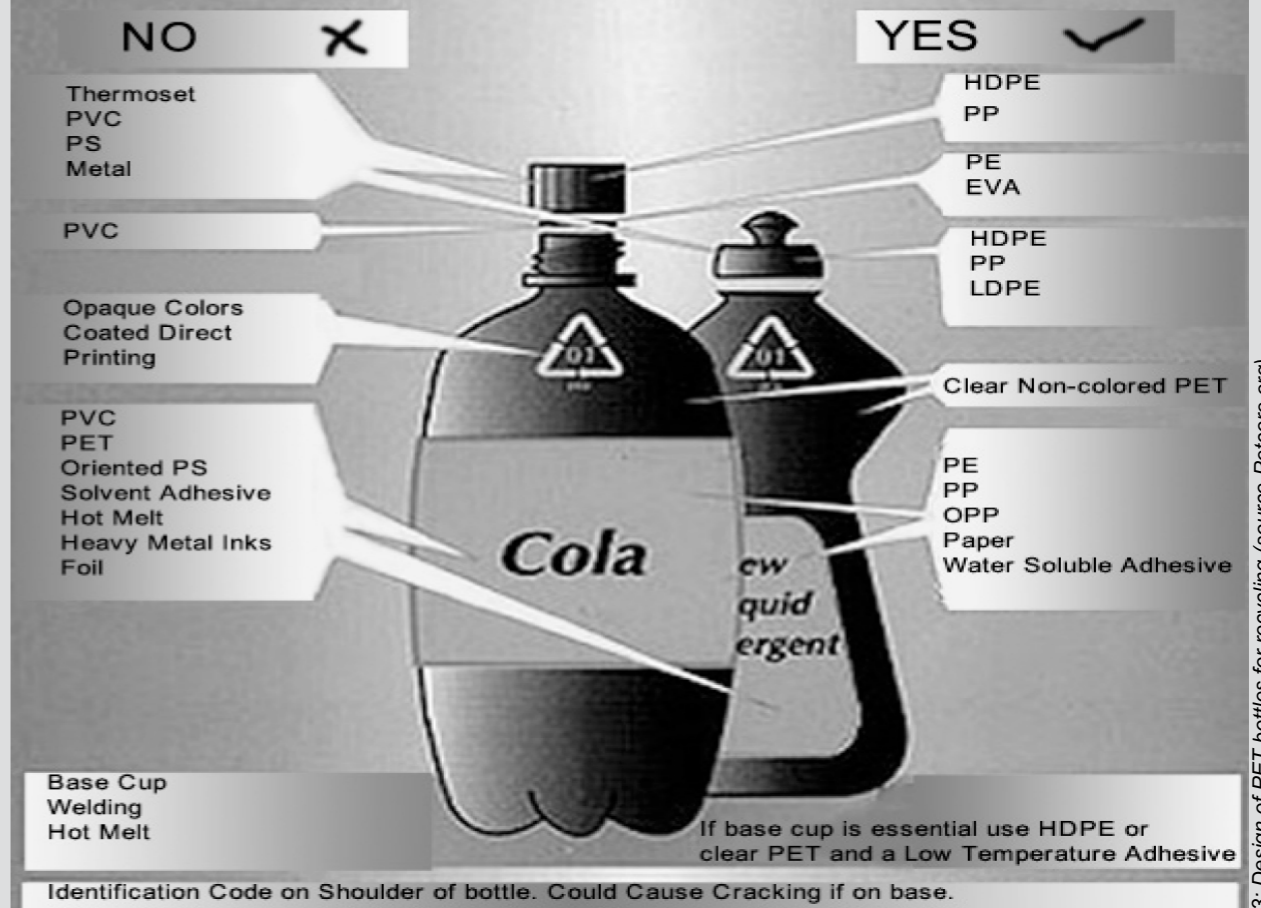


Figure 3: Design of PET bottles for recycling (source-Petcore.org)

PET bottles: An emerging problem for Bangladesh

PROF. DR. M. ANWARUL AZIM AND FAIZ AHMED

The world is experiencing a phenomenal and unprecedented development of technology. This development process in the 21st century will be regulated and controlled, amongst others, by

1. The rapid technological development.
2. Free market economy and Uruguay Round agreements.
3. Depletion of world's natural resources.
4. Environment and sustainable development.
5. Human Rights.
6. Role of government as executing agency of development.
7. Phenomenal growth of electronics and information technology.

In addition to the exorbitantly high consumption of natural resources by the industrialised countries, the demand for the same is increasing in the developing world. This has caused a serious strain on Mother Earth, which has a fixed natural resource reserve. This will consequently demand from engineers a search for new sources of raw material and alternative raw materials. Design for disassembly and design for recycling allows reuse of the end product, increasing material productivity. In the context of the above, PET (or commonly plastic) bottles, a revolutionary innovation indeed, is an interesting case study. Despite the many inherent advantages PET bottles are destined to pose a serious problem for Bangladesh.

Emergence of PET in our civilization

Robertson of WEPSP (World Engineering Partnership for Sustainable Development) warns: "Given energy and material use, we have a 25 to 30 year window of opportunity to develop balanced economic development that is environmentally sensitive". People are now redefining productivity in terms of green productivity. Non-biodegradable (or negligibly so) waste products like plastics have become a menace to the human civilisation. In Japan, people are charged ¥ 8000 per m³ of plastics they dump in a landfill. To solve the problem Coca-Cola Co. and Pepsi Co. of USA are chemically resolving used PET bottles into terephthalic acid and ethylene glycol for reuse.

The first manmade plastics were unveiled by Alexander Parkes in the 1862 Great International Exhibition in London. This was the beginning of plastics. In 1888 Celluloid made its debut, Bakelite was invented in 1907, Nylon came in 1920, PVC in 1926 and so on.

The emergence of PET (Polyethylene Terephthalate) is quite fascinating. The soft drink industry was the main driving force behind the development of the PET bottle. Before 1960, almost all carbonated soft drinks were packaged in returnable glass bottles. Changing consumer lifestyle created a demand for larger one-way containers, which could not be served by glass bottles because they were too heavy (a one-litre bottle weighed 900 gram) and potentially dangerous to handle in large sizes. The result was a race to find a new packaging material that would allow the one-way family-size bottle to reach its full market potential. To serve this purpose Aluminium can was introduced. But it increases the overall cost of the product and as result the can was accepted by a limited number of people. That is why a food grade plastic called PET came in. Though PET had been patented as a fibre-forming polymer in England in 1941, the first PET carbonated soft drink bottles appeared on the market of USA in March 1977.

Uses of PET: World scenario

As PET is referred to as the food grade plastic, it has a wide spread use in beverage packaging. The most important point here is the level of recycling. The developed countries have their own legislation to maintain the sustainable development as well as to utilize the resources. They have a very high level of recycling facility. The recycled PET (RPET) can be used for sheet & film, strapping, engineered resin, food & beverage bottles, non-food bottles, etc.

Uses of PET: Situation in Bangladesh

The history of PET bottle use in Bangladesh is quite recent. The PET bottles are principally used for soft drinks, mineral waters, edible oils, and small jars for tea and confectionary item, small pharmaceutical bottles and others. PET bottles are replacing glass, PVC, and HDPE (High Density Polyethylene) bottles to a great extent.

Consequently, the number is also increasing with increased amount of PET production by increased quantity of raw material import. Number of companies using PET products is given in Table-1.

Figure 1 shows the total countrywide yearly production of the PET bottles. This graph clearly shows an alarming rate of increase. Within the next ten years the total annual production of PET bottles can be as high

Table 1: Number of companies using PET containers and their fixed asset

Year	Edible Oil		Mineral water and soft drinks	
	No. of Establishments	Total Fixed Asset (000 Tk.)	No. of Establishments	Total Fixed Asset (000 Tk.)
1991-92	404	1480081	7	279447
1992-93	452	2180048	7	606998
1993-94	422	2334906	24	393830
1994-95	Not Available	Not Available	Not Available	Not Available
1995-96	480	1764227	25	459880

Source: Report on Bangladesh Census of Manufacturing Industries, Bangladesh Bureau of Statistics

as 120 million dozens.

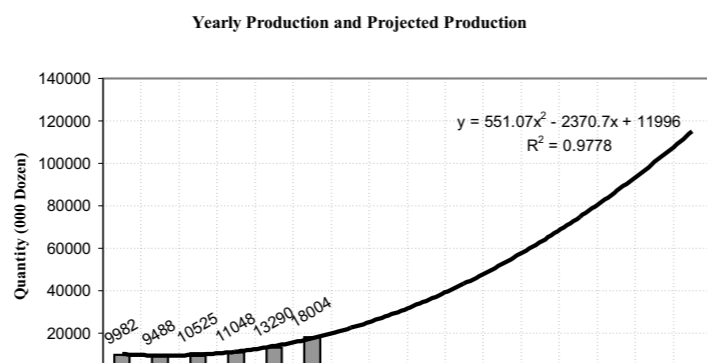


Figure 1: Trend of annual production of PET bottles [BBS]

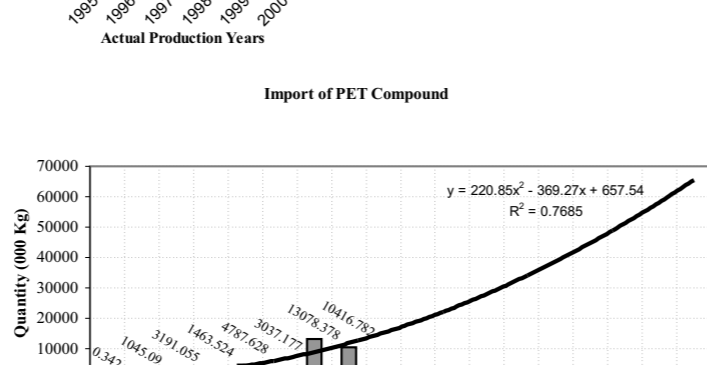


Figure 2: Import of PET compounds in Bangladesh from the year 1991-92 to 1998-99.

Figure 2 shows the import of PET compounds in Bangladesh from the year 1991-92 to 1998-99. Although the quantity of import does not show a smooth increasing trend, but the overall increasing trend is well noticed, especially the drastic increase between 1996-97 and 1997-98 fiscal years. After ten years the import will be as high as 65 thousand tons. Also it will create a demand on foreign exchange in the present acute situation.

Problems for Bangladesh

Increasing consumption of PET: PET has become an ideal food packaging material. Its low weight helps to reduce transportation costs and the convenience to handle and use has gained for it higher consumer acceptance than glass. As a result PET is substituting glass in packaging all over the world as well as in Bangladesh. With the rising use of PET bottles PET waste, if stored in an area of 10000 ft², would fill up a minimum of 5085 feet (a 508-storied skyscraper) in 2010 (Figure 1).

Poor collection of PET waste: Although the informal network is quite active in collecting plastics, PET bottles do not figure out in their list. The waste-pickers reveal that there is no demand for the PET bottle waste in the informal and formal chain of marketing. Since the PET bottle cap is made of a HDPE, it carries a value in the informal sector and is collected by the waste-pickers.

How others are solving the problem

The only solution to this problem is to recycle the product. European Union issued a Directive on Packaging & Packaging Waste (94/62/EC). According to this directive packaging made of plastics must achieve, like other material types, a minimum of 15% recycling. The Directive sets no targets for individual polymers and makes no distinction between used household and commercial/industrial packaging [European Legislation, 2002].

In total over 50% of packaging waste must be directed to recovery processes that create value from (valorise) the waste. This includes

means such as recycling and waste-to-energy. Countries must refer back to the EU before exceeding 65% recovery or 45% recycling of packaging to ensure that such action does not unfairly disadvantage other member states.

EU Member countries have introduced or are developing national measures to meet the directive targets and other related local laws. Economic instruments are increasingly being employed to encourage waste minimization.

Other than the EC Directives, there are some other laws that prevail in different countries. They are Landfill Taxes (designed to make recycling more attractive by increasing the cost of waste disposal), Eco Tax, (Scandinavian countries have introduced "eco-taxes" on beverage containers, including PET), Deposits (introducing the deposit systems for specific types of PET container), Householder Charging (local governments require householders to buy special bags in which to set out refuse), Packaging Levies (packaging companies have devised their own solutions to meet national and European recovery targets).

To attain the target of recycling, the recyclability of the bottles is important. Petcore, PET Containers Recycling Europe, is a non-profit European association fostering the use and development of PET containers and facilitating both PET recycling and the development of recycled end material. They have suggested some basic design for recyclability guideline that the manufacturer has to abide by to facilitate PET bottle recycling.

The basic design for recyclability guideline must be considered when making material choices for any attachment to the bottle for its general compatibility with the base resin (PET) or the removal efficiency in conventional water-based separation systems. Attachments may include cap, liner, décor, label, base, etc. There are some rules for selection of materials for those attachments. (Figure 3 above)

For caps, use of thermosets, PVC and metal are restricted whereas HDPE, PP and LDPE can be used. For liners PVC must be avoided rather PE and EVA should be used. The décor must not be printed with opaque colours on the body; rather it must be embossed on the body because non-coloured, non-pigmented PET has the highest value, the highest recycling rate and widest variety of end markets. Foil, lacquered and coated labels become contaminants and are undesirable. Heavy, intense printing of labels should be avoided as this increases the density and so prevents separation. Labels should not delaminate in the recycler's washing process. PP, OPP or polyethylene label stock is preferred. Paper is acceptable as a secondary material but increases the contamination of the PET due to fibre carry over. PS labels are acceptable if they are of low-density material, which can be separated in the flotation process. Adhesives used should be minimized and preferably water soluble, or dispersible at 60 to 80° C. Welding of attachments should be avoided. If glued on with adhesive that is resistant to hot water (60 to 80° C) containing detergent or caustic solutions they will stay attached to the PET particles and contaminate the PET. It is preferred that no base cups, handles, transportation aids or other attachments are used, but unfilled HDPE, PP or clear PET is acceptable for base cups. If glued on they should separate in hot water (60 to 80° C) containing detergent or caustic solution. Adhesives usage/area should be minimized and preferably water soluble, or dispersible at 60 to 80° C.

Suggestions for Bangladesh

As the PET recycling plant involves a heavy investment, the Government should take the initiative first. The following suggestions are made in this regard.

Motivation for Reuse: Recycling of plastic items can occur in several ways (Figure 4). A product might be reused, which is what happens when a glass bottle is washed and reused instead of being thrown away. Or the plastic items can be sent back to product remanufacture, where the materials it contains are used to make another product. A paper cup, for example, might be shredded and used for animal bedding. Finally, it might be recycled to materials manufacture, where it is converted into raw material for further processing.

As product remanufacture and material recycle involves a high initial investment, it may not be achieved right now. But what can be achieved right now is the product reuse. It can be achieved in two stages. First, the bottles should be made reusable. For this, the design of the bottles is to be improved so that it can withstand more force and resist shape distortion. It can be done by changing the body design and by increasing the thickness of the bottles. Now a one-litre bottle has an average weight of 40 gram and an average thickness of 0.29 mm, whereas a five-litre oil bottle has the average thickness of 0.46 mm. By doubling the weight (80 gram) as well as the thickness (0.58 mm) in the one-litre bottle, the increased raw material cost will be less than 0.01 Taka per bottle.

Secondly, to motivate people to reuse the PET bottles, a refund money system can be introduced, which is prevalent for glass bottles of different beverage companies.

If 50% of bottles can be reused, it will bring down the raw material

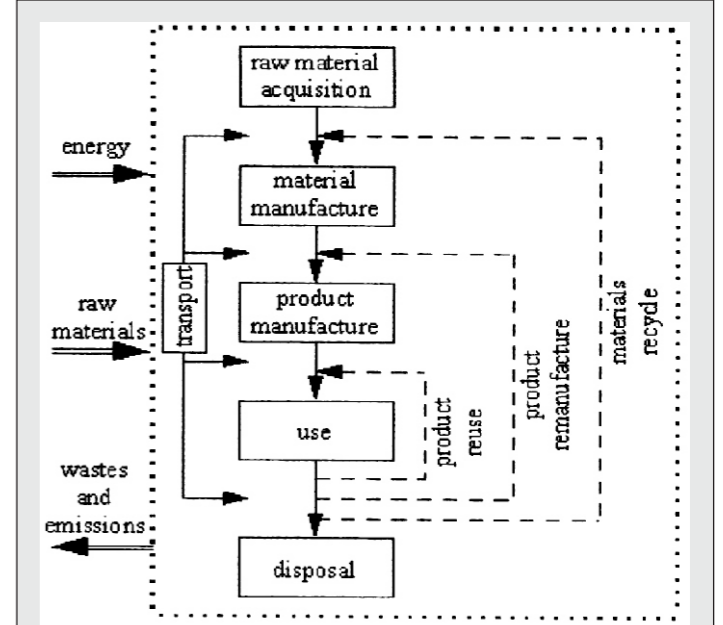


Figure 4: Product life cycle for plastics

demand of 65 thousand ton to 33 thousand ton in 2010, which would amount to a foreign exchange saving of Tk. 1.55 billion, which is quite significant for a foreign exchange hungry country like Bangladesh.

Alternate use as a reducing agent: NKK Corporation of Japan is using, since October 1996 waste plastics (excluding PVC) as a reducing agent in its blast furnaces. This is feasible when commercially run to recycle approximately 800,000 tons of plastics per year. A steel work near Bremen, Germany is using a similar technology in its blast furnace. In 1994, Fuji Recycle constructed a commercial petrorefaction plant, which recycles plastics into naphtha and LPG, subsequently naphtha into gasoline, kerosene and light oil. Bangladesh can also plan for using this technology in future.

Imposing the environmental tax on plastic items: The government can impose eco-tax on PET bottles, which is commonly practiced in many developed countries. The revenue earned thereby can be mobilized to PET waste management. The Government can facilitate the dustbins with separate containers for collecting plastic items specially PET bottles. A washing and compressing plant can be set-up to wash and compress the collected bottles. In India there are a number of PET recycling plant, which are importing PET waste from other countries to convert it into polystyrene fibres. So Bangladesh has a chance to earn foreign exchange by exporting the PET waste.

Population growth and the rapid urbanization pose serious environmental challenges for Bangladesh, especially for its urban population. One of these challenges is the waste management, especially that of plastic waste management. The Government has taken a bold and timely step to ban the production and the use of polyethylene shopping bags. Another serious problem that is coming is that of used PET bottles, which are now being seen here and there. The production of PET bottles is expected to shoot up to 120 million dozens annually with a span of ten years from now, causing a colossal problem for the environment of the country. Some long and short-term solutions have been proposed in the paper. In the short term, the thickness of bottles can be increased (for example, for 1 litre bottle from 0.29 mm to 0.58 mm) so that they can withstand more force and resist shape distortion. The increase of cost due to the material is negligible. Along with it the refund money system can be reintroduced. This solution is expected to save foreign exchange amounting to 1.55 billion Taka in the tenth year. In the long term, alternate recycling methods (use as a reducing agent in blast furnace) and export of compressed PET bottles etc. should be seriously studied. The Government may levy certain amount of eco-tax on PET bottles, which can be mobilised to PET-waste Management and encourage the nation to PET reuse.

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