CHAPTER 5

Techniques for Green Productivity

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Objective of the lecture

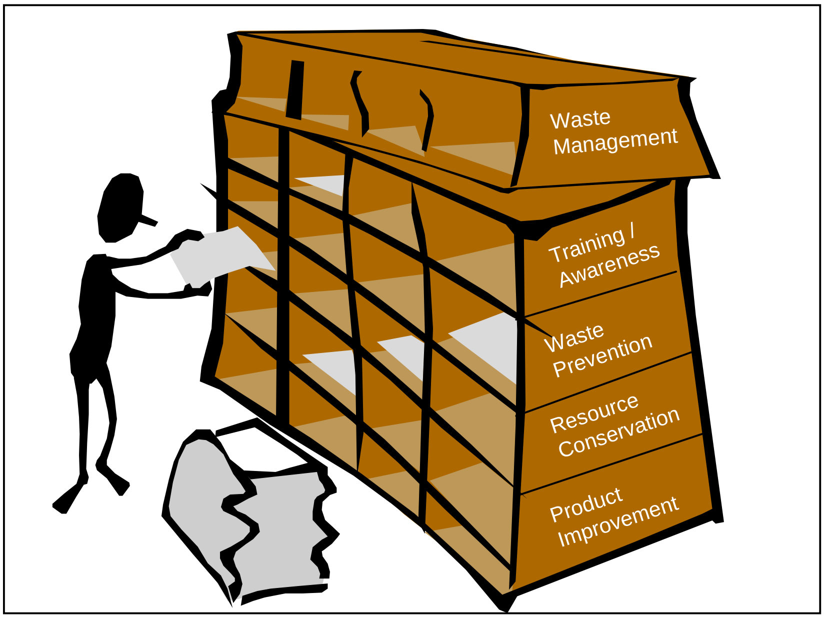
Implementation of the GP methodology requires integrating and applying various productivity and environmental management techniques.

The heart of the GP methodology is essentially identifying good options.

This lecture aims at introducing the participants to some of the potential techniques that could be used in GP. It attempts to explain GP techniques that provide ways and means to generate options.

5.1 Organization of the Techniques

Organization of the GP Techniques



Organization of the Techniques

The GP Techniques have been categorized as under:

Waste Prevention

1. Improved Operating Procedures
2. Waste Segregation
3. Good Housekeeping
4. 5S Program
5. 7 Wastes

Resource Conservation

Recycle , Reuse & Recovery

Off-site Recycling

On-site Recycling

Energy Conservation

Process Modification

Input Material Changes

Process / Equipment Changes

Pollution Control

Air Emission Control

Effluent Pollution Control

Solid Waste Management

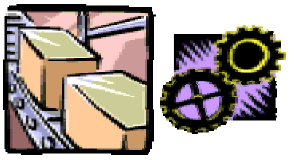
Product Improvement

Design for Environment

Productivity & Quality Improvement

5.2 Improved Operating Practices

Improved Operating Procedures



- Operating procedures and process specifications
- Scheduling Operations
- Equipment operation procedures
- Maintenance procedures
- Material and product handling and storage
- Safety considerations for staff
- Comparison with resource and energy consumption norms

CHECK !

Improved Operating Procedures

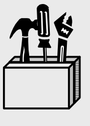
Procedural aspects of a manufacturing operation include the management, organizational, and personnel functions of production. Improved operating practices can be implemented in all areas -- production; maintenance; raw material, product, and waste handling; and storage. Because good operating practices can often be implemented at low cost, they usually have a high return on investment. Rational operating procedures should be employed.

Material Handling and Storage

All production facilities store raw materials, intermediates, products, and industrial wastes and transfer these items from one area of the plant to another. Proper material handling, transfer, and storage minimizes the possibility of spills, leaks, fire and/or explosion, or any other losses that could result in waste. Companies have strong economic incentives to handle and store materials properly.

Material and Energy Consumption

Industry and sector norms can be used to ensure that the consumption of resources and energy are within limits.

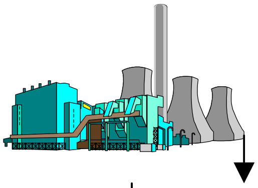


Benchmarking could be effectively used here to compare with norms in the industry sector so as to identify deviations. Walk-through exercise enables the team to observe and check the operating procedures in an industry.

Scheduling Operation

Batch production of a variety of products using common equipment plays an important role in generating wastes. Timing has a special significance in batch production operations, where the amount of waste from equipment cleanup waste is directly related to the cleaning frequency. To reduce cleaning frequency, batch sizes should be maximized or followed with a similar product, which may not require cleaning between batches. This action requires diligent managerial scheduling and planning, as it may affect inventories of raw materials, finished products, and shipping deliveries.

Example of Improved Operating Procedures



Glycerin losses in process were high

High COD wastewater

Improvement in Operating Procedure of Glycerin

Increase in productivity by 32 per cent.
Daily glycerin yield increased by 5 per cent i.e., an additional 6 kilograms.
Reduced chemical oxygen demand (COD) of wastewater.

Example

Philipinas Kao Inc. manufactures chemicals and chemical products such as fatty alcohol methyl ester, refined glycerine, tertiary amines, alkanolamides and surfactants, monoalkyl phosphates.

The company identified that glycerine loss from the process contributed to high chemical oxygen demand (COD) of wastewater. Philipinas Kao's engineers, with the help of Japanese engineers, organized an evaluation team to analyze and evaluate the existing operating parameters of the glycerine process. This revealed a substantial deviation between the actual and design operating conditions of this process.

Reference Look Up

United Nations Environment Program - Technology Industry & Economics (UNEP TIE) "International Cleaner Production Information Clearinghouse Web version, 1998".

Through constant monitoring, Philipinas Kao was able to optimize operating conditions of the glycerine process.

This led to an increase in productivity by reduction of glycerine loss by 32 per cent. Daily glycerine yield increased by 5 per cent, that is, an additional 6 kilograms.

Prevention of glycerine loss at the source reduced chemical oxygen demand (COD) of wastewater.

Economic benefits were as follows:

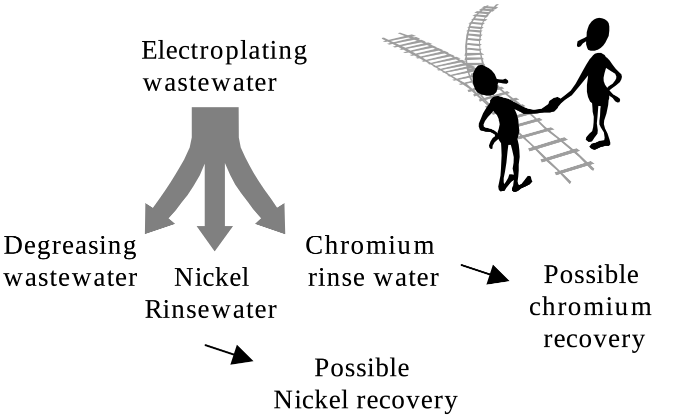
- Increased glycerine recovery generated P32, 000
- Savings on chemical treatment costs were P1 600000

5.4 Waste Stream Segregation

Waste Stream Segregation

Advantages of Waste Segregation

- Ease in end-of-pipe treatment of a non-compatible pollutant stream
- Increased possibility of recycling / reusing a waste stream



Waste segregation refers to the separation of waste streams according to points of generation, composition, volume or media as may be beneficial from the point of view of management, recyclability, treatment and disposal.

Segregation at the source can reduce the quantity of disposal of hazardous wastes. When a non-hazardous waste is mixed with hazardous waste, the entire mixture is classified as hazardous; not allowing hazardous and non-hazardous wastes to mix reduces the amount of hazardous waste disposal and yields substantial savings. Furthermore, isolating hazardous waste by contaminant (i.e., by segregating wastes) often reduces disposal requirements.

Incompatible hazardous waste types should not be mixed. For example, segregating spent solvents from metal parts cleaning and used motor oil fosters the reclamation of each.

Some Benefits of Waste Segregation

- Ease in end-of-pipe treatment of a non-compatible pollutant stream
- Increased possibility of recycling / reusing a waste stream

Difficulties in Segregating Waste

- More space requirements
- Higher capital and operating costs for waste transportation and storage

Normally, due to increased recyclability and better treatment / disposal, the benefits outweigh the initial investments incurred for segregating waste streams.

5.5 Good Housekeeping

An important statistic to consider:

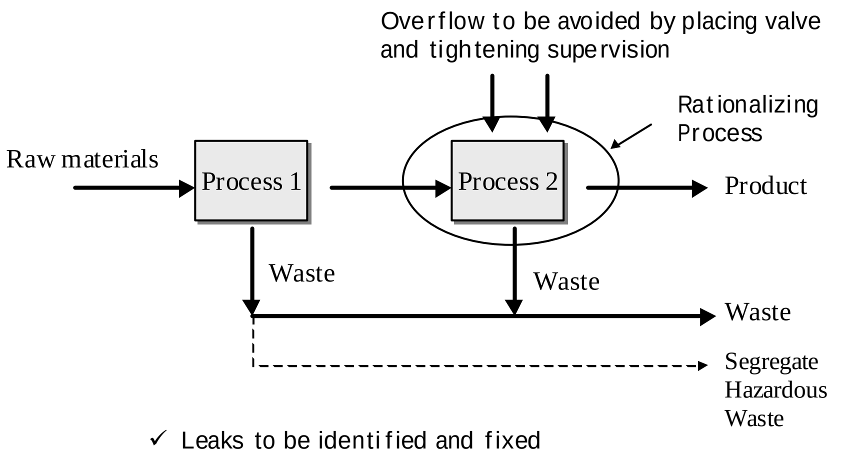
50% of waste can be reduced by adopting 'Good Housekeeping ' practices and making small operational changes

Source: UNEP, France

'Good Housekeeping' Guide GTZ - Pilot Programme for the Promotion of Environmental Management in the Private Sector of Developing Countries (P3U) Wachsbleiche 1, 53111 Bonn, Germany

Walk-through Eco-mapping

Good Housekeeping



- ✓ Leaks to be identified and fixed
- ✓ Accidental spillage to be avoided
- ✓ Maintain up-to-date operating manuals and update records

Good housekeeping refers to a number of practical measures based on common sense that organizations can undertake to improve their productivity, obtain cost savings and reduce the environmental impact of their operations.

Good housekeeping is more of a *habit* than a technique.

Housekeeping is aimed at :

- Rationalizing the use of raw materials, water and energy inputs;
- Reducing the volume and / or toxicity of waste, wastewater and emissions related to production;
- Conserving material and energy;
- Improving working conditions and occupational safety.

The implementation of these good housekeeping practices is relatively easy and the cost is usually low. Thus, they can be readily implemented by SMEs.

'Good Housekeeping' practices can provide a real economic asset and advantage for a company in terms of minimising waste, as well as the use of raw materials and energy. Minimising waste can enable enterprises to reduce the loss of valuable material inputs and therefore reduce operational costs.

The example in the viewgraph presents the use of housekeeping techniques to minimize wastewater overflow.

The 5S Technique

- Seiri - Sorting
- Seiton - Arranging
- Seiso – Cleaning and Inspecting
- Seiketsu – Improving and Standardizing
- Shitsuke - Self-Discipline

The 5S are a set of management techniques that focus on maintaining processes, equipment, workplaces and people the way they should be.

Seiri
In general terms, this means sorting out what is necessary and disposing of those that are unnecessary.

Seiton
Seiton means arranging the necessary things in a systematic manner. This means having things in the right places or the right layout so that they can be used in a hurry. It is a way of eliminating searches.

Seiso
This means cleaning and inspection. This step ensures that things can be kept clean and in good functional order when required.

Seiketsu
Seiketsu means improvement and standardization. This process is continually repeated until the required standard is achieved.

Shitsuke
Shitsuke means self-discipline and doing what had been decided as a habit. By teaching everyone what needs to be done and having everyone practice, bad habits are broken and good habits are formed.

REFERENCE Look Up

The 5S's, Five keys to Total Quality Environment
Takashi Osada,
Asian Productivity Organization,
1991

7 Wastes

• Waiting	Leaving resources waiting during production
• Transporting	Moving materials unnecessarily in the factory
• Processing	Wastes inherent in the process or design itself
• Inventory	Keeping high inventory or work-in-process (WIP)
• Motions	Unnecessary movements of the worker during operation
• Defects	Producing defective parts or poor service
• Overproduction	Produce more than what is needed

Tips

The 7 wastes can be used as a guide when identifing areas for improvement.

We often think of waste as physical things like materials, water, electricity, etc. However, in the context of productivity, waste is defined as any form of work which does not add value to the final output. In the famous **Toyota Production System**, waste has been defined as 7 Wastes to include things like excessive stocks, waiting, movement or transport.

Waiting

This is one form of waste that is very familiar to us. We encounter it everywhere. For example;

- Waiting for a machine that has broken down;
- Delay in arrival of materials;.
- Somebody is late for meeting

The causes of such waste are often bad planning, bad organization, lack of proper training, lack of control and sometimes laziness and lack of discipline.

Transporting

This is another common form of waste; transporting or moving things from one place to another. This does not add to the value of the product. Hence, it should be eliminated or reduced as far as possible. There are two aspects to be considered.

- Eliminate the need for transport by better layout;
- Improve the method of transport by using materials handling equipment.

contd...

7 Wastes

Processing

These are wastes inherent in the process or design itself. For example:

- An electronic type-writer has much less parts and processes than a mechanical type-writer.
- Replacing a metal dust-bin with a plastic one can reduce several steps in the production process.
- Using pre-printed forms can save a lot of paper work.

Inventory

When excessive inventory is carried, it ties up valuable financial resources and may deteriorate over time. It also takes up space in the factory.

Motions

All physical work can be broken down into basic motions. Motion Study is one aspect of Industrial Engineering that assists us to reduce wasted motions. Usually this is done by improving the workplace layout, practicing good housekeeping and workplace organization, and introducing jigs and fixtures and low cost automation.

Defects

Waste caused by producing bad quality products and defective parts or poor service is another common form of waste. Time is often spent to rework bad products or addressing customer complaints. Space is wasted to store them. Last minute urgent requirements may disrupt our systems and cause delays in delivery to our customers. Sometimes bad quality can even cause accidents.

Overproduction

Very often in manufacturing, we produce more than what we actually need. The unused products may have to be discarded when not required at a later stage. This is very costly. Over-production is caused by poor planning, poor forecasting, producing too early and lack of quality control.

5.6 Preventive & Productive Maintenance

Preventive and Productive Maintenance

The Preventive Maintenance comprises of the following active items:

- Cleaning
- Lubrication
- Inspection of protective coating
- Replacement of parts & overhauls

<u>Design of a Cost Effective Maintenance System</u>:

These are the following steps in designing a cost-effective maintenance system:

- ➔ Classification and identification of equipment
- ➔ Collection of information
- ➔ Selection of maintenance policies
- ➔ Preparation of preventive maintenance program
- ➔ Preparation of corrective maintenance guidelines
- ➔ Organizing for maintenance

In the changing times, as more and more industries are going for hi-tech capital intensive and complex equipment, maintenance system has a major role to play in the organization. The objective of maintenance is to achieve the desired plant availability at an optimum cost. As the machinery becomes older, the maintenance becomes essential and requires a comprehensive program for preventive maintenance.

The plant or equipment availability depends on the following factors:

Reliability
Down time due to

- Off-line preventive maintenance
- Corrective maintenance
- Non-availability of resource
- Non-availability of information

Reliability of the equipment essentially depends on the extent of preventive maintenance and the design. Improvement in preventive maintenance practices and development of a suitable preventive, maintenance plan is vital for improving the reliability of the equipment.
The preventive maintenance comprises the following active items:

Cleaning
Lubrication
Inspection of protective coating
Replacement of parts & overhauls

Productive Maintenance

Maintenance techniques and systems over the last two decades have witnessed significant developments and have progressively changed from the concept of breakdown maintenance to that of Fixed Time (Periodic) Preventive Maintenance, Condition Based Maintenance, Corrective Maintenance, Predictive Maintenance and Reliability Engineered Maintenance. Though each of these maintenance systems is quite powerful by itself, its singular application has failed to produce desired results in industries.

In fact, the better strategy would be to integrate these different techniques and systems and make their application as per the given situation and requirement to improve overall maintenance effectiveness and thus derive best economic advantage and productive improvement.

Proper maintenance of equipment is indispensable to ensure its higher operational availability for higher output and productivity. Thus, scientific maintenance, an important requirement of equipment for maximizing its uptime, cannot be viewed in isolation from other related management techniques and systems. This necessitates integration of various functional disciplines and Productive Maintenance (PM) Concept is the result of such integration of maintenance with production to achieve higher productivity.

The concept of Productive Maintenance as a means to improve productivity was first mooted at General Electric of the U.S. in 1954. This idea found wide application in Japanese industries, where the scope of PM was further broadened taking into account life cycle performance and costing. PM ushered a positive meaning in Maintenance Culture and widened the frontiers for all concerned.

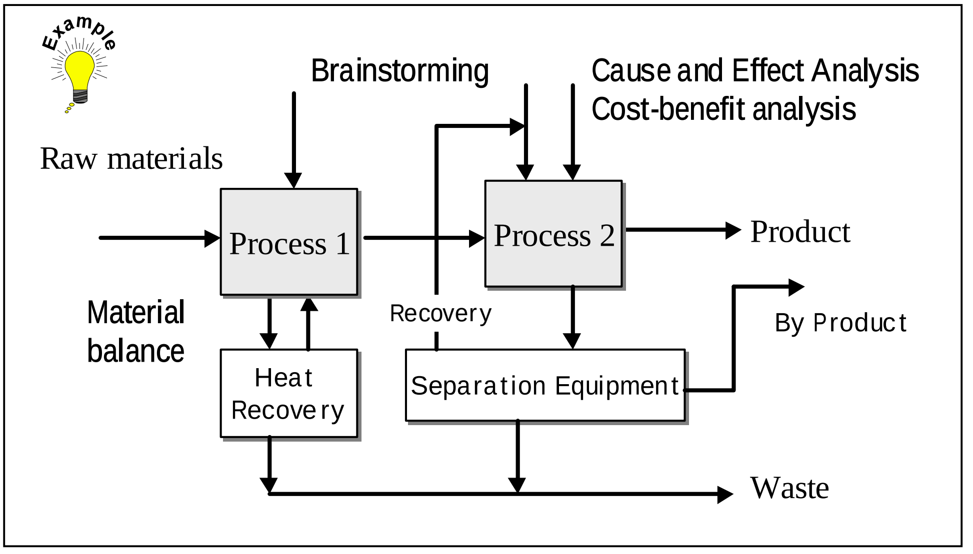
Design of a Cost Effective Maintenance System

These are the steps to designing a cost-effective maintenance system:

- Classification and identification of equipment
- Collection of information
- Selection of maintenance policies
- Preparation of preventive maintenance program
- Preparation of corrective maintenance guidelines
- Organizing for maintenance
  - -Resource structure
  - -Administrative structure
  - -Work planning and scheduling system

The classification and identification of equipment is the first step for successful implementation of the maintenance system. All equipment should be classified and codified to enable keeping of the maintenance records, instruction manuals, drawings, cost data, down time data, etc., and it will aid computerization and control.

Recycle, Reuse and Recovery



Recycle refers to recycling materials and energy within the process.

Reuse involves selling materials or waste to external dealers i.e. off-site or on-site, where the material or waste is reprocessed / recovered and reused within the industry.

Recovery is the process of reclaiming valuable resources from wastes in the form of raw materials, by-products / products. Recovery normally is the preceding activity to recycle or reuse.

However, recycling and reuse options can incur somewhat increased risk and liability due to threats to product quality risks.

Recycle Within the Industry (on-site)
Waste generated in a manufacturing process in many cases can be recycled to the original process with or without treatment to remove impurities. For example, material containers can be reconditioned and re-used with minimal efforts. If waste cannot be directly reused in the original process because of potential contamination, it may be treated to remove contaminants. For example, organic solvents used in parts cleaning and pharmaceutical manufacturing processes are often collected, distilled, and recycled to the original process. Sometimes if the impurities in the material are high it may not be recycled in the original process but used in a secondary process (e.g. water in washing, used solvents in degreasing)

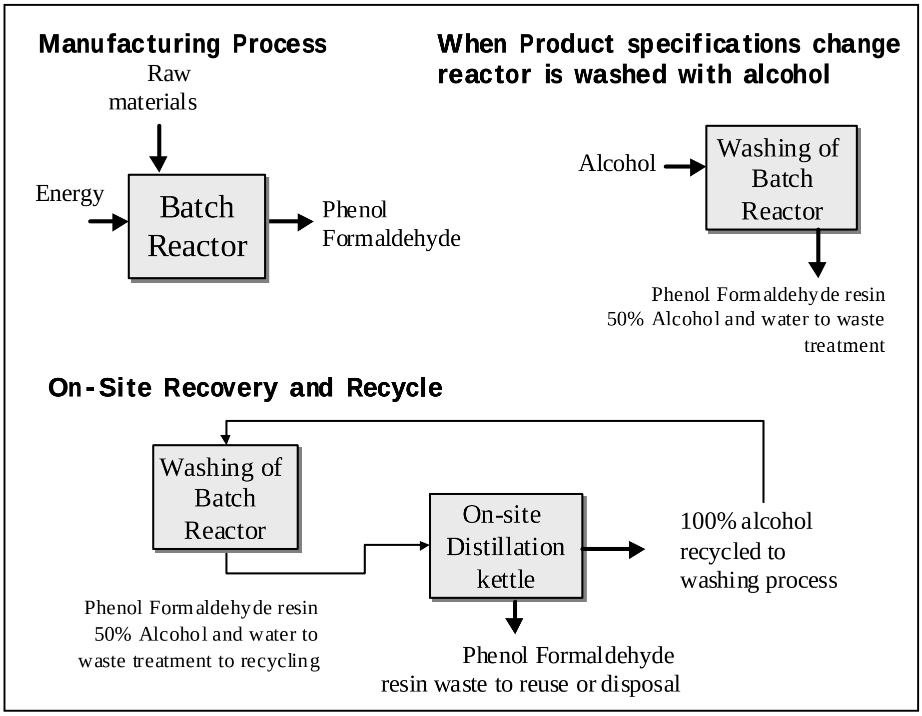
Recycle Outside the Industry (off-site)
This refers to recycle options which send material to external users. The waste that is not of any use on site is sold off to other industries / users for whom this waste could be an process input.

Tips

It may not always be feasible or economical to recover waste at the operating unit that generates it. If a plant has a number of different departments and processes generating waste solvents, a central distilling department within the plant may offer economic advantages. A single recovery operation may be less expensive from both a capital and operating labor standpoint. The disadvantages of this type of operation are the additional storage, segregation, and handling requirements, all of which increase the possibility of environmental risks and liability. The overall economics of centralizing a recovery operation must be assessed on a case-by-case basis.

Material / Energy Balance would identify the resources, that are wasted and should be recovered. Other tools that can be of use in deciding on how to recycle / recover /reuse are Cause-Effect analysis (Ishikawa), Cost-benefit analysis

On-site Recovery and Recycle



Cost assignment to waste streams conducted in the planning step identifies and prioritizes resources wasted according to their worth. On-site recovery and recycling is practiced by industries to recover these valuable resources to be reused in the process or sold. On-site recycling is employed when the resource can be easily segregated, it has a substantial reuse value to the industry or a external market and when there are no risks involved to the industry in recovery process.

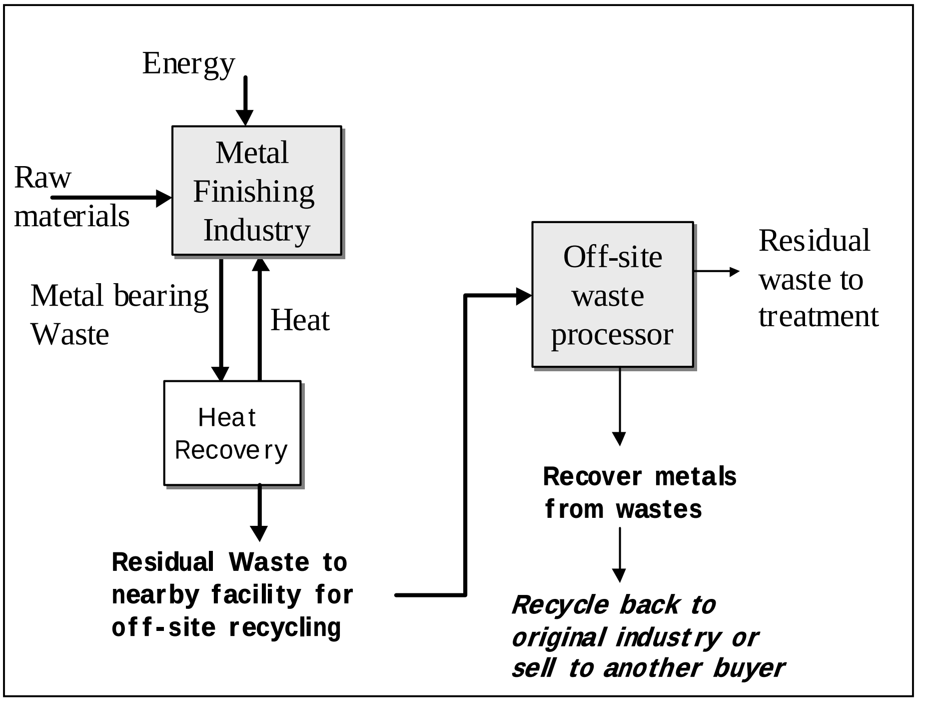
On-site Recycle and Reuse in a Chemical Industry

In this plant, Phenol formaldehyde is manufactured in batch reactors. The reactors are cleaned with alcohol every time a change is made in product specifications. The plant generated 6,000 gal / year of reactor wash solution containing approximately 50% alcohol, phenol formaldehyde resin, and water. Economic considerations prompted the plant to recycle on-site by distilling and reusing the alcohol. A distillation kettle was already available on site. Steam was available at negligible costs. The resin removed from the reactor could also be reused.

More than 67% reduction of waste generated was possible. Liabilities were reduced due to reduction of the quantity of hazardous waste generated and $15,000 annual savings in material and treatment costs were achieved.

International Cleaner Production Information Clearinghouse (ICPIC DV 3.0) UNEP, Paris France 1997

Off-site Recovery and Recycling

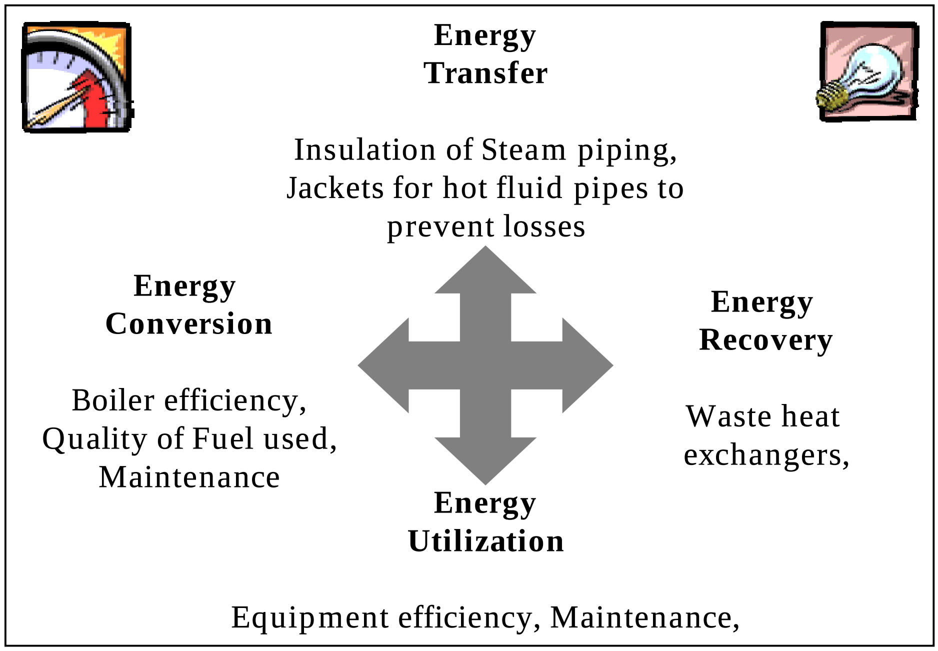


On-site recovery options are normally attempted first by the industries so as to recover valuable material from waste and save costs. But if such on-site reuse options are not feasible, then the next step is to investigate off-site recovery & recycling and save on treatment and disposal costs. The recycled material could be either returned to the generator for reuse at the generation site, or sold for use at other facilities. Material exchanges, waste exchangres, waste brokers, commercial recyclers or co-operative agreements can assist in mnatching the generators and potential end-users.

Example

The example in the above viewgraph presents a case of off-site recycling where a metal finishing industry sends its metal bearing wastewater to a recovery firm which extracts valuable metals from the waste and disposes the residual wastes.
The recovered metal can either be sold to the original generator or could be sold to other buyers.

Energy Conservation



Energy conservation at a facility or process is possible at three points:

Energy Conversion – Here, the focus is on the energy conversion efficiency of the units such as industrial boilers, power reactors, etc., that convert fuel to steam, or fuel to electricity.

Energy Transfer - When energy is transferred from the point where it is generated to the point where it is used, there could be losses. The energy transfer efficiency of the energy conduits and steam piping can contribute significantly to reduce losses in energy transfer.

Energy Utilization - This refers to the actual end usage of energy in a process. Here, the individual equipment efficiency in terms of unit product output per energy utilized comes into the picture.

Energy Recovery - Energy can be effectively recovered and recycled back to the processes. Sometimes, hot effluents are discharged to the treatment plants. If heat exchangers are employed to draw the excess heat in the effluent, it can be used back in the process. Sometimes, the material in a waste or by-product which is disposed off, could have a high calorific value. This component could be used as secondary fuel.

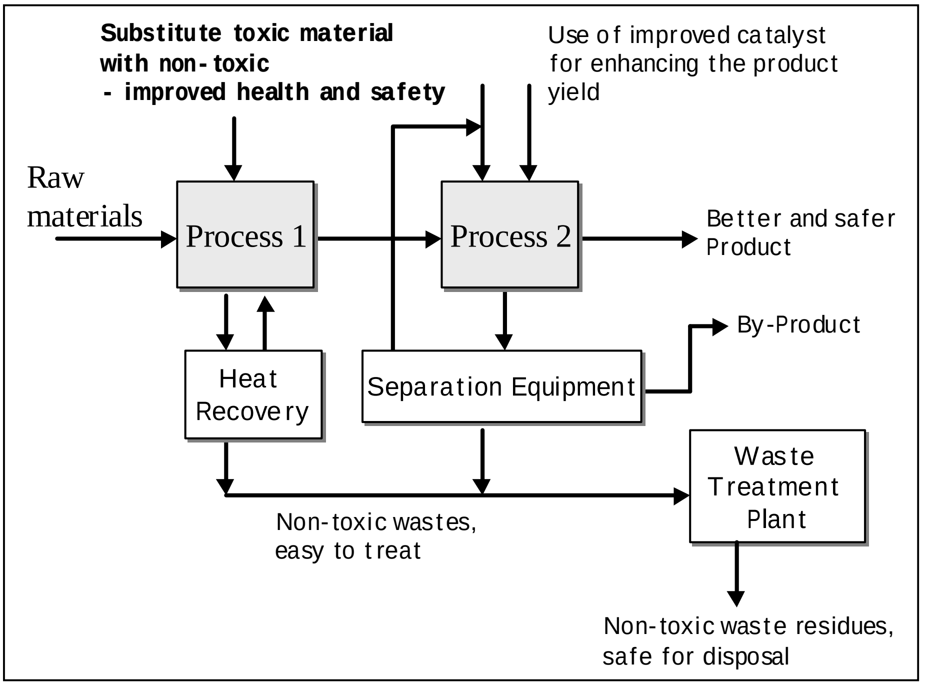
Tips

Electricity
- Efficient and optimal use
- Use appliances consuming lesser electricity
- Reduce transmission losses

Process Heat
- Select environmentally friendly fuel
- Use fuel optimally
- Reuse / recycle heat wherever possible
- Reduce transmission losses

5.8 Input Material Changes

Input Material Changes



Input material changes could be described as the substitution of existing material inputs to a process, by materials that are environmentally friendlier, without adversely affecting the product quality.

Environmentally friendlier materials are those,

- that are less toxic to the environment
- that can be easily treated
- that make the working place safer
- that are more efficient, i.e., less energy intensive

Input material changes fall into two major categories:

- for reducing and eliminating hazardous process residues
- for enhancing the process conversion efficiency

Under material substitution, for example, water-soluble cleaning agents can be used, in many cases, in place of organic solvents that may have to be disposed of as hazardous wastes or recycled off-site after they are used.

Benchmarking

Higher purity raw materials may be used to reduce the quantity of wastes generated. For example, using an organic liquid or acid that is relatively free of metals or other impurities may reduce waste typically generated due to reaction or non-reaction of these substances. Another example could be using coal with lower percentage of sulphur, in the industrial boilers, so that SO_2 emissions of the boiler are minimized.

Certain input materials may be more effective in reaction or catalytic actions on the process and hence would increase the process efficiency.

5.8 Input Material Changes

5.8.1 Example

Examples of Input Material Changes

Dunalakk Paint Producing and Servicing Ltd., Hungary

Industry sector: Paint manufacture Size: SME Push Factor: Pressure from the Western European market, stricter legislation, community pressure, worker health and safety. Measures: replacing solvent-based paints in its product range with solvent-free, water-soluble or aqueous dispersion paints; reusing paint wastes generated during application through use of air filters. Productivity benefits: Improved working conditions; increased sales; improved market position; improved community image; superior product quality. Economic benefits: Investment of HUF 50-60 million and 10 to 30% higher costs for eco-friendly product development. Turnover increased from HUF 830 million in 1994 to HUF 1,300 million in 1995 and exports from HUF 16 million to HUF 80 million. Environmental benefits: Waste recovery and reuse, regulatory compliance and improved worker health and safety.

REFERENCE Look Up

http://www.inem.org. This case study was provided by KOVET (INEM Hungary) for inclusion in the INEM Casebook, Case Studies in Environmental Management in Small and Medium-Sized Enterprises.

Dunalakk Paint Producing & Servicing Ltd., Budapest, Hungary.

The company was under pressure from the requirements of the Western European market and the introduction of stricter environmental legislation in 1995. Initially, one of the main factors causing the company to consider the development of environmentally sound products was the fact that the factory, which had once been on the outskirts of Budapest, was now surrounded by the city and a residential area. So in addition to dealing with new environmental legislation (lower emission limits, etc.) on the national level, it was also being put under pressure by the local community and authorities concerning its environmental impact.

The implementation of environmentally sound practices was further perceived by Dunalakk as an opportunity **to improve health and safety conditions for its employees**. Without consideration of Western European standards and legislative developments in this market, Dunalakk also realized that its products would be in a weaker competitive position.

As early as 1972, Dunalakk's management realized that powder coating paints, which they had first produced in 1968, could become the most significant future coating material. These powder coatings produce no chemical emissions during application. In 1972, Dunalakk bought the production process patent from the first powder coatings producer in the world in, Liber, Belgium.

Since 1976, the Dunalakk plant has produced powder coatings as an independent product line. Dunalakk decided to develop further environmentally sound painting products for its product range, such as solvent-free two-component paints, water-soluble and aqueous dispersion paints.

contd...

5.8 Input Material Changes

5.8.1 Example

Dunalakk outlined several areas that needed to be dealt with in order to develop an environmentally sound product strategy. These areas are as follows:

- minimization of manufacturing process emissions;
- reduction in the use of hazardous raw materials;
- reduction of chemical emissions during paint application;
- minimization of the fire and safety hazards associated with certain raw material usage, accompanied by improvement or preservation of product quality;
- reduction of hazardous wastes produced during paint application.

Alternatives for replacing solvent-based paints in its product range were explored. The main objective was development of solvent-free, water-soluble or aqueous dispersion paints.

In 1996, the company's solvent-based concrete enamel was replaced by an aqueous dispersion-based paint, Naofix, a paint that can be used for concrete and asbestos slate.

The company has also developed technologies for reusing paint wastes resulting from the application process.

During application of powder coatings, the use of air filters facilitates collection and reuse of six per cent of the material used, which is normally incinerated. The recovered material is reprocessed in a special mixtruder. *Use of the air filters improved health and safety at the workplace.*

Dunalakk also advises the companies to whom it provides paint application technology on the recovery alternatives available.

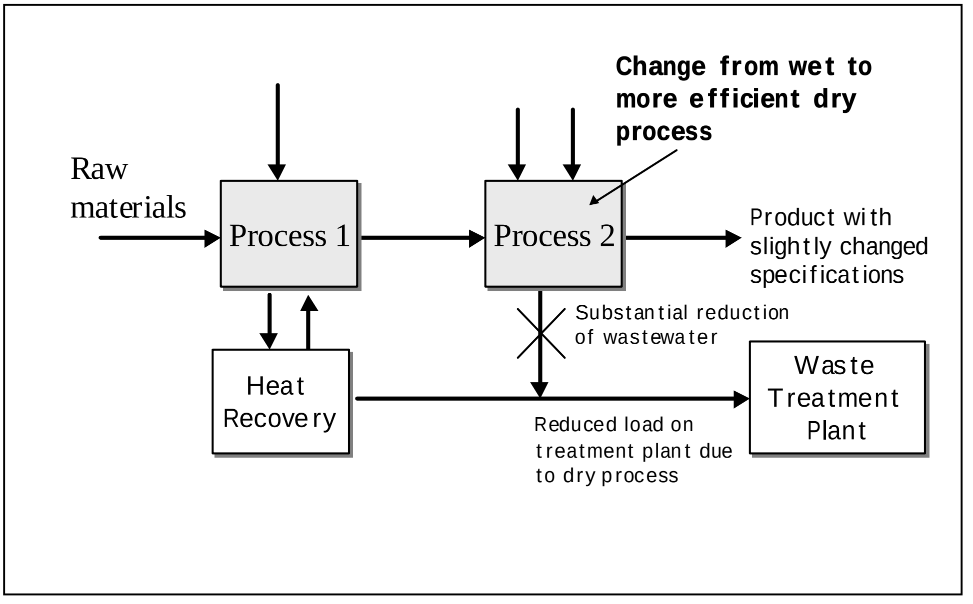
Installation of special mixtruder required investment of HUF 50-60 million. In addition, the development of environmentally sound products has involved 10 to 30 per cent higher costs than those associated with the development of more traditional products.

In 1994, turnover was HUF 830 million, and the value of exports was HUF 16 million. In 1995, turnover increased to HUF 1,300 million, and exports to HUF 80 million.

The company estimated that between 50 and 60 tonnes of paint waste is collected for reuse per year. The payback period on this investment was about four to five years.

5.9 Process/ Equipment Changes

Process / Equipment Changes



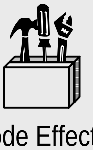
Modifying a process to reduce waste means developing an alternate process to obtain the same or better product specification, while generating less waste.

Replacing inefficient or old processes with newer technology can often reduce waste.

Reactor design changes can also significantly reduce waste by providing proper mixing and catalyst and reactant contact, minimizing temperature and concentration gradients, and optimizing procedures for reactant addition and temperature profiles.

The illustration in the above viewgraph presents the use of process modification such as changeover from wet process to dry process, thereby reducing wastewater generated as well as processing time.

Tools such as failure mode effect analysis could be effectively used while making process changes, for example to assess the product quality risks involved.



Failure Mode Effect Analysis can be used to investigate the failure modes of a proposed process modification and corrective actions can be planned

Example of Process/Equipment Change

Print Works, Massachusetts, USA

Industry: Textile printing and finishing

Size: Medium Scale

Push Factor: Inferior product quality and health and safety concerns for the workers.

Measures: Modification of the acid ageing process during dyeing using azoic dyes. Control charting used to identify and implement minimization of usage of toxic substances like acetic acid during dyeing.

Productivity Benefits: Product quality improved extensively; Improved worker health and safety.

Economic Benefits: Reduction of acetic acid procurement costs by over $33,280 annually. Total savings in chemical costs approx. $78,520 while wastewater treatment costs have been saved by $200,000.

Print Works in Massachusetts, USA

This is a case where productivity is the driving force and productivity tools were used in problem diagnosis and rectification.

Azoic dyes were being used at the plant for dyeing. Acetic acid is being employed in the process. Acetic acid was being manually fed into the process. This led to variability in the process conditions affecting product quality. Moreover, being a toxic substance, it had health and safety implications on the workers, too.

A multi-disciplinary team applying the Deming Quality Process adopted control charting for processes throughout the plant with the intention of minimizing use of toxic substances while improving product quality.

Using control charting, the management identified and implemented a set of measures involving modification of the acid aging process to minimize environmental impacts and generate economic benefits for the company.

Process improvements resulting from control charting have reduced annual acetic acid usage by over 128,000 pounds. The quality of the product improved extensively and it has dramatically reduced worker exposure to acetic acid.

Acetic acid procurement costs have reduced by over $33,280 annually. Total savings in chemical costs have been approximately $78,520 while treatment costs have been saved by $200,000.

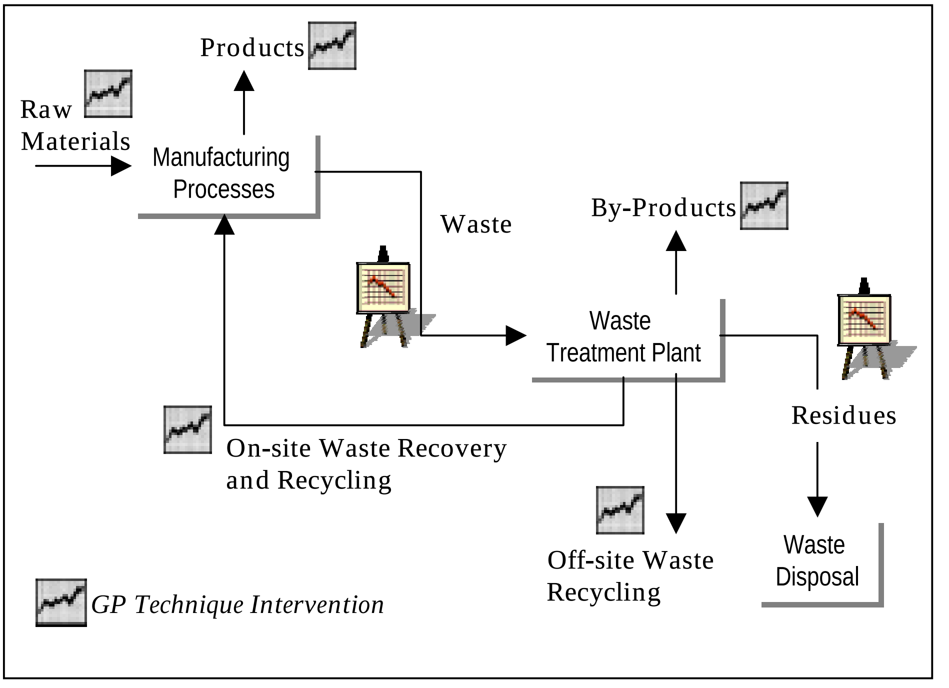
5.10 Pollution Control

Tips

The waste treatment facilities for air,effluent and solid waste should also be treated like manufacturing processes.

Wastes from manufacturing processes become inputs to these facilities whereas treated wastes are the products. If the conversion process is inefficient off-spec product would be produced. That is, the treated waste, would not comply with environmental standards, and would have to be further treated.

Pollution Control



Manufacturing processes do not have a 100% conversion efficiency. Consequently, some waste in the form of air emissions, effluents, solid wastes and heat releases is generated. GP techniques described in this lecture attempt to improve on the conversion efficiency and reduce generation of wastes.

The wastes need to be treated and disposed in a scientific manner abiding the applicable environmental legislation. This task is achieved by setting of waste treatment and disposal facilities, either on-site or off-site. Waste treatment facilities also do not have a 100% conversion efficiency and residues & rejects get generated in the process of treatment. These residues can be minimized once again by following some of the GP techniques.

The waste management / treatment typically includes:

Air emission control for:

- Stack emissions
- Fumes/odors at the workspace

Effluent treatment plant for:

- Industrial effluents
- Domestic / sanitary wastewater (cooling water)

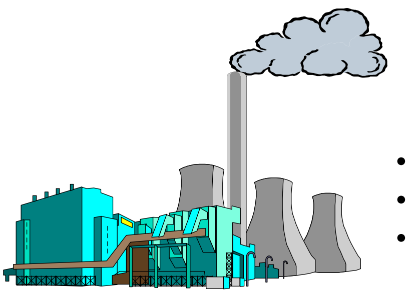
Solid waste management for:

- Industrial solid wastes (hazardous and non-hazardous)
- Effluent treatment plant solid / sludge residues

5.10 Pollution Control

5.10.1 Air Emission Control

Air Emission Control



Particulates
Gaseous pollutants

- Industrial Boiler emissions
- Acid Bath Fumes
- Chemical Odours

Techniques for Air Emission Control

- Gravitational settlers
- Cyclonic collectors
- Bag filters
- Wet scrubbers
- Electrostatic precipitators
- Adsorption towers
- Adsorption columns

Tips

The air pollution control equipment and devices mentioned on this slide are not a complete treatment system in themselves.

Residues would be left in the wastewater (liquids from wet scrubbers) or solid waste (particulate from filters) forms for which again proper residual treatment and disposal needs to be adopted.

Industry contributes to air emissions in several ways:

All combustion reactions generate emissions containing unburnt carbon and its compounds such as CO, CO2, etc., gaseous compounds arising due to impurities (e.g. sulphur in coal forms SO2).

These combustion reactions occur in the industrial boilers or process furnaces.

Fumes and odor from the reaction and storage tanks and piping systems are other sources of fugitive emissions.

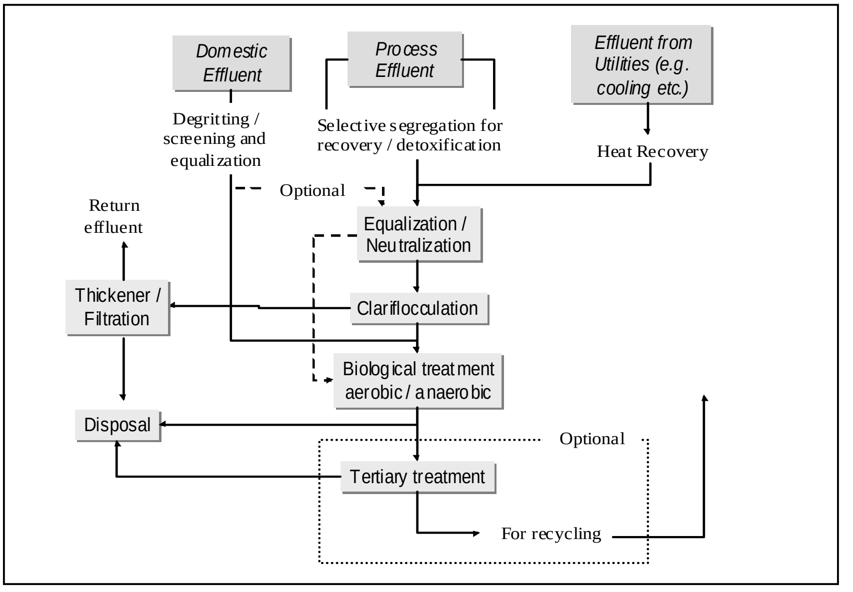
Some of the Primary Air Pollutants of Concern Are:
Carbon monoxide, oxides of nitrogen, hydrogen sulphide, methyl and ethyl mercaptans, hydrogen fluoride, etc.

Devices That Control Particulate Matter Are:
- Gravitational settlers
- Cyclonic collectors
- Bag filters
- Electrostatic precipitators
- Fabric filters

Devices That Control Gaseous Pollutants Are:
- Adsorption equipment using adsorbents like activated carbon, alumina, bauxite etc.
- Absorption units like spray towers, plate or tray towers, packed towers and venturi scrubbers
- Condensors using surface and contact condensors
- Combustion equipment using direct flame or thermal or catalytic combustion

5.10.2 Wastewater management

Wastewater Management



Any industry generates three kinds of effluents. One is the domestic effluent (this would include wastewaters from the offices, administrative blocks and canteens). Second is the industrial process effluent. Third is the effluent released from cooling water operations and washings. The pollutant loads in these streams are such that they cannot be discharged without treatment. Different techniques are employed to treat these wastewaters.

It would be beneficial if effluent streams were segregated prior to treatment, according to the treatment required, flows, and concentrations so as to facilitate handling, treatment, recovery, reuse and disposal.

Domestic effluent is mostly highly organic in nature with little or no inorganics or heavy metals. For this wastewater, mainly biological treatment (with some essential unit operations such as screening, grit removal etc.) alone is used to reduce the organic load. Sometimes domestic and process effluents are blended to increase the treatability.

The industrial effluent contains several contaminants of varying nature and concentrations and is the most difficult to treat. Industrial effluents are typically characterized by high Chemical Oxygen Demand / Biochemicalk Oxygen Demand, heavy metals, toxic chemicals, inorganics etc. Many techniques need to be applied in the proper sequence and with adequate control to achieve the desired outlet effluent standards.

Most of the treatment technologies require a uniform flow pattern for effective treatment and hence the various flows from the industry need to be equalized first. Process effluent is acidic or alkaline in nature and needs to be neutralized. Further, depending on the amount of organics, anaerobic treatment might be necessary before aerobic biological treatment to bring down the BOD. Heavy metal streams on the other hand are segregated, oxidized / reduced before blending with the rest of the industrial effluent.

If high volatile organics are present in the effluent, then it might be economical to recover or separate these by stripping / extraction and recycled to the same process or other secondary uses. The effluents are sometimes treated at tertiary level if it merits recycling either on-site or off-site.

Tips

Design of the treatment plant should be robust yet economical. It should achieve and maintain the desired treatment efficiency and most important of all comply with the outlet regulatory standards.

Residues of the wastewater treatment would be in the form of sludge and dried cakes of settled matter. These residues need to channeled to the proper solid waste management and disposal system

Example of Wastewater Management

Peter Paul Philippines Corporation, Philippines

Industry sector: Food Processing (dessicated coconut production)

Size: Medium scale

Push Factor: Serious environmental non- compliance due to very high levels of Biological and Chemical Oxygen Demand (BOD and COD).

Measures: Utilization of 80,000 liters of wasted coconut water through a recovery process to produce a commercial drink; improvement of operational practices.

Productivity benefits: Profitability due to new by-product; Increase in production of dessicated coconut.

Economic benefits: Annual savings of US $ 370,000 due to increased production; treatment cost savings of US $ 3700 per year.

Environmental benefits: Regulatory compliance possible due to reduction in effluent BOD by 50%.

Example

Peter Paul Philippines Corporation, Philippines

This project was carried out under the Industrial Environmental Management Project (IEMP) of the Philippines.

This case is an illustration of how waste can be utilized as a resource to generate revenue as well as improve environmental performance.

Waste coconut water generated from the production of dessicated coconut had high BOD and COD levels.

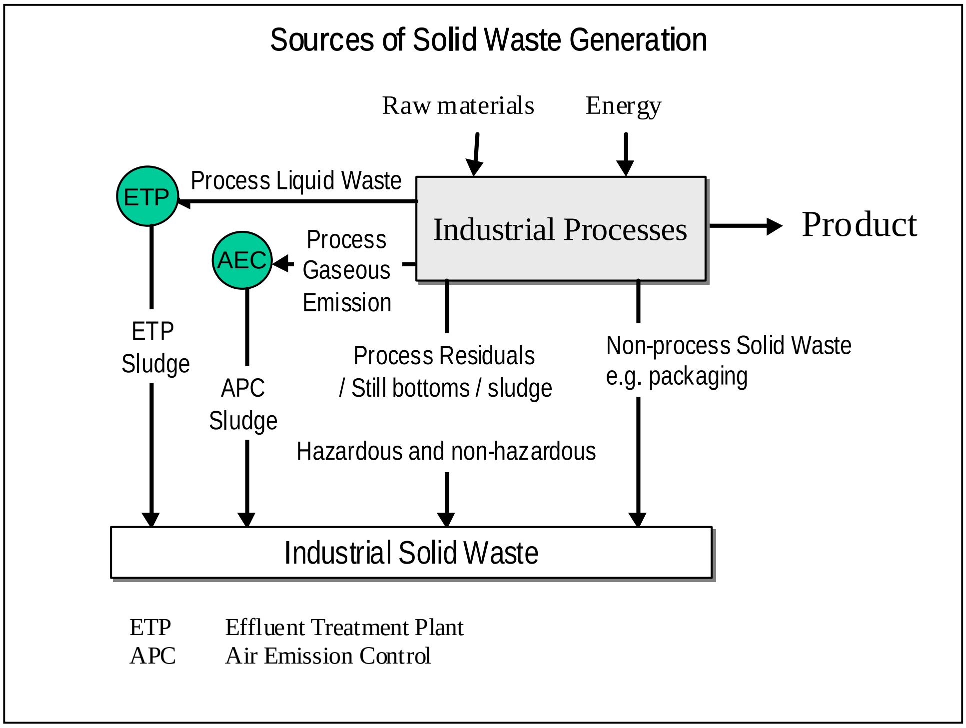
Collaboration with a Chinese company resulted in the recovery of the coconut water which was collected from Peter Paul Philippines Corp. and channeled to the Chinese company's plant for processing and freezing. It was sent to Taiwan for sale as a commercial drink. Breakers were installed to improve coconut water collection.

Operating practices such as paring of coconut were improved. Incentives were provided to workers in the form of payment for each full pared coconut resulting in improvement of quality of dessicated coconut.

Production of dessicated coconut increased by 13.6 kg / ton of coconut processed. This led to annual savings of US$ 370,000.

The main environmental benefit is the reduction in BOD level by 50%. This reduced the annual operating cost of the wastewater treatment plant and thus the treatment cost is reduced by $3700 per year.

Solid Waste Management



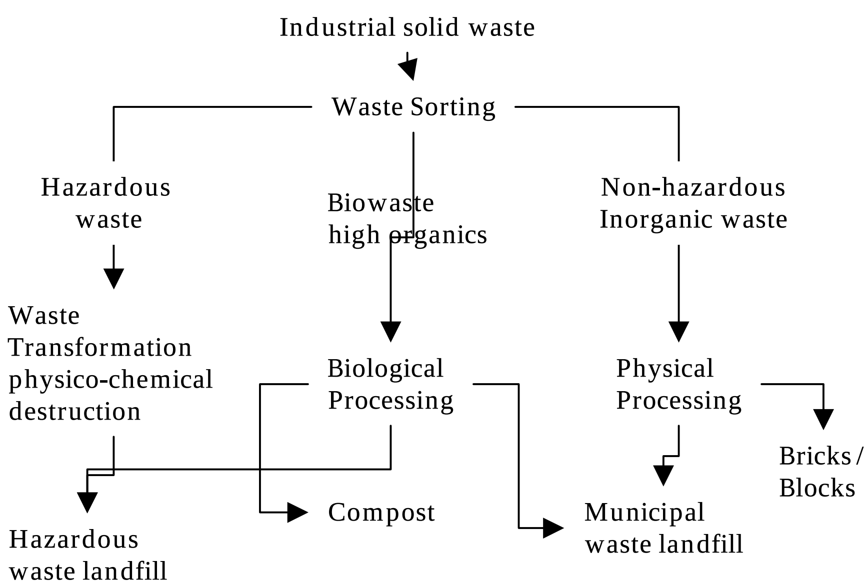
Various sources of solid waste generation at an industrial facility are shown in the viewgraph.

The major components are:
• Residual solid wastes / sludge from effluent treatment plant (e.g. from thickeners, filter press or sludge drying beds)
• Residual solid wastes from air pollution control equipment (e.g. particulate from bag filters)
• Direct process solid waste (e.g. tank bottoms, stills etc.)
• Non-process solid wastes (e.g. unused raw materials, containers, packaging material, etc.)

Tips

Solid waste management presents several opportunities of waste recovery, reuse and recycle whereby material, money and energy can be saved.

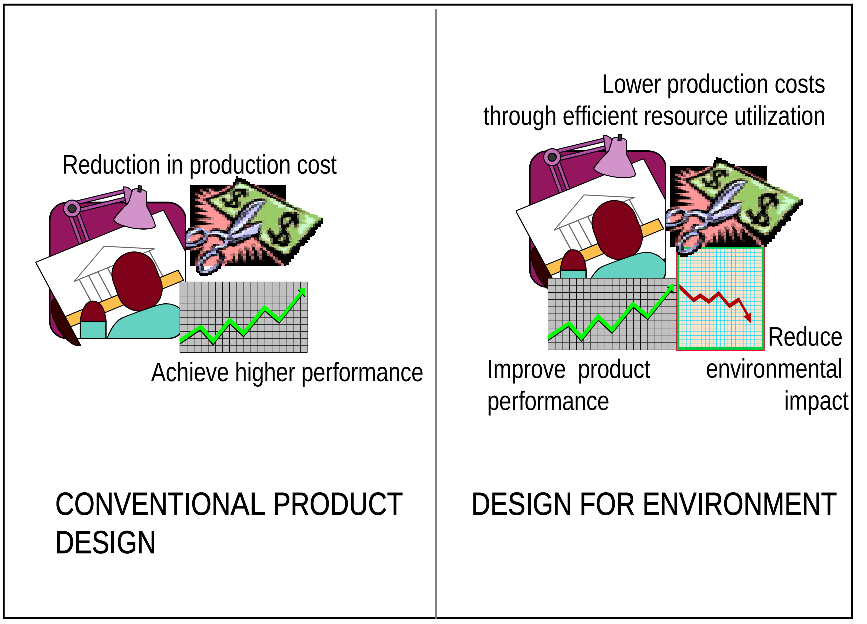
The solid waste strategy to manage these wastes is summarized in the chart below.



As mentioned earlier, residues from the air pollution and wastewater pollution control facilities finally come to the solid waste management facility where they are further treated required and are disposed in a suitable landfill

5.11 Design for Environment

Design for Environment



The conventional product design and development process emphasizes how economic value can be enhanced i.e., how to reduce production costs and achieve higher performance. Today, recognizing the power of tools like LCA, the GP framework has incorporated the principles of eco-design into its framework. Product design therefore becomes design for environment.

Design for Environment (DfE) is currently interpreted as a design process in which environmental attributes are treated as a design objective rather than a constraint. What is important in DfE is to increase eco-efficiency i.e., lower the environmental impact and improve the performance of products.

Increasingly industry is redesigning existing products. This is being done by increasing the amounts of recycled or recyclable materials used in manufacture; substituting toxic and hazardous materials by suitable less / non-toxic alternatives; reducing material intensity for a given product. The aim is to reduce the environmental impacts of consumption. This however must be done while ensuring that the quality of the product is maintained or improved.

Opportunities for substituting toxic and hazardous materials as well as those which have long-term impacts on a regional as well as global scale, have been taken by industry and the services sector. This has resulted in an impact on the life cycle of the product leading to manufacture of products that are less demanding on natural resources while at the same time satisfying the needs of the customer.

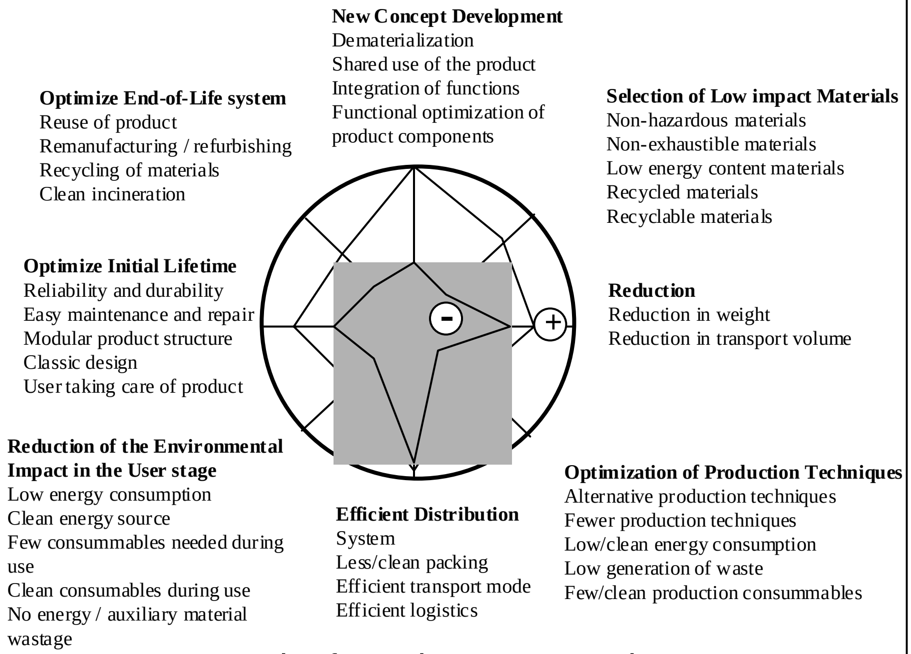
Manufacture here includes not only the product but also its packaging. The way it is used and disposed by the consumer also impacts the environment. A number of companies worldwide are substituting conventional packaging with more environmentally benign materials which has led to improved productivity.

DfE guidelines vary between different countries, however the focus is on eco-friendly product design.

5.11 Design for Environment

5.11.1 Strategies for Design of Environment (DFE)

Design for Environment (DFE)



Design for Environment Strategies

Environmentally compatible products minimize the adverse effects on the environment resulting from their manufacture, use, and disposal. The environmental impact of a product is to a large extent determined during its design phase. By taking environmental considerations into account during product planning, design, and development, a company can minimize the negative impact of its products on the environment.

Various product improvement techniques address various aspects involved in product development and design, such as:

- New concept development
- Selection of low impact materials
- Optimization of production techniques
- Reduction of the environmental impact in the user stage

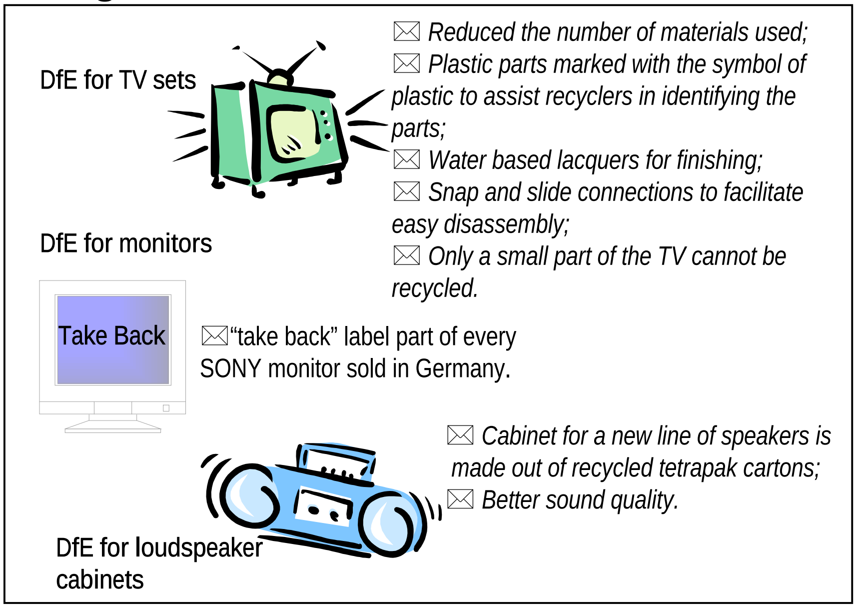
Product design changes involve manufacturing a product with a lower composition of hazardous substances, or less toxic materials being formed, or changing the composition so that no hazardous substances are involved. For example, a manufacturer could use an active ingredient in a formulation with a non-hazardous solvent rather than a chlorinated solvent. Other examples include using mineral oil in electrical transformers instead of PolyChlorinated Biphenyl (PCB) liquids or organic pigments in paints rather than heavy metal pigments.

An illustration of an environmentally friendly design of a bicycle is presented in the next handout.

5.11 Design for Environment

5.11.2 Design for Environment (DFE)-Illustrations

Design for Environment - Illustration from SONY



UNEP Industry and Environment, Volume 20, No. 1-2, 1997. P.28

SONY has made a number of initiatives to minimize environmental burden without compromising on quality by addressing various stages of the product's life cycle.

Design changes have been made in the materials used for the manufacture of their modern TV sets. As a result, theoretically only 1% of the total weight of the product will have to be disposed; the rest can be recycled. Design changes have reduced the number of materials used and all plastic parts are marked to facilitate recycling.

Air moulding technology has been used in the manufacture of the TV cabinet as a result of which the amount of plastic used has been reduced drastically. An LCA to compare the air moulded cabinet, a steel cabinet and mixed cabinet shows clear advantages for the air moulded model. It not only imposes a lower environmental burden but has better mechanical qualities and lower production costs.

The disassembly time for this TV unit (time needed to dismantle the unit and sort components according to materials) has been reduced drastically. In fact, due to snap and slide connections, the need for tools has been minimized and it can easily be opened by hand. Water based lacquers are used in finishing the product.

A new line of loudspeaker cabinets has been made with recycled material (Tectan a material made from shredded and pressed tetrapak cartons). This cabinet has better sound quality than that of similar boxes made of conventional material.

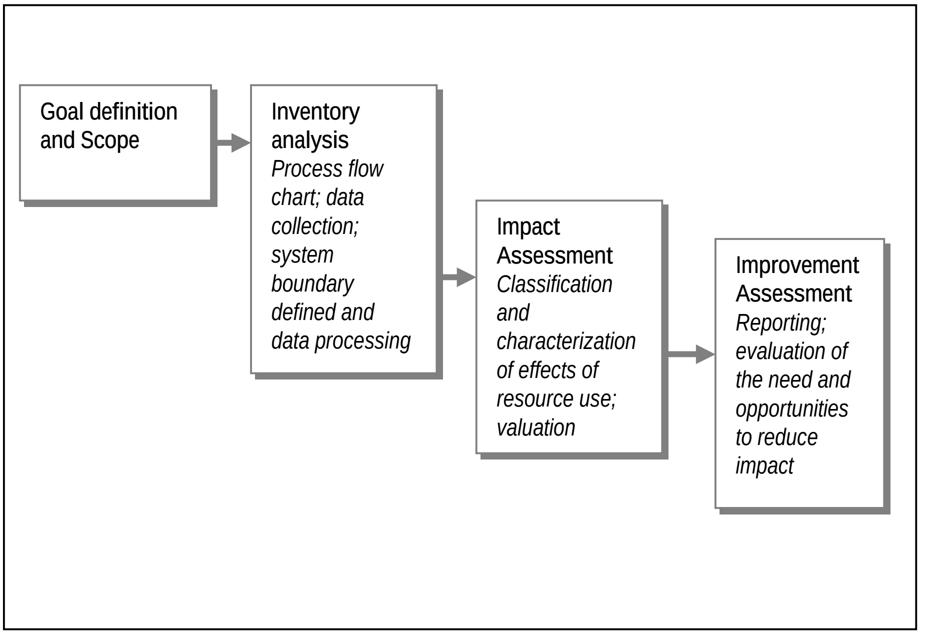
As part of its product stewardship initiatives, in Germany, a "take back" label is part of every SONY monitor sold since March 1996. When the monitor is to be disposed of, the customer sticks the label on the product and returns it to one of the 800 take-back points. In cooperation with Rethmann Electrorecycling GmbH, SONY guarantees that the monitor will be dismantled and recycled in an environmentally sound way. Thus LCA to ecodesign can be a very feasible and sound route both environmentally and business-wise.

5.12 Life Cycle Assessment

UNEP, CML, Novem, RIVM, Govt. Of Netherlands, *Unilever, Life Cycle Assessment: What it is and How to do it*, UNEP, 1996. *Guidelines for Life Cycle Assessment : A Code of Practice,* from the SETAC workshop at Portugal, 1993. Society of Environmental Toxicology and Chemistry (SETAC), 1993.

The LCA procedures have been structured into a framework with the formulation of a Code of Practice by the Society of Environmental Toxicology and Chemistry.

Life-Cycle Assessment



Life cycle assessment (LCA) is the process of evaluating the effects that a product has on the environment over the entire period of its life cycle. LCA sets out to provide objective answers and its aim is to suggest more sustainable forms of production and consumption. It uses a scientific approach in which the quantification of effects plays a dominant role. A complete LCA is composed of three separate but interrelated components :

Life-cycle inventory: An objective data-based process of identifying and quantifying the environmental loads involved – the energy and raw materials used, and the emissions and wastes consequently released (e.g. air emissions, liquid effluents, solid waste) throughout the life cycle of a product, process or activity.

Life-cycle impact analysis: A technical quantitative and / or qualitative process to characterize and assess the effects of the environmental loading identified in the inventory component. The assessment should address both ecological and human health considerations as well as such other effects as habitat modification and noise pollution.

Life-cycle improvement analysis: A systematic evaluation of the needs and opportunities to reduce the environmental burden associated with energy and raw materials use and environmental releases throughout the whole life cycle of the product, process or activity. This analysis may include both quantitative measures of improvements such as changes in product, process and activity design; raw material use; industrial processing; consumer use and waste management.

Using LCA , the environmental impact of processes, product cycles, and economic activities can be minimized by reducing the material flow through cleaner processes, cycles, and activities. If the reduction in material flow occurs without loss of service or quality of the product as required by the consumer, then it leads to improvement in the material efficiency of those processes.

5.12 Life Cycle Assessment

Together with information on costs, convenience, and consumer safety, the information obtained from an LCA, can be used by organizations to make decisions on how to develop, improve, and produce products.

Efficiency improvement can occur at various points in this cycle. In production processes, improving the material efficiency could mean for example avoiding leaks and spills, better materials handling, closing internal material loops for auxiliary materials and designing and redesigning processes for improved material and energy efficiency. It is important that material efficiency should include energy efficiency, because energy supply is either explicitly or implicitly dependent on material flows.

In terms of consumption patterns, improved material efficiency means improving the utilization of products, designing products for longer service lives, and reversing the throw- away mentality of the existing consumer society.

Improving the material efficiency of the economy in the broadest sense means reducing the material needs of any given service provided by the economy and therefore reducing the material requirements upon which economic welfare is based.

By adopting the life-cycle approach and focusing on efficiency of processes leading to productivity improvement, GP moves upstream and downstream of a product. It encompasses the environmental impact of not only raw materials but also the usage of the product by the consumer. Therefore it integrates the supply chain into the strategy for environmental improvement.

This approach has implications for SMEs today. They form part of an extensive supply chain of a number of large enterprises. As the business strategies of these enterprises move towards sustainability the SME suppliers will have to suitably modify their approaches too. The current demand for quality in the supply chain will be expanded to include environmentally and socially sound practices.

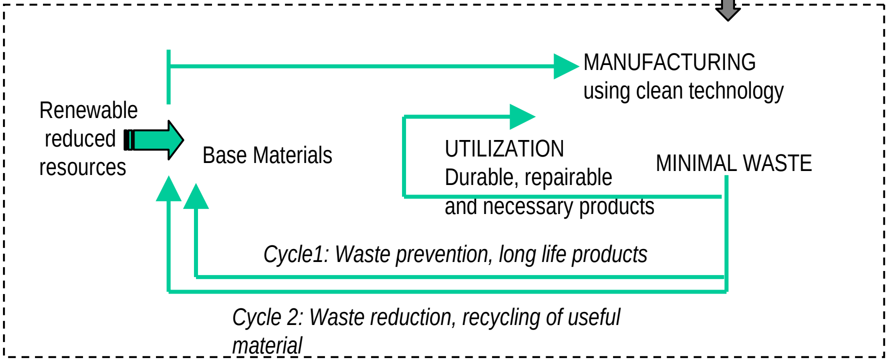
5.12 Life Cycle Assessment

5.12.1 Life Cycle Assessment - Illustrations from Japan

Life-Cycle Assessment - Illustration from Japan

Establishment of the Life Cycle Assessment Society of Japan in 1995 with the support of the Keidanren and the Ministry of International Trade and Industry. Almost all industries have assisted in its activities.

The basic premise is that product design should take LCA and environmental advantage into account and **life cycle engineering** approach should be adopted to maintain sustainable development.



Top Management Forum. Green Productivity and Role of Top Management in Search of Sustainable Asia through Green Products and Services. APO, Tokyo, 1998.

The significance of Life Cycle Assessment in sustainable product design was recognized in Japan leading to the formation of the Life Cycle Assessment Society of Japan in 1995. The Society was established with the support of Keidanren and the Ministry of International Trade and Industry. (MITI)

LCA has formed the basis for product assessment in Japan where recycle-conscious design has begun to play a very important role particularly in the household appliances and automobile sectors.

The origin of this concept of product assessment in Japan began with the enactment in 1991 of the Law for Promotion of Utilization of Recyclable Resources (Recycling Law). Following this in 1994 the Industrial Structure Council, a consulting council for MITI issued a guideline that must be referred to when manufacturing companies prepare manuals for implementation of assessment required to be conducted when they design products. LCA serves as a very useful tool in the conduct of such an assessment.

Product assessment guidelines have been developed by various industry associations for each industrial sector.

Using the principles of LCA, national projects were carried out in Japan between 1993 and 1998 to identify ecomaterials showing that e.g., impact of recycling aluminum and glass has a much lower impact than recycling virgin copper. Such findings were very important for materials based industries. A list of 55 categories of products that exert a lower burden on the environment vis-à-vis their conventional counterparts has been developed by MITI.

A copy machine made by Fuji Xerox has incorporated a number of reused parts. As of 1996 the ratio of reused parts had reached 30%.

An electric vacuum cleaner designed by Hitachi uses optic fibre instead of Copper wire because the latter has higher environmental impact.

LCA is thus being used by Japan to (a) examine the contribution that products make to reducing global problems (b) determine their environmental impact using ecoindicators and (c) develop newer safer and more sustainable products based on this information.

5.13 Green Purchasing

Green Purchasing

Three basic principles of Green Purchasing

⌧Consideration of product cycle

⌧Management policies and practices regarding Green Purchasing

⌧Availability of eco-related information to evaluate products manufacturers and distributors

Green Purchasing is at two levels
- Procurement of safer eco-friendly materials, technology etc.by the producers
- Consumers seeking ecofriendly products

LCA identifies the environmental impact of a product through various stages in its life cycle. Using this information DfE is initiated by product manufacturers. In order to incorporate principles of DfE, one of the avenues is to use safer and more environmentally benign materials. This is where Green Purchasing comes into the GP framework.

Green Purchasing is at two levels: (I) that of the producer procuring and using raw materials goods and services that are more eco-friendly and (II) that of the consumer demanding more sustainable goods and services.

Under the concept of Green Purchasing, priority is given to the acquisition of products and materials that place less load on the environment, in addition to price and quality considerations. Green Purchasing for industry has far reaching implications along the supply chain. The impact particularly on SMEs is significant. Those supplying larger corporations that adopt green purchasing policies would be under pressure to develop and provide goods and services that are environmentally friendly.

In Asia Green Purchasing has seen great strides in Japan. A Green Purchasing Network was organized in Japan in 1996. By 1998 there were 1000 firms, local governments and NGOs participating in this network. Europe and the US saw emergence of such networks in the late 1980s and 1990s.

contd…..

5.13 Green Purchasing

JUSCO the largest retail chain in Japan served as a board member on this Network. It recognized three major principles in green purchasing.

The first emphasizes the importance of the product life cycle and therefore a product is bought only after considering its cumulative environmental load through its life-cycle. The second principle is to assess adoption of green purchasing policies so as to select products manufactured and distributed by corporations with an active interest in environmental protection. The third is to gather and apply environmental information to evaluate products, manufacturers and distributors.

These three principles of green purchasing are valid and applicable both for industry and the consumer.

Apart from business and government initiatives to make consumption patterns sustainable and to promote green purchasing, the GP approach can also trigger citizen initiatives, which will in turn, have an impact on greening the supply chain.

Two such initiatives are provided below:

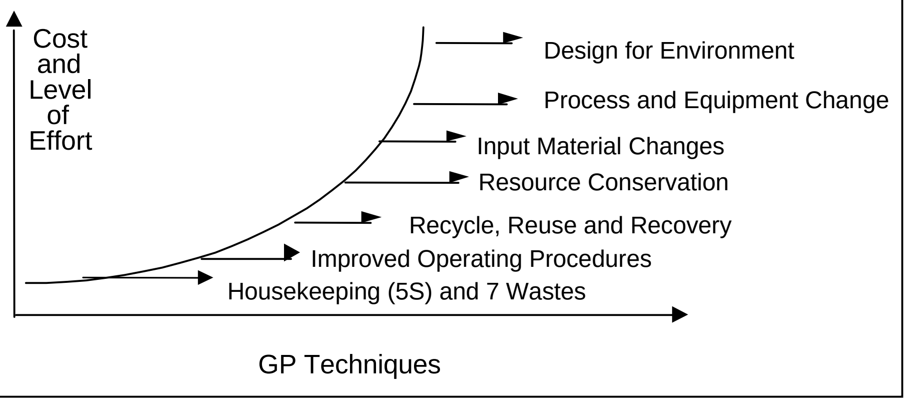
1: In Mumbai, India over 16,000 households now belong to the Mumbai Grahak Panchayat which operates a collective purchasing system that provides good quality foods and other products at a competitive price. It provides its members with a fair and efficient system of consumption, the system also benefits local producers, provides an incentive for sustainably produced food, reduces traffic, cuts waste by re-using cloth bags and restrains impulse buying.

2: In Japan, the Nippon Ecology Network operates a weekly organic food home delivery service for over 25,000 households. Recently this has been supplemented by the Green Purchasing Network bringing together over 1000 companies, public authorities and citizen groups to promote the choice of sustainable goods and services across Japan.

Green Purchasing initiatives of consumers can serve as one of the driving forces creating a market demand for eco-friendly products as discussed in Lecture 2. This in turn would "push" producers towards eco-design which would drive Green Purchasing by producers from their suppliers. As a result the entire supply chain would be addressed.

5.14 GP Techniques: Cost & Level of Improvement

GP Techniques, Cost and Level of Effort



As we move up from simple housekeeping techniques to design of environmentally compatible products the cost of implementing the technique rises correspondingly.

Implementing simple techniques like housekeeping, rationalization of operation, reuse, recycle in most cases is easy. Moreover, it is possible to implement these techniques in a fairly short period of time and relatively less capital investment.

The techniques presented in the above viewgraph, bring about incremental improvements, although some increments might be significant than the others. Techniques are applied in combination and rarely in isolation.

Sometimes moving directly to Design for Environment (DFE) may result in a complete change of product lines resulting in substantial benefits. This is because, all environmental and productivity aspects are already incorporated in the product development process. As indicated in the viewgraph however, the cost and the level of effort required for DFE would be rather high and the time schedules also could be longer.

Learnings from the Lecture

At the end of the lecture the reader should have a very clear idea of the techniques to be used in implementation of GP. In fact, the reader should feel confident in applying these techniques independently in support of GP methodology. The principal use of the GP techniques is in the generation of options.

Some of the questions for which answers may be sought from this lecture are:

- ❑ What is the relationship between GP Tools and GP Techniques? Provide illustrations.
- ❑ Compile a sector specific list of preferred GP techniques, e.g., for a tannery or a textile processing industry.