Cleaner Production:

A Pollution Prevention Strategy

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Preamble:

India has been predominantly an agricultural economy and it has only since early eighties that the industrial sector has almost become at par with agriculture. A major feature of the industrial scenario of India has been the growth of Small and Medium Enterprises (SMEs). The major thrust area in Industrial development of India has been the small scale sector. Presently, there are more than three million Small Scale Industries (SSIs) in India. The aim was to group the industries on economic scale in suitable sites with facilities of water, transport, electricity, bank, etc. and provide with special arrangement for technical guidance and common facilities. All the factors have a direct impact on the environmental angle of the SMEs, which is so far been grossly under rated. Although the pollution from a single unit may not create severe environmental damage but their collective discharge from an industrial estate causes significant damage to the human health and environment. It is estimated that SMEs in India contribute to 65 % of the total industrial pollution.

Gujarat, for ages together has been known to an entrepreneur's dreamland. A state that brings together all the amenities to make some of the most crucial industrial torchbearer of development. From its dependence on agriculture and textiles industries, chemicals and petrochemicals, pharmaceutical and is processing rapidly in the field of engineering, fertilizer and more.

All type of industries use resources of one kind or another to produce products and deliver services for meeting needs of other businesses and / or communities. In this process, some resources remain unspent, or unwanted products get produced as waste because 100% conversion or transfer of resources is seldom possible. This waste when discharged to the environment causes pollution. These waste many be solid waste of Gaseous. The first hand approach adopted for solving this problem was "End of Pipe" (EoP) treatment/ handling. Major Steps were taken towards pollution control in Industrial estates like effluent collection system, treatment, disposal of treated effluent, disposal of solid waste.

In view of this there is a need to take steps towards reducing, recycling and reusing waste.

This leads to the concept of CLEANER PRODUCTION/ CLEAN TECHNOLOGY - Step towards Pollution Prevention.

About Cleaner Production:

The United Nations Environment Program (UNEP) definition of "Cleaner Production", and the one in most common use is, **"cleaner production means the continuous application of an integrated, preventative environmental strategy to processes, products and services to increase eco-efficiency and reduce risks to humans and the environment".** For **production processes**, Cleaner Production results from one or a combination of conserving raw materials, water and energy; eliminating toxic and dangerous raw materials; and reducing the quantity and toxicity of all emissions and wastes at source during the production process.

For **products**, Cleaner Production aims to reduce the environmental, health and safety impacts of products over their entire life cycles, from raw materials extraction, through manufacturing and use, to the 'ultimate' disposal of the product. For **services**, Cleaner Production implies incorporating environmental concerns into designing and delivering services.

Cleaner Production can **reduce operating costs, improve profitability, worker safety and reduce the environmental impact of your business.** Companies are frequently surprised at the cost reductions achievable through the adoption of Cleaner Production techniques. Frequently, minimal or no capital expenditure is required to achieve worthwhile gains, with fast pay-back periods. Waste handling charges, raw material usage and insurance premiums can often be cut, along with potential risks. Yet most companies in the region remain unaware of the potential cost savings and environmental benefits of cleaner production.

Cleaner production is the improvement of operational processes to make more efficient use of inputs such as power, raw materials, and water along a company's value chain. On a broader scale, Cleaner Production can help alleviate the serious and increasing problems of air and water pollution, ozone depletion, global warming, landscape degradation, solid and liquid wastes, resource depletion, acidification of the natural and built environment, visual pollution and reduced bio-diversity. Effective cleaner production interventions not only help conserve resources and reduce waste, pollution and greenhouse gas emissions, but can also reduce operating costs.

Cleaner Production does not deny growth; it merely insists that growth be **ecologically sustainable**. It should not be considered only as environmental strategy, because it also relates to **economic considerations.** In this context, waste is considered as a **'product' with negative economic value.**

Each action to reduce consumption of raw materials and energy, and prevent or reduce generation of waste, can increase productivity and bring financial benefits to enterprise. Cleaner Production is a **'win-win' strategy**. It protects the environment, the consumer and the worker while improving industrial efficiency, profitability, and competitiveness. The key difference between pollution control and Cleaner Production is one of timing. Pollution control is an after-the-event, **'react and treat'** approach. Cleaner Production is a forward-looking, **'anticipate and prevent'** philosophy.

About Gujarat Cleaner Production Centre:

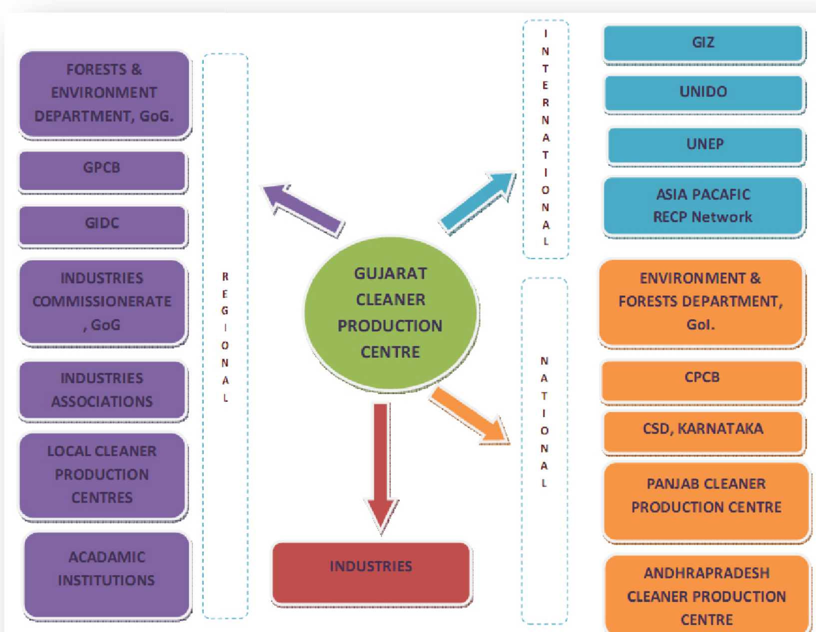
The Gujarat Cleaner Production Centre (GCPC) has been established by the Gujarat Industrial Development Corporation (GIDC) in the year 1998 under the technical guidance of UNIDO and since then the centre is actively engaged in the promotion of Cleaner Production (CP)/Clean Technology (CT) through its various activities such as orientation/awareness programmes, CP Assessment Projects and CT Assessment Projects etc. GCPC has been registered in August 2008 under the Society Act, 1860 and Trust Act, 1950.

Contributions of GCPC over the years towards promotion of Cleaner Production in the state of Gujarat to improve the productivity and the environmental problems faced by SMEs have been significant. GCPC had also played active role in framing Industrial Policy 2003, 2004 and 2009 and also supported in developing many schemes pertaining to CP/CT. Several success stories from implementation of CP have been documented. In appreciation of the efforts of GCPC, though GCPC is a regional CP Centre, UNIDO has recognized it at par with National CPC and included in RECP (Resource Efficiency and Cleaner Production) networking membership.

GCPC have so far conducted 40 orientation programmes in different colleges, organizations and industries associations. The centre has successfully completed 23 demonstration projects in various sectors like chemical, petrochemical, pharmaceutical, fish processing, etc.

GCPC Objectives:

- To create awareness on Cleaner Production.
- To provide cost effective training to industrial personnel on Cleaner Production assessment and implementation.
- To organize and conduct Cleaner Production Assessment Projects in different clusters.
- To develop expertise and thus provide consultancy / advisory services on Cleaner Production.
- To prepare guidelines and manuals preferably in local language on Cleaner Production.
- To promote local Cleaner Production centres.
- To conduct Cleaner Technology Assessment Projects in different industries of Gujarat.
- To assist Government in framing the policy for CP/CT promotion.



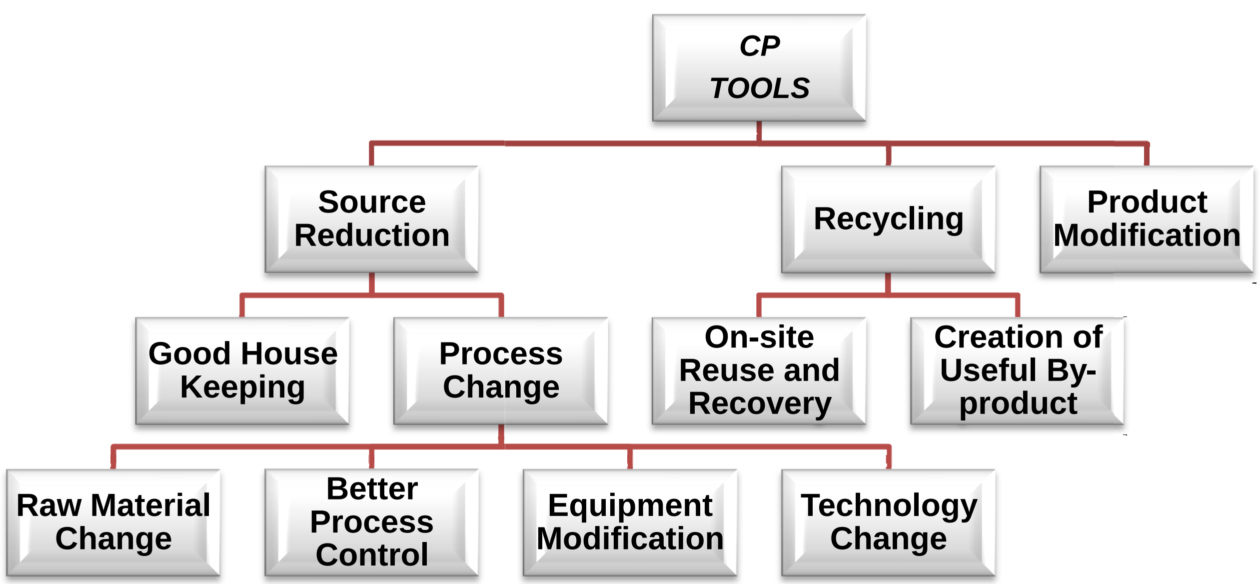
Achievement of GCPC:

- Established as an Environment cell of Gujarat Industrial Development Corporation (GIDC).
- MOU executed with National Productivity Council for carrying out Demo Project with GCPC.
- **Functioning as an** Environmental Information System (**ENVIS) Centre on the subject area "Cleaner Production and Technology"** of MoEF, Government of India (GoI).
- Declaration of CP Scheme under Industrial Policy 2004.
- Up gradation from ENVIS Node to ENVIS Centre.
- CP included in Curriculum of Graduate & Post Graduate Studies.
- Workshop on CII and Canadian Government for Developing Successful CDM Projects in India.
- Government of Gujarat published a GR No. GID-102007-2561-G dated 12th Feb, 2008 and established GCPC as a separate Society under Society Act 1860 and Public Trust Act 1950.
- Declaration of CP Scheme under Industrial Policy 2009.
- MoU between GIZ, UNIDO, GIDC and GCPC for 'Planning and Development of Eco Industrial Park in Gujarat' (Case study of Naroda and Vatva).
- Publication of Book on CP Concepts and Case studies.
- MOU between GIZ and GCPC for Pilot Projects and Capacity Building on Eco Industrial Development in Gujarat.
- Regular Member of RECP Network of UNIDO.
- Setting up of Training Centre at GCPC.

Further Initiatives:

- Taking more CP Assessment Projects covering all sectors of industries.
- Creating a network of trained personnel to continuously interact with the Industries on the Techniques of the Cleaner Production and operate as their consultants suggesting solutions for Cleaner Production.
- Creating a legislative framework for setting up an Authority for Accrediting Certifying Bodies.
- Creating agencies of the trained personnel for regular Inspection of certified units.
- Assisting in getting Financial Assistance for the New Technology Adoptions in terms of soft loans from financial institutions.
- To work as a facilitator for CT assessment/ Technology Transfer.

CP Tools:



CP Methodology:

1. **Getting Started**

** Make CP Team
** List Process Steps
** Identify Wasteful Process

2. **Analysis Process Steps**

** Process Flow Steps
** Material and Energy Balance
** Assign Cost to Waste Stream
** Identify Cause of Waste

3. **Generating CP Opportunities**

** Develop CP Opportunities
** Select Workable Opportunities

4. **Selecting CP solutions**

** Technical Feasibility
** Economic Feasibility
** Environmental Aspects
** Select Solutions

5. **Implementation**

** Prepare for Implementation
** Monitor and Evaluate Results

6. **Maintaining CP**

** Sustain CP

Case Study:

1. **Climate Change Vulnerability Assessment in Industries**

Pilot Study on "Climate Change Vulnerability Assessment in Industries" Under the ASEM Programme of the Indo German Development Cooperation, GIZ has initiated a pilot study on "Climate Change Vulnerability Assessment in Industries" in Gujarat. The study has been taken up for selected industries in Naroda Industrial Estate located near Ahmedabad main city.
The study has been taken up through the Gujarat Cleaner Production Centre (GCPC) during
November 2011 under technical guidance from Adelphi, Germany. The purpose of the study undertaken for identified industries in the Naroda Industrial Estate near Ahmedabad in the state of Gujarat was to assess vulnerability of industries to climate change on a case study basis so as to establish the relevance to industries, as well as test and establish a methodology for further replication in other industrial areas.

During the study, it has been observed that in past forty years, Gujarat has experienced 12 years of drought and four major scarcity situations and that the intensity and return period of major drought events have increased substantially in last couple of decades. Also, it is observed that there would be a general increase in rainfall over western part of the India with more intense rain events. This may possibly be correlated to the climate change. The need was seen to study systematically the impact phenomenon, especially on to industries and industrial areas.

The potential direct and indirect losses to industries are summarized in Table below.

Potentail Direct and Indirect Losses to Industries from Climate Change

Direct Losses	Indirect Losses
Primary Direct Losses	**Primary Indirect Losses**
Physical damage to buildings	Loss of production due to direct damages
Physical damage to production equipments	Loss of production due to infrastructure disruptions
Physical damage to raw material	Loss of production due to supply chain disruptions
Physical damage to product in stock	
Physical damage to semi-finished products	
Physical damage to control installations	
Physical damage to service installations	
Secondary Direct Losses	**Secondary Indirect Losses**
Secondary hazards and damages (e.g. due to explosions)	Market disturbances (e.g. from higher prices for raw materials)
Costs for remediation and emergency measures	Decreased competiveness
	Damage to company's image
	Extra labour for process recovery

The study carried out by GCPC included the following main steps:

- Training to GCPC team by GIZ experts on climate change adaption and mitigation, vulnerability risk assessment grid, past and future impact assessment in industries.
- Identification of volunteering climate sensitive industries (upto 5 nos.)
- Undertaking assessment in the identified industries
- Report preparation and Stakeholder dialogue

The three industries initially selected included one industry each from Dyes & Dye Intermediate, Textiles and Chemical sector. These industry sectors are strongly dependent on the energy, water and transportation and on workers as well, and these factors are highly vulnerable to climate change.

For the Vulnerability-Risk Assessment (VA) of selected industries, a self-explanatory assessment matrix for the selection of sectors relevant for the Naroda Industries Association was used.

A standard format for questionnaire sheet was prepared to assess the impact on:

- Infrastructure
- People
- Process
- Market
- Logistics stocks
- Finance

Data was collected through field visit to the industries. After having a good conception of the topic, the literature review was carried out to have a better understanding of the problems, and thus the methods and approaches to be used were decided. The problems in and around the study area were analyzed and accordingly countermeasures were framed depending on the availability of the data.

On assessing the data collected, the following reactive adaptation measures were identified:

Vulnerable sources	Reactive Adaptations	Anticipatory Adaptations
Water Resources	▪ Protection of groundwater resources ▪ Improved management and maintenance of existing water supply systems ▪ Protection of water catchment areas ▪ Improved water supply ▪ Groundwater and rainwater harvesting and desalination	▪ Better use of recycled water ▪ Conservation of water catchment areas ▪ Improved system of water management ▪ Water policy reform including pricing and irrigation policies ▪ Development of flood controls and drought monitoring
Energy Resources	▪ Improved energy supply ▪ Increasing energy efficiency by proper measures like putting machine on invertors	▪ Better use of recycled energy ▪ Developing the efficiency of machines ▪ Use of renewable sources

		at maximum extent
Human health	▪ Public health management reform ▪ Improved housing and living conditions ▪ Improved emergency response	▪ Development of early warning system ▪ Better and/or improved disease/vector surveillance and monitoring ▪ Improvement of environmental quality ▪ Changes in urban and housing design
Transportation	▪ Use of electric or compressed natural gas based vehicle or Hybrid vehicle ▪ Implementation of vehicle emission standard ▪ Executive employees use public transportation	▪ Focusing on mode switching and other behaviors affecting transportation ▪ Encourage the use of Cleaner alternative fuel

The assessment of vulnerability to climate change is designed to provide critical information for adaptive management, including planning, development actions as well as conservation initiatives.

2. Cleaner Production Implementation in Textile Sector:

Option No: 1 WATER RECYCLING in Jet Dyeing Machine & Recycling and Reuse of water in printing Machine.

Cost Analysis:

- Investment: Nil
- Saving: 618,050 Rs
- Payback Period: Immediate

Environmental benefits:

- It reduces the consumption of fresh water.
- It also reduces the energy consumption.

Option No: 2 Fuel switch over change- the fuel from lignite to biomass.

Cost Analysis:

- Investment: 888,850 Rs

Environmental benefits:

Biomass fuels produce virtually no sulfur emissions, and help mitigate acid rain.

Biomass fuels "recycle" atmospheric carbon, minimizing global warming impacts since zero "net" carbon dioxide is emitted during biomass combustion, i.e. the amount of carbon dioxide emitted is equal to the amount absorbed from the atmosphere during the biomass growth phase.

Biomass combustion produces less ash than coal and reduces ash disposal costs and landfill space requirements. The biomass ash can also be used as a soil amendment in farm land.

Option No:3 Provide Invertor on Different Machine.

Cost Analysis:

- Investment: 1,111,150 Rs
- Saving: 8,159,900 Rs

- Payback Period: 1.7 Months

Environmental benefits:

It result in energy saving.

Option No: 4 Provide A.C Invertor in Jet Dyeing Machine.

Cost Analysis:

- Investment: 33,350 Rs
- Saving: 61,250 Rs
- Payback Period: 6.5 months

Environmental benefits:

It result in energy saving.

Option No: 5 Reduce raw water tapping in Jiggers, J.T 10, MERCERIZER, SOAPER.

Cost Analysis:

- Investment: Nil
- Saving: 234,700 Rs
- Payback Period: Immediate

Environmental benefits:

It results in water and energy saving

Option No: 6 Batch washing instead of countineous washing of fabrics in Jets.

Cost Analysis:

- Investment: Nil
- Saving: 98,900 Rs
- Payback Period: Immediate

Environmental benefits:

It results in water and energy saving.

Option No: 7 Provide A. C. Invertors on Fans of Stenter- Chambers.

Cost Analysis:

- Investment: 333,350 Rs
- Saving: 493,350 Rs
- Payback Period: 8.1 Months

Environmental benefits:

It result in energy saving.

Option No: 8 Replace existing Chocks with Electronics Ballast.

Cost Analysis:

- Investment: 41,700 Rs
- Saving: 140,600 Rs
- Payback Period: 3.6 Months

Environmental benefits:

It result in energy saving.

Option No: 9 Replace existing tube Lights with energy efficient Metal Halide Lamps.

Cost Analysis:

- Investment: 133,350 Rs
- Saving: 237,750 Rs
- Payback Period: 6.7 Months

Environmental benefits:

It result in energy saving.

Option No: 10 Implementation of COLD PAD BATCH DYEING.

Cost Analysis:

- Investment: 888,900 Rs
- Saving: 683,350 Rs
- Payback Period: 15.4 Months

Environmental benefits:

It reduces the pollution load by 50% because; earlier the dye fixation of mono-functional dye is very less as compared to current bi-functional dye. Therefore, unfixed dye is going into final effluent.

Option No: 11 Use of BI-FUNCTIONAL DYE inplace of REACTIVE DYE.

Cost Analysis:

- Investment: Nil
- Saving: 257,500 Rs
- Payback Period: Nil

Environmental benefits:

By adopting this process, steam and pollution load reduced by 50%.

Option no: 12 Energy Conservation in Lighting System- Switch off Tube Lights during day time.

Cost Analysis:

- Investment: Nil
- Saving:6,650 Rs
- Payback Period: Immediate

Environmental benefits:

Energy Saving and GHG Reduction.

Option No: 13 Energy Conservation in Lighting System- Replacement of Conventional 36W & 40W Tube Lights by 28W Tubes with Electronics Ballast.

Cost Analysis:

- Investment: 159,500 Rs
- Saving: 23,750 Rs
- Payback Period: 8 Months

Environmental benefits:

Energy Saving and GHG Reduction

Option No: 14 Replace D.C. Motors by A.C. Motors with Variable Frequency Drive for main and mangle motors in Stenter.

Cost Analysis:

- Investment: 77,800 Rs
- Saving: 95,500 Rs
- Payback Period: 10 Months

Environmental benefits:

Energy saving and GHG Reduction.

Option No: 15 Installation of Economizer on Boiler.

Cost Analysis:

- Investment: 444, 800 Rs
- Saving: 444,450 Rs/annum
- Payback Period: 12 Months

Environmental benefits:

Reduction in Energy uses.

Optimized and more efficient operation of Boiler leads to reduce GHG emission.

Option No: 16 Improving Power factor by Installing Capacitor.

Cost Analysis:

- Investment: 20,000 Rs
- Saving: 14,700 Rs
- Payback Period: 16 Months

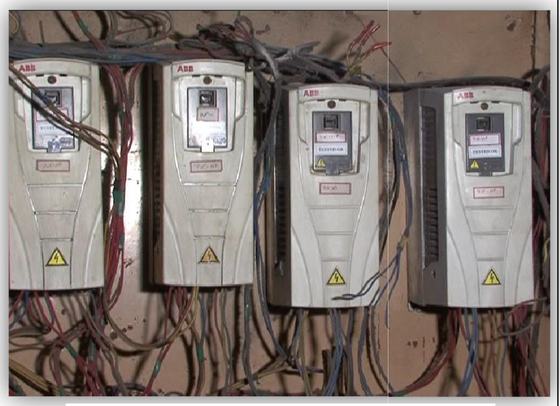
Environmental benefits:

There are no immediate environmental benefits because increasing the power factor does not result in reduced electricity consumption. However, it contribute to a reduced need to construct a new power station, and this brings benefits to the environment in the long term.

- Photographs of some implemented options in Textile Sector:

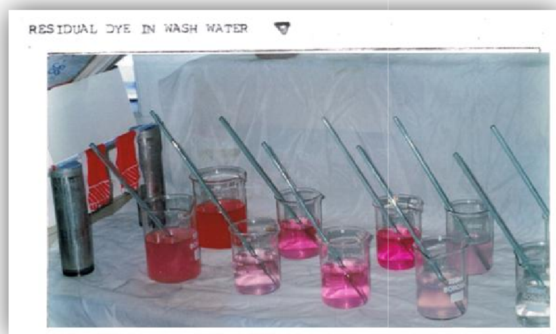
Water recycling in Jet Dyeing

Fuel Switch-over- Lignite to biomass

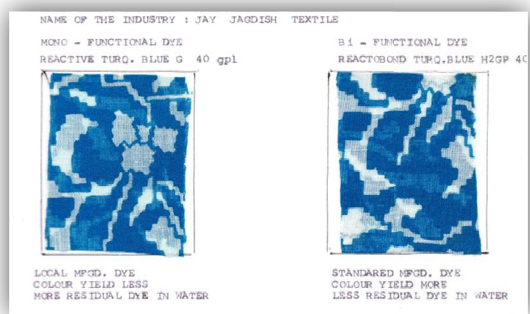


Installation of Invertors

Batch washing in Jet Dyeing Machine



Use of Bi and Poly functional Dye in place of Mono functional dye.



Use of Bi and Poly functional Dye in place of Mono functional

3. CHEMICAL SECTOR

GCPC has worked on implementation of Cleaner Production in Chemical Sector in Gujarat. During the project, various options of Cleaner Production Tools like Good House Keeping, Input Material Change, Onsite Recycling, Better Process Control, Equipment Modification, By-Product Recovery and Technology Change were suggested to the industries.

Following Cleaner Production Options were recommended:

- **GOOD HOUSE KEEPING**

SR NO	CP OPTION
1.	To optimize the wash water so as to reduces the quantity of the wastewater
2.	Training of operator and worker
3.	Maximum water should be removed from the cake at a neutch filter only so that cake is not in slurry form.
4.	Smooth flooring of this area for the collection of spillage
5.	To plan the production activity of the derivatives so that vessel washing cycle can be minimized
6.	To elevate the exhaust of the tray dryer so that moist air can be dispersed away from the dryer
7.	To collect this small quantities from all drums manually in bigger drum and use the same
8.	Operator training to minimize spillage by way of proper maintenance of the filtration equipment
9.	To provide adequate spillage collection system
10.	To use high purity raw materials so that minimum isomers are left out as a distillate residue

11.	Timely repair/sealing of water and steam leakages from pipes, valves, flanges etc.
12.	Installation of appropriate chutes to collect screening rejects.
13.	Covering all granular/ powdery material transfer systems and storage tanks by proper lids
14.	Control of leakages and spillages in the handling and preparation of chemicals and additives.
15.	Proper collection and storage systems for rejects from raw material preparation
16.	To Clean the ice and SPCP bags before use.
17.	To use hopper for charging Phthalic anhydride.

- INPUT MATERIAL CHANGE

SR NO	CP OPTION
1.	Application of Anthraquinonesas pulping additive
2.	Using Poly-Aluminium Silica Sulphate instead of Alum
3.	Substituting existing dyes with less toxic dyes
4.	Substituting chlorine based bleaching by chlorine free bleaching
5.	Selecting high quality raw materials
6.	Use better quality of Iron for reduction to reduce consumption

- ON SITE RECYCLING

SR NO	CP OPTION
1.	Chrome recovery from waste tanning liquor
2.	Recycling couch decker filtrate in pulp washing
3.	Condensate recovery and reuse in boiler house
4.	Reusing exhausted dye liquor
5.	Print paste recovery from textile printing belts
6.	Recovery of bath solution in drag out tanks in electroplating
7.	To purify sulphuric acid and recycle partially to process to match water balance
8.	To concentrate a spent acid to 63% and recycle to process as a raw material
9.	Recover Phase Transfer catalyst by R & D work
10.	Recovery of the organic mass from the carbon by providing washing.
11.	To collect and purify sulfanilic acid.

- BETTER PROCESS CONTROL

SR NO	CP OPTION
1.	To use hot alkaline wash water to neutralize acidity as fast as possible. This shall reduce quantity of wash water
2.	Optimization of water quantity to reduce quantity of the aqueous phase without affecting separation of both phases
3.	To provide uniform mixing and heating at the reduction stage of the process to avoid formation of tar and isomers
4.	Controlled water pressure for edge cutting nozzles on paper machine
5.	Optimization of pulp cooking process
6.	Provision of fuel feed controller mechanism in boiler
7.	Preventive maintenance for main components of plant equipment and utility systems
8.	Preventing over drying
9.	Improving incoming materials control
10.	Change the method of operation so that methanol does not go along with other impurities
11.	Change the method of operation to eliminate this high COD stream
12.	To carry out sulphonation with sulphur trioxide and avoid generation of spent acid.
13.	Optimize the usages of NaOH & KOH as per the stochiometry.
14.	Use of vacuum in neutch filter.

- EQUIPMENT MODIFICATION

SR NO	CP OPTION
1.	Installation of level controllers
2.	Consistency indicator in pulp feeding to paper machine
3.	Provision of high velocity hood in steam dryer for cloth/paper
4.	Double felting to reduce press pickling
5.	Proper insulation of all steam and condensate pipes, tanks, valves, flanges etc...and digesters
6.	Rationalization of steam, condensate and water lines
7.	To carry out washing of the vessels with pressurized water so that minimum water is used
8.	Use pump with longer siphon/suction pipe
9.	To modify the design of vessels so as to clearly identify the inter face during the gravity separation of the both phases
10.	Install screw type feeder on the reactor for caustic flakes feeding which is open from top for caustic flakes addition.
11.	Installation the Neutch filter under the dumping vessel so that transformer can be eliminated.
12.	Use of Agitated neutch filter in place of neutch and centrifuge.
13.	Timer on centrifuge.
14.	Use of Chilling plant & Jacked vessel for neutralization.
15.	Use of larger size of centrifuge to conserve the time and material losses due to repeatedly handling of material.

- TECHNOLOGY CHANGE

SR NO	CP OPTION
1.	U-Tube Jet Dyeing instead of winch dyeing
2.	Hot stock refining
3.	Falling film evaporators instead of multi effect evaporators
4.	Vacuum drum washers (counter current operation)
5.	Enzymatic de-hairing
6.	Counter current reactive rinsing
7.	Cold pad- batch dyeing
8.	Miscella refining for edible oil processing
9.	Change reduction process to catalytic hydrogenation or use of some other reducing agent

- BY PRODUCT RECOVERY

SR NO	CP OPTION
1.	Recover Aq. phase as KCl solution as by-product to use in other industry for salting out operation
2.	Use iron sludge for by-product such as ferrous sulphate and filler in brick
3.	Recover the methanol by circulating more chilled water
4.	Recovery of sodium chloride & salting it as byproduct.
5.	Separation of sodium sulphite and potassium sulphite as by product.
6.	Solar evaporation of effluent and Recovery of the salt.
7.	Separated plant for the waste treatment and recovery of salts as byproduct.

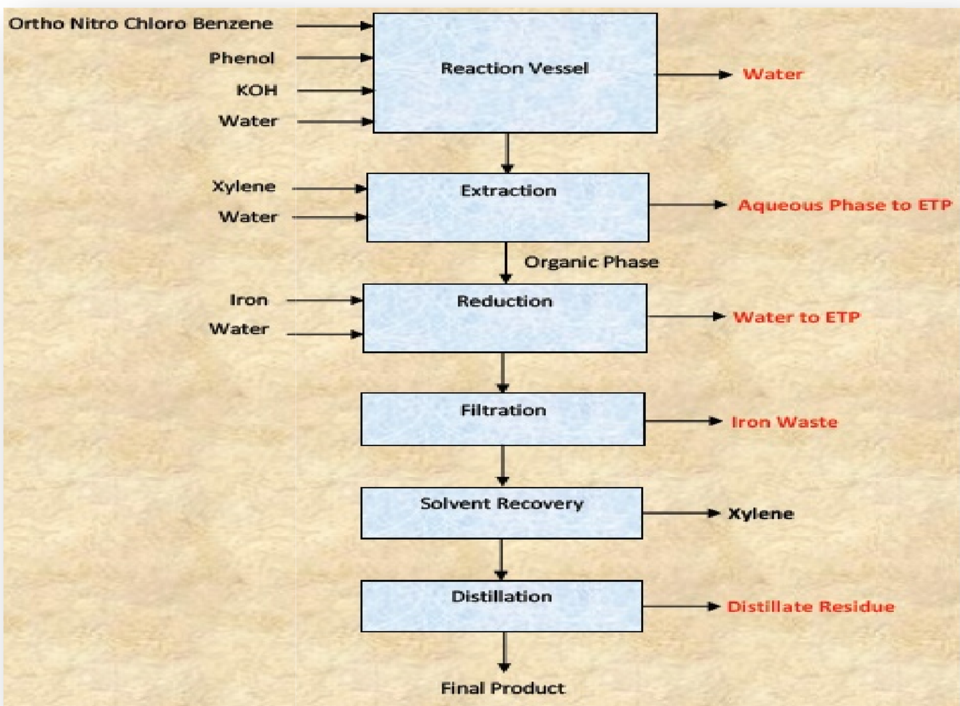
- **USEFUL BY-PRODUCTS**

SR NO	CP OPTION
1.	Application of black liquor
2.	Application screening rejects inboard manufacture
3.	Preparation of utensils cleaning powder from waste liquor of klier
4.	Use of cloth rags for mattress making
5.	Use of cashewnut – shell oil as coating for corrosion prevention
6.	Reuse of the filtrate of tartrazine production

Case Study – Amino Diphenyl Ether

The CP assessment unit manufacturing Amino Diphenyl Ether as a main product, unit located at GIDC, Sachin, Surat. In order to select audit focus area a walk through survey in the industry was conducted to know about the process and operations and also to identify major waste streams. During walk through survey following major waste streams were observed as showed in Block diagram in red color.

Manufacturing Process:

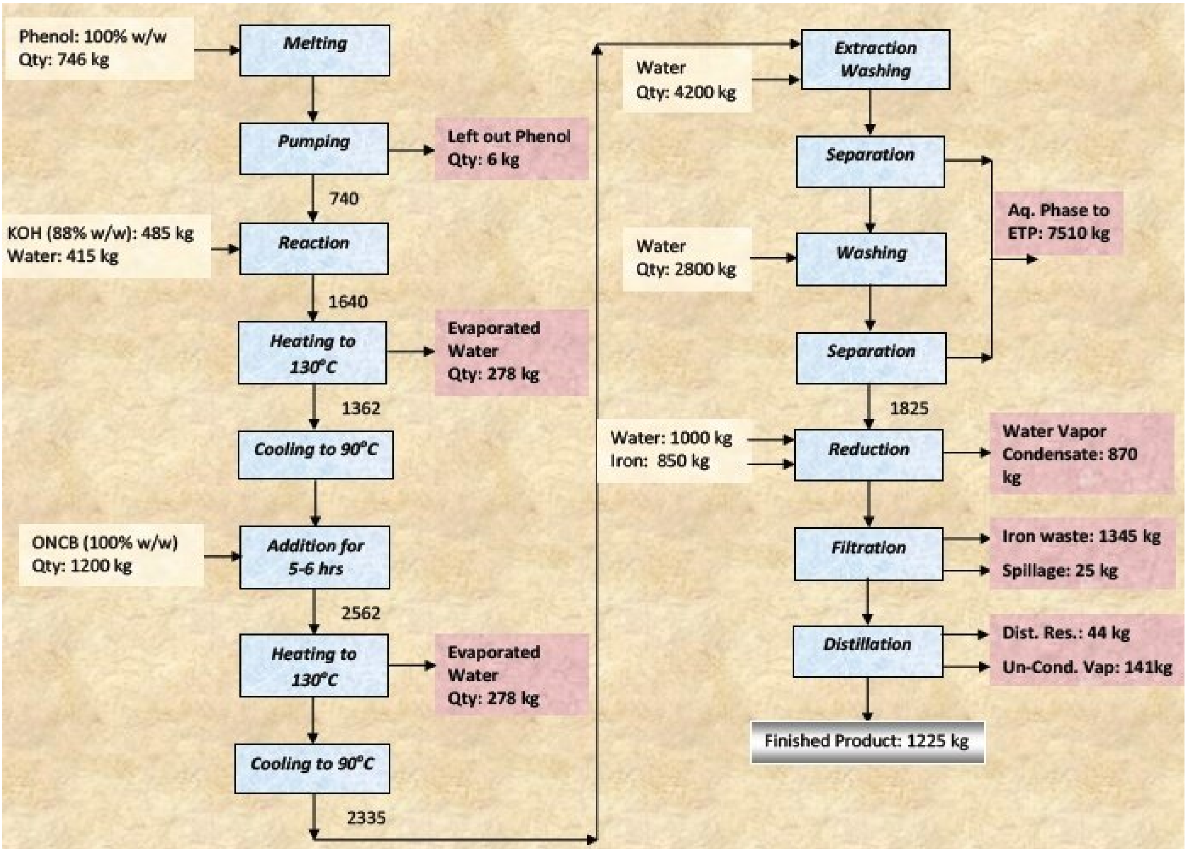


Observations:

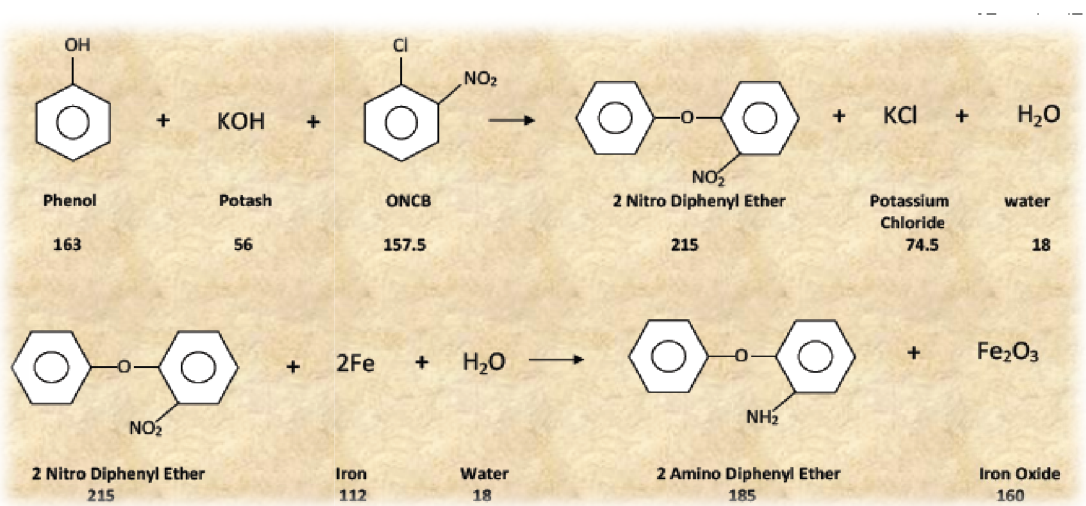
Waste stream no	Description of waste stream
1	Aqueous inorganic salt stream
2	Distillate residue
3	Waste Water effluent

4	Solvent loss
5	Iron waste

Material Balance:



Chemical Synthesis:



Component Balance:

Batch Wise Quantity; Basis: Kg/ Batch	Composition	Amount (Kg)
RAW MATERIAL		
Phenol	100 %	746
ONCB	100 %	1200
KOH KOH Water	88 % 88 % 12 %	485 426.8 58.2
Iron	100 %	850
Water	100 %	8415

Batch Wise Quantity; Basis: Kg/ Batch	Composition	Amount (Kg)
WASTE STREAMS		
Aqueous stream KCl & Other Inorganic Water Organic	8.34 % 89.34% 1.82 %	7510 626 6747 137
Left out phenol in drum		6
Iron Waste Inorganic Water Organic	86.84 % 8.92 % 4.24 %	1345 1168 120 57
Spillages During Filtration	Calculated	25
Distillate Residue		44
Evaporated Water		505
Condensed Water		865

Un condensed Water vapor	Calculated from water balance	141

Waste Stream Characterization and Cost Assignment:

Sr. No	Waste Stream	Quantity Kg/batch	Characterization of Waste Stream		Cost Assigned Rs/batch
1.	Left out phenol in drum	6	N/a	100 %	270
2.	Evaporated water during heating – 1	278	pH: 8.2 COD: 42 mg/l	100 %	8
3.	Evaporated water during heating – 2	227	pH: 7.8 COD: 24 mg/l	100 %	7
4.	Aqueous phase after extraction	7510	pH: 7.8 COD: 14230 mg/l TDS: 8345 mg/l	KCl & other inorganic: 8.34 % Organic: 1.82 % Water: Balance	14129
5.	Water vapor condensate during reduction process	865	pH: 7.2 COD: 15 mg/l	-	-
6.	Iron waste from reduction process	1345	Moisture: 6.4% Loss on ignition: 3.7% Balance: inorganic	Inorganic: 86.84% Water: 8.925 Organic: 1.82%	12764
7.	Spillage during iron sludge filtration	25	NA	-	-
8.	Distillate Residue	44	Moisture: Nil Loss on ignition: 99.97% Balance: Inorganic	Organic: 100%	2244

Cause Analysis and CP Opportunities:

Sr. No.	Cause	Sr. No.	CP Options
Waste Stream no. 1: Left out phenol in the drum			
1.1	Ignorance on the operator part	1.1.1	Operator training
1.2	Not possible to remove balance phenol from drum by pumping	1.2.1	To collect this quantities from all drums manually in bigger drum and use the same
		1.2.2	Use pump with longer siphon/ suction pipe
Waste Stream no.2: Evaporated water during Heating - 1			
2.1	Process requirement to remove water by heating	2.1.1	Recover this water by condensing and recycle for other purpose such as floor washing etc.
Waste Stream no.3: Evaporated water during Heating – 2			
3.1	Process requirement to remove water by heating	3.1.1	Recover this water by condensing and recycle for other purpose such as floor washing etc.
Waste Stream no.4: Aqueous phase after extraction			
4.1	Process requirement of separation of aqueous and organic phase after extraction/ washing of inorganic phase with water	4.1.1	Optimization of water quantity to reduce quantity of the Aq. phase without affecting separation of both phases
		4.1.2	To modify the designs of vessel so as to clearly identify the interface during the gravity separation of both the phases
		4.1.3	Provision of second stage of separation vessel can also be considered
		4.1.4	Recover Aq. phase as KCl solution as by-product to use in other industry for salting out operation
Waste Stream no.5: Water vapor condensate during reduction			
5.1	Water part available in the reduction mass is converted to vapor which is condensed in condenser	5.1.1	To collect condensate and recycle back to process or other applications
Waste Stream no.6: Iron waste from the reduction process			
6.1	Use of iron in the process for the reduction step of the process	6.1.1	Use better quality of Iron for reduction to reduce consumption

		6.1.2 6.1.3	Change reduction process to catalytic hydrogenation or use of some other reducing agent Use iron sludge for by-product such as ferrous sulfate and filler material in brick.
Waste Stream no.7: Spillage during iron sludge filtration			
7.1	Spillage during filtration of iron sludge in filter press after reduction is completed	7.1.1 7.1.2 7.1.3	Operator training to minimize spillage by way of proper maintenance of the filtration equipment To provide adequate spillage collection system To use alternative filtration equipment to minimize spillage
Waste Stream no.8: Distillate residue			
8.1	Distillation of product as final purification step results in isomers/ tar/ impurities as distillation residue at the bottom of distillation column	8.1.1 8.1.2	To use high purity raw materials so that minimum isomers are left out as distillate residue To provide uniform mixing and heating at the reduction stage of the process to avoid formation of tar and isomers

Conclusion:

Most of the options are directly implementable which requires fewer modifications. The cost associated with modifications is negligible in compared to its savings. Implemented options results in good financial saving but on the same side it also reduces its environmental impact and load on Effluent Treatment Plant.