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STUDY ON PROTOTYPE WASTE MINIMISATION DEMONSTRATION PROJECT IN CLUSTERS OF SMALL-SCALE INDUSTRIES

NC/PAK/92/041

PAKISTAN

Report*

Prepared for the Government of Pakistan
under UNDP-financed TSS-1 facility

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The preparation of this report was coordinated by the Industrial Sectors and Environment Division. It is based on the work of Mr. Ralph A. Luken, Senior Environmental Adviser, Environment and Energy Branch, Messrs. Terry Foecke and Darrell J. Reeve, international experts, and Hagler Bailly Pakistan, a national consulting firm.

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Exhibits

The POWERS project

(Process Optimization through Waste and Energy Reductions in Small-Scale Industries)

EXECUTIVE SUMMARY

The purpose of the POWERS project was to introduce the waste minimisation approach to one small-scale industry sector in Pakistan and to create conditions for continuing and expanding waste minimisation after the project was completed. There were four separate, but closely interrelated, objectives:

- to demonstrate to one sub-sector of Small-Scale Industries (SSIs) in Pakistan that waste minimisation is possible in the short-term and has financial and environmental benefits;
- to identify barriers to the introduction and sustainability of waste minimisation and to formulate strategies for overcoming them;
- to design, on the basis of the above, a cleaner production programme, including training activities, that would service several sub-sectors and geographic areas;
- to recommend other measures that are needed to promote cleaner production in Pakistan.

Waste Minimisation

Cleaner production can be defined as "the continuous use of industrial processes and products to prevent the pollution of air, water and land, to reduce waste at the source and to minimize risk to human populations and the environment.

With a view to facilitating the acceptance of the cleaner production concept and methodologies by entrepreneurs, the term *waste minimisation* was adopted rather than *cleaner production*. The interpretation given to waste minimisation is, however, essentially equal to the one given to cleaner production above.

Waste minimisation is best practiced by reducing the generation of waste at the source itself. After exhausting source reduction opportunities, attempts should be made to recycle waste within the production unit. Finally, one might think of modifying or reformulating the product itself so as to be able to manufacture it with minimal waste generation.

Workplan

The project was carried out in four phases. Phase One was an introductory workshop at the Gujranwala Chamber of Commerce and Industry for plant personnel from ten plants in the sanitary fixture and textile dyeing and finishing sectors. Phase Two was conducting a waste reduction audit at four sanitary fixture plants. Phase Three was identification of low- and no-cost measures at these four plants. Phase Four was implementation of some of the measures at two of the plants.

Results

The four participating plants identified and evaluated a total of 15 different waste minimisation options, most of which were applied to each plant. The options were classified into two main categories -- raw materials/chemicals and energy. The nature and complexity of the options ranged from comparatively simple improvements of housekeeping practices and repair of leaks to relatively radical technology changes.

The environmental benefits of the raw material/chemical options is significant (57 per cent categorized "high") when compared to the energy options (none categorized as "high"). Also, the payback period for the raw material/chemical options is more attractive (on average 0.60 year) than the energy options (on average 1.18 years).

The implementation status of the 15 options at the end of the project is disappointing with only two plants implementing measures. Only 20 per cent were implemented and 21 started during the lifetime of the project. Another 46 per cent are planned and 13 per cent rejected. The implementation and start of the options was less than anticipated because only two of the four plants participated in the project to its end and there were interruptions in the technical services provided by the international and national consultants to the plants.

Constraints

The main constraints that need to be dealt with in an effort to foster implementation of waste minimisation in small-scale industries are essentially the same as found in other countries in the region. These are attitudinal, systematic, organizational, technical, economic and governmental constraints. This categorization is, however, not always unequivocal; barriers encountered in a company might be the result of a number of coinciding constraints.

Conclusions

1. There are many opportunities for waste minimisation in the sanitary fixture sub-sector and presumably in other sectors as well. These can be detected by making an integral analysis of the company, including - but not limited to - its production processes, input materials, waste streams and emissions.

2. Waste minimisation is much broader than technical modifications. It can be achieved by improvement of operating practices, changes of input materials and recycling practices.

3. Many of these waste minimisation opportunities can be implemented by the sanitary fixture sub-sector and presumably other sub-sectors within the short term (one to two years).

4. The implementation of waste minimisation options will benefit sanitary fixture plants. These benefits include monetary savings as well as less tangible benefits, such as improvement of working conditions, improvement of product quality and improvement of local environmental conditions around the plants.

5. For a waste minimisation effort to be successful, it must systematically and comprehensively address potential constraints. The experience of the project shows that intensive guidance and company-specific supervision by outside trainers cum consultants can eliminate a number of constraints and thus foster waste minimisation.

Recommendations

1. A National Cleaner Production Centre (NCPC) should be set up in Pakistan along the lines of those being supported by UNIDO/UNEP. The NCPC would be a coordinating and catalytical focal point for cleaner production. It would provide technical advice, support factory-level demonstrations of cleaner production techniques and technologies, conduct training programmes for industry and government staff and advise governments on policies that would encourage cleaner production. Preferably, the NCPC would be located in an existing industrial trade association/chamber of commerce and industry or industrial productivity centre. it would be staffed by experienced country nationals who would be advised by international experts.

2. A centralized laboratory for testing of metals should be established in Gujranwala. The lack of quality control of brass is one of the major reasons for waste in the sub-sector. Although such a public sector testing facility exists in Lahore, the participants in the project reported that the laboratory could not produce timely analyses. Given the high costs in setting up such a laboratory, it should be jointly funded by industry associations and the government.

1. Introduction

1.1 Background

Environmental protection makes the production of goods and services more costly and is, therefore, a luxury developing countries cannot afford, is a theory deeply rooted in industrial as well as environmental management agencies and industries in developing countries (and only to a lesser extent in developed countries). The invalidity of such an argument was reaffirmed by the United Nations Conference on Environment and Development (UNCED), held in Rio de Janeiro in June 1992, which established new goals for the world community involving environmentally benign forms of development. Cleaner production not only contributes to the sustainable forms of economic development endorsed in Agenda 21, but also minimises the need to compromise between economic growth and environment, between worker safety and productivity, and between consumer safety and competition in international markets.

Optimising several goals at the same time in this way leads to the ideal 'win-win' situations where all stand to gain. Such a strategy serves to protect the environment, the consumer and the worker while improving industrial efficiency, profitability and competitiveness. Cleaner production can prove particularly attractive to developing countries because it provides industries for the first time with an opportunity to 'leap frog' over older, more established industries. Countries following this strategy will be able to reap the benefits of an opportunity which for once favours development in poorer countries over the already industrialised.

The primary model for this study is the PRISMA project undertaken in the Netherlands. This project worked with ten small- and medium-sized firms over a period of two years and successfully demonstrated the financial and environmental advantages of waste minimisation. The study identified 164 prevention options of which 60 were implemented during the life of the project. The majority of these preventive solutions were cost effective and with pay back periods of less than three years. The mode of implementation consisted of a small group of firms that applied the techniques of waste auditing (a systematic approach to waste and emission reduction) to their own establishments with assistance from consultants.

Although pollution from individual Small-Scale Industries (SSIs) may not create significant environmental damage, their collective discharge in medium-sized cities and industrial estates does pose a severe threat to human health and environment. This study was sponsored by UNIDO to prove that considerable scope exists for demonstrating the financial and environmental benefits of waste minimisation to SSIs in Pakistan. A cluster of sanitary fittings manufacturers located in the Gujranwala area were selected for this purpose, i.e. regarding waste reduction audits (WRAs). After successful application in one area, this approach could be adopted by the industry itself and applied to other industrial sectors and geographic areas within the country.

1.2 Waste Minimisation

Over the last few decades, industries have responded to environmental degradation in four typical ways: ignoring the problem, diluting pollution, controlling or treating pollution, or preventing pollution and waste generation at the source of production. The last activity has become the ultimate goal of cleaner production or waste minimisation. It combines maximum positive effects on the environment with substantial financial gains for industry and society. As such, cleaner production can be defined as "the continuous use of industrial processes and products to prevent the pollution of air, water and land, to reduce waste at the source and to minimise risk to human population and the environment" (UNEP, 1994). Essential features are:

1. **Cleaner production is a problem–solving strategy rather than a solution:** cleaner production puts the waste generating process (the root problem) in first place and employs a preventive mind-set to develop alternative solutions. A variety of technical, operational, educational and managerial practices can be used to this end, but not exclusively to this end, which goes to show that cleaner production cannot be considered as a fixed set of solutions and technologies.

2. **Cleaner production is 'built-in' instead of 'added on' to industrial activity:** cleaner production requires the integration of environmental concerns into the design and operation of industrial activity, being either the delivery of products or the application of processes. For products and services, it aims at a reduction of the environmental impacts along the entire life cycle of the product, from raw material extraction through materials processing, product manufacturing, trade and consumption, to disposal of the discarded product. For processes, cleaner production aims at conserving raw materials and energy, eliminating the use of toxic materials and reducing the quantity and toxicity of all emissions before they leave a process.

With a view to facilitating the acceptance of the cleaner production concept and methodologies by entrepreneurs, the term 'waste minimisation' was adopted rather than 'cleaner production'. The interpretation given to waste minimisation is, however, essentially equal to the one given to cleaner production above.

Waste minimisation is best practised by reducing the generation of waste at the source itself. After exhausting source reduction opportunities, in the second step attempts should be made to recycle waste within the unit. Finally, one might also think of modifying or reformulating the product itself so as to be able to manufacture it with minimal waste generation.

Waste minimisation thus includes the following eight techniques:

1. **Good housekeeping:** appropriate provisions to prevent leaks and spills (such as preventive maintenance schedules and frequent equipment inspections) and to enforce existing working instructions through proper supervision, training etc.

2. **Input material change**: substitution of input materials by less toxic or renewable materials or by adjunct materials with a longer service lifetime.

3. **Better process control:** modification of working procedures, machine instructions and process record keeping in order to run higher processes with a higher degree of efficiency and lower waste end emission generation rates.

4. **Equipment modification:** modification of existing productive equipment and utilities – for instance, by the addition of measuring and controlling devices – in order to increase efficiency as above.

5. **Technology change:** replacement of technology, processing sequences and/or synthesis pathways in order to minimise waste and emission generation during production.

6. **On-site recovery and reuse:** reuse of waste materials within the same process or company.

7. **Production of useful by-products:** modification of the waste generation process in order to transform waste material into material that can be reused or recycled for applications outside the company.

8. **Production modification:** modification of product characteristics in order to minimise the environmental impacts of a product during or after its use (disposal) or to minimise the environmental impacts of its production.

Exhibit 1.1 contains illustrative examples for each waste minimisation technique in the small scale sanitary fittings manufacturing industry in Pakistan.

1.3 Objectives

In proving the merits of a waste minimisation approach to the industry and formulating a program that could be implemented, there are four main objectives involved:

- To demonstrate to one sub-sector of Small-Scale Industries (SSIs) in Pakistan that waste minimisation is possible in the short-term and has financial and environmental benefits;

- To identify barriers to the introduction and sustainability of waste minimisation and to formulate strategies for overcoming them;

- To design, on the basis of the above experience, a cleaner production programme, including training activities, that would service several sectors and geographic areas;

- To recommend other measures that would promote cleaner production in Pakistan.

1.4 Workplan

This study was conducted in the following four phases:

Phase 1: A workshop was organised to introduce pollution prevention to plant personnel from 10 plants in the sanitary fixture sectors and textile dyeing and finishing sectors. It combined lectures and discussions with personal participation in a waste reduction audit (including identification and analysis of pollution prevention options) at one plant.

Phase 2: Five plants were selected for the purpose of this study. Waste reduction Audit (WRA) teams were formed and WRA conducted at only four plants because one declined to participate despite initial confirmation..

Phase 3: Low- and no-cost waste minimisation techniques and technologies were introduced in four plants with the advice from programme advisors.

Phase 4: A demonstration project of the recommended measures in two plants was carried out with the help of UNIDO consultants.

1.5 Project Organisation

The study was funded by the United Nations Industrial Development Organisation (UNIDO) and completed in close collaboration with the Ministry of Industries, Government of Pakistan. UNIDO provided the services of international experts and a national consulting firm.

The responsibilities of UNIDO in this study were:

- to organise the demonstration project;
- to provide experts from the organisation and other international and national experts;
- to provide specific sectoral advice;
- to evaluate the results of the case study;
- to design follow-up projects.

International experts were provided by UNIDO to give technical advice and to supervise the field work of the local consultants. A national counterpart in the MOI was also engaged by UNIDO to solicit industry participation in the project, to involve other government agencies in the effort and to participate in the workshops and comment on the project reports.

A national consulting firm worked under the guidance of UNIDO and the international experts to:

- collect and analyse data for waste audits;
- assist UNIDO staff and the international expert with the introductory workshop;
- monitor the progress of the participating plants in implementing waste minimisation measures;
- assemble the data for the final report.

Exhibit 1.1: Examples of the Waste Minimisation Techniques

Waste Minimisation Technique	*Examples*
1. Good housekeeping	• Repair all leaks. • Keeping taps closed when not in use. • Avoid spillage.
2. Input material change	• Use alkaline water based degreasers instead of organic solvent for metal parts cleaning.
3. Better process control	• Adoption of better firing practices in down draught kilns. • Maintain process parameters (temperature, pressure etc. as close as possible to the desired level with basic minimum instruments.
4. Equipment modification	• Install drip hangers to recover drag out from plating operations. • Use of storage tanks of appropriate capacity to avoid overflows.
5. Technology change	• Apply static rinse instead of continuous rinse in electroplating. • Apply electrostatic spraying techniques to minimise paint over-spray.
6. On-site reuse	• Reuse used moulding sand for the preparation of new moulds.
7. Product reformulation or modification	• Eliminate excessive product packaging.

2. Constraints, Catalysts and Enabling Measures[1]

2.1 Introduction

The implementation of waste minimisation requires a shift in the way environmental factors are dealt with at the company level. Instead of dealing with environmental problems after wastes and emissions are generated, a proactive approach should be developed in which environmental concerns are integrated into the design and operation of industrial activity, thereby avoiding waste generation in the first place. International experiences, however, show that the development of such proactive approaches is hampered by a number of constraints whether economic or technical.

The main constraints that need to be dealt with in an effort to foster the implementation of waste minimisation in SSIs are discussed systematically here. The findings have been organised in seven major groups:

1. Attitude constraints;
2. Systemic constraints;
3. Organisational constraints;
4. Technical constraints;
5. Economic constraints;
6. Governmental constraints.

This categorisation is, however, not always unequivocal; barriers encountered in a company might be the result of a number of coinciding constraints. The above sequence reflects to some extent, the sequence in which barriers are often encountered in practice in the course of the implementation of waste minimisation in a particular company.

In each of the subsequent sections, a division can be made between constraints, catalysts and enabling measures. The constraints are the factual barriers that emerged in the preparation and implementation of the project. Catalysts refer to specific circumstances that were encountered in one or a few of the participating companies, which greatly helped in overcoming one or several interrelated constraint. The enabling measures refer to generic approaches which can be adopted in general by the industry to facilitate the identification, evaluation and implementation of waste minimisation options.

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[1] This is related to the report *Study on Cleaner Production Techniques and Technologies covering Clusters of Small-Scale Industries in Selected Areas* prepared by UNIDO for the Government of India under UNDP-financed TSS-1 project NC/IND/92/032

2.2 Attitudinal Constraints, Catalysts and Enabling Measures

Although attitudes disregarding the need for waste minimisation are common, they are seldom, if ever, based on practical experience or real cost estimates and are therefore perfect examples of attitudinal barriers inhibiting the entrepreneur from undertaking waste minimisation activity. Attitudinal constraints often remain unrecognised in the first place. Further study shows that various obstacles, even though formulated in financial or technical terms, are in fact attitudinal. In the project, therefore, emphasis was given to the introduction of the waste minimisation concept.

The project revealed that attitudinal constraints in SSIs tend to be of two sorts:

1. Indifference towards housekeeping and environmental affairs, particularly with regard to family run enterprises, and a general sense of unawareness warrants inefficiency and mismanagement, and that too is taken for granted as an inevitable part of industrial operations.

2. Resistance to change is essentially rooted in the reluctance to experiment where this involves the possibility of failure. Waste minimisation techniques represent a deviation from what is tried and tested.

2.2.1 Catalysts

In order to ease these attitudinal constraints, the study team decided to try and activate the following catalysts as part of the waste minimisation project in each company:

1. **Early success with waste minimisation:** since early successes might encourage management as well as operators and supervisors to continue experimentation with waste minimisation, the waste minimisation assessments in the companies were aimed at the identification of obvious, no-and-low-cost waste minimisation options in the first place. Such no-and-low-cost options often consisted of the elimination of lapses in housekeeping, maintenance and process control, which could easily be identified during the first joint visits of the national and international experts to the company and which had obvious financial pay–offs. These positive experiences then paved the way for more detailed data gathering and analysis and the development of more complex, and often higher cost, waste minimisation options.

2. **Employee involvement in waste minimisation:** given the need to change operators' and supervisors' attitudes, full attention was given to involving employees right from the start. While doing so, it was found that in many cases employees were willing to accept and implement changes if the benefits were properly explained and illustrated.

2.2.2 Enabling measures

With a view to the dissemination of waste minimisation practices, the following enabling measures have been proposed in order to deal on an on-going basis with the attitudinal constraints in SSIs:

1. **Encourage experimentation especially with no-and-low-cost options:** resistance to change should be gradually eliminated, which might call for specific, on-the-spot guidance and instructions for experimentation with modifications of working procedures, alternative raw or auxiliary materials etc. In order to minimise risks, waste minimisation practices, such as improved housekeeping and process optimisation, can gradually be extended on the basis of the lessons learnt and experience gained.

2. **Publicise early waste minimisation successes:** it is recommended that both the financial and the environmental benefits of the early waste minimisation successes be emphasised in order to create an awareness of the need for waste minimisation among the entire workforce and to sustain commitment and involvement from the key decision-makers or owners.

2.3 Systemic Constraints, Catalysts and Enabling Measures

In the absence of production monitoring data and routine procedures for analysis and evaluation of such data, waste minimisation auditing is deemed to end in tedious discussions. Data collection and the development of information systems within the company are the obvious remedial actions. For the entrepreneur, the financial benefits of avoiding production record-keeping may outweigh the obvious advantages of appropriate data collection and evaluation for the purposes of production process optimisation.

Although the collection of baseline data is an important starting point for the development of waste minimisation activities, it is often not necessary to do so until obvious lapses in housekeeping and equipment maintenance have been eliminated. Generally speaking, it makes far more sense to repair, for instance, a leak than to monitor the water or steam losses caused by the leak. Since it was anticipated that lack of documentation and reliable records would be a major obstacle towards waste minimisation in the project, provisions were made for on-the-spot monitoring of energy, water and materials consumption, productive output, wastes and emissions.

Systemic constraints in SSIs can be grouped as:

1. The general lack of professional management skills, particularly in family-run enterprises, implies that owners are seldom qualified decision-makers or supervisors and are more concerned with their day-to-day working schedule rather than with a more long term reduction of production costs.

2. Low quality production records, day-to-day production schedules and the absence of record keeping seriously hampers data analysis and evaluation and, consequently, the systematic identification of waste minimisation options and assessment of the impact of implemented measures.

2.3.1.1 Catalysts

In the course of the company level waste minimisation audits, the study team found that certain companies with distinct features dealt far better with initiating waste minimisation processes. Such systemic catalysts encompassed:

1. **Proper documentation and planned layout:** Previously, the design, procurement and installation of productive equipment would take place in far too haphazard a manner, following the entrepreneur's perceived business opportunities and supplier preferences, with little or no comparative evaluation of different technical opportunities or planning of the equipment layout.

   The result was inefficient plant layout and sub optimal dimensioning of various parts of the productive equipment and utilities. It was encouraging, however, to note that most of the participating units realised the shortcomings of such an approach and had improved the preparation and documentation of their latest revamp and capacity expansion projects. This documentation served as excellent starting material for collection and evaluation of the necessary data for waste minimisation assessments.

2. **Proper housekeeping and maintenance provisions:** Although generally imperfect or incomplete, some companies had made good progress in developing housekeeping controls and inspections of incoming goods, materials utilisation etc. Generally, companies with in-house maintenance and basic fabrication facilities were ahead of companies which had to rely on outside contractors for equipment maintenance and revamping.

2.3.1.2 Enabling Measures

With a view to the dissemination of waste minimisation practices, the following enabling measures deal with systemic constraints:

1. **Training of plant level waste minimisation team:** It is highly recommended that a training session be conducted to clarify the objectives of waste minimisation in the first place, i.e., the reduction of environmental impacts through improvement of production efficiency. In addition to this, it should illustrate the importance and benefits of planned production and the need for the collection and evaluation of realistic production records. Finally, problem-solving approaches, preferably with an example from within their own company (such as lapses in housekeeping or maintenance) should be illustrated. The best results are to be expected if key decision-makers and owners as well as shop floor supervisors participate in such training sessions.

2. **Development of simple management indicators:** In the absence of professional management skills, simple indicators should be developed in order to enable management and supervisors to regain control over production processes and to minimise wastage of materials, water and energy. Indicators as simple as input material and water and energy consumption per unit of productive output might be sufficient to illustrate the benefits of improved housekeeping and initiate ongoing efforts in this field. The control parameter should fit the basic production processes, and the level of detail should, in principle, meet the level of detail of the existing accounting systems in the company.

3. **Top-down housekeeping drive:** As proven through the experience of those companies which started with the introduction of housekeeping controls, housekeeping will only improve once key decision-makers take the lead. This can be done by pinpointing, on a routine basis, lapses in housekeeping (such as leaking equipment and pipes, material spills etc.) and following up on the elimination of these lapses. In addition, shop floor managers and supervisors should provide a intervene suitable example by refraining from intervening in the execution of the production process, for instance by forcing workers to deviate from standard production procedures in order to increase production output with a possible loss of product quality.

4. **Dissemination of success stories:** Waste minimisation success stories will always encourage general awareness and interest. Such examples should be well documented with "before waste minimisation" (baseline) and "after waste minimisation" (accomplishment) financial as well as environmental figures in order to pinpoint the crucial role of accurate information systems in achieving waste minimisation. Sectoral as well as generic manuals and workshops can contribute to the dissemination of such information.

2.4 Organisational Constraints, Catalysts and Enabling Measures

The organisational structure of the company may tend to hamper the introduction of proactive environmental management practices. In this context, it is essential to assess how the tasks and responsibilities with regard to production management and environmental issues are divided up in the company and to suggest changes favouring waste minimisation. Companies were encouraged to involve shop floor supervisors and technical staff members in the project team, which in turn cooperated with the outside consultants.

The experiences in the participating companies illustrate that the organisational constraints can best be categorised under three separate, but strongly interrelated, organisational features of SSIs:

1. The concentration of decision-making powers with the owner of an enterprise allows no motivation or incentive towards commitment to new projects, such as waste minimisation, among indifferent employees. This lack of involvement, coupled with a high turnover of technical staff, allows little of the experience gained in waste minimisation to be sustained within the firm.

2. The strong emphasis on increasing production ignores the greater degree of depreciation of capital and machinery, particularly since employees tend to be paid on a production of output basis.

2.4.1.1 Catalysts

In the course of the project, the study team found that some of the participating companies had developed certain effective mechanisms to cope with limitations stemming from the company's organisational structure. These were:

1. **Family supervision:** Huge differences existed in both the level and the quality of the involvement and supervision of owners and their families in the daily operation of the companies. For companies with technically qualified owners, who lived next to or on factory premises, it proved to be easier to organise waste minimisation efforts effectively. Apparently, technically qualified owners receive greater satisfaction from optimising production than do non-technically qualified owners who cooperate with chartered engineers and consultants in running the production.

2. **Sharing of information on costs etc.:** Information-sharing proved crucial in almost all company level assessments. Within the company, sharing of cost data between managers and operators encouraged operators to work more carefully with high-cost materials. On the other hand, sharing of information on perceived causes of equipment failure or off-specification products among operators and between operators, supervisors and technical staff enabled problem-solving approaches to eliminate waste generation causes. Moreover, it was found that to some extent, information on cost-effective waste minimisation opportunities could be shared among companies.

2.4.1.2 Enabling Measures

On the basis of the experiences in the project, the following enabling measures are recommended in order to deal with the organisational constraints in SSIs:

1. **Organisation of a capable project team:** A capable and well-organised waste minimisation team is vital for the development of waste minimisation assessment as well as minimisation in the elimination of numerous constraints. It should, however, be kept in mind that it is not always easy to establish such an effective team, given the constraints discussed earlier. A balance has to be found between the preferred situation with a properly functioning project team being able to develop and implement waste minimisation on its own, and the present situation which inhibits the delegation of any decision-making power and blocks creative problem solving. In this perspective, a team leader with the authority to implement at least low- and no-cost waste minimisation measures, should be selected. Also, efforts should be undertaken to involve one or preferably a few of the most concerned supervisors and operators (shop floor workers) in the waste minimisation team.

2. **Recognition for waste minimisation efforts:** Once the team has started with the identification and evaluation of waste minimisation opportunities, steps should be taken to encourage the team. To this end, various schemes might be put in practice, like public recognition, rewards, publicising early successes etc.

3. **Assigning costs to production and waste generation:** In order to expand the scope from just production output to more comprehensive control over the efficiency of production, it is necessary to assign costs to the different production factors and waste streams. Comparatively simple calculations of the monetary value of the raw materials, chemicals and products lost with a particular waste stream normally encourage managers to take action.

2.5 Technical Constraints, Catalysts and Enabling Measures

Waste minimisation is essentially equal to environment-driven optimisation of the use of technology. Consequently, waste minimisation requires technical changes to installations, tools, input materials, auxiliaries, processes and equipment. Given this important role of technology in the implementation of waste minimisation, technical factors often emerge as constraints to waste minimisation. However, upon secondary analysis, technical constraints put forward in the course of the waste minimisation assessment can often be resolved through technology management rather than technology as such. Since it was anticipated that technical obstacles could have a destructive impact on the success of the project, provisions were taken to provide proper technical backup by both domestic and international experts.

Technical constraints in SSIs, therefore, include:

1. **Limited technical capabilities:** The lack of technical manpower and monitoring facilities meant that participating companies strongly relied upon the technical expertise of the NPC, which in turn had to expand the envisaged level of technical assistance to each. Moreover, with facilities and personnel adequate only for routine maintenance, major maintenance jobs, including machine overhaul, motor rewinding etc., all essential in waste minimisation, have to be entrusted to external firms which are expensive and time-intensive.

2. **Limited access to technical information:** Generally SSIs have limited access to information and technical literature on low resource consuming and low waste techniques within the country. The information available from abroad is neither directly relevant nor tailor-made to the technical status and size of operations involving SSIs in Pakistan.

3. **Technology limitations:** There has been no specific technology development for this sector. Old discarded technology is merely cut to fit on a trial and error basis, resulting in inefficient, sub-optimal equipment and consequently higher waste generation.

2.5.1.1 Catalysts

Several of the companies participating in this project possessed a comparatively skilled technical staff and/or in-house fabrication facilities which enhanced their progress. The following illustrates these interrelated technical catalysts:

1. **Technically skilled staff:** Given the need to improve the operation and management of the production technology, companies with technically skilled staff members had less trouble initiating the waste minimisation process. In general, such staff members had already taken the lead in their company in trying to develop quality assurance policies and tools and/or started to experiment with, for instance, the use of alternative chemicals or raw materials. Being open to new ideas such as the concept of waste minimisation, they proved their ability to transfer the general working method to the specific circumstances in their own company.

2. **In-house fabrication facilities:** Given the tradition in SSIs of developing and modifying production equipment from old discarded equipment, experience and expertise have been gained in finding smart, but simple, technical solutions for problems encountered in the operation of the previously discarded equipment. Those companies using in-house fabrication facilities (mechanical, electrical or civil workshops) possessed such experience and expertise, and could employ this in order to identify appropriate waste minimisation solutions or to modify suggested improvements from the outside expertise into such solutions.

2.5.1.2 Enabling Measures

The technical constraints discussed above are not specific to waste minimisation only. These inhibit any innovation in SSIs being in favour of product quality improvement, production expansion, energy conservation etc.. Therefore, most general measures undertaken to improve the technical skills and capabilities for SSIs will also favour waste minimisation. These might include technology development, demonstration and diffusion projects, technical training and building an infrastructure for technical support to SSIs. In addition to these generic enabling measures, the following can be recommended to specifically foster waste minimisation:

1. **Dissemination of waste minimisation techniques and technologies:** Given the prevalence of the Not Me First syndrome, wherein people would be willing to be the second person to try an idea provided it has been successfully implemented elsewhere, dissemination of success stories of waste minimisation techniques and technologies could be a very powerful instrument to abate existing technical constraints. The publication of technical waste minimisation manuals as well as the organisation of workshops and seminars are valuable starting points. However, it should be kept in mind that numerous SSIs are difficult to reach since, by themselves, they do not read technical literature nor consult technical service institutes. Therefore, intermediary organisations, like small industries service institutes, professional organisations, industry associations and probably even equipment suppliers, should become involved in delivering the successful waste minimisation techniques and technologies to the companies.

2. **Need-based support for environment-driven R&D:** There are obvious areas in which state of the art technology is not yet able to prevent environmental problems at typical production scales for SSIs. In order to eliminate these technology and technique gaps, R&D support could be useful. This support, however, has to meet the needs of SSIs (to fit to the existing technical status, size and investment capabilities of SSIs) and integrate minimisation of the environmental burden as one of the development objectives in the technical research.

2.6 Economic Constraints, Catalysts and Enabling Measures

Although the project proves the validity of the waste minimisation adage 'from waste to profits', economic constraints can still hamper the development and implementation of waste minimisation in companies. This is essentially so because resources (staff time, monitoring efforts, etc.) have to be invested up front in the waste minimisation assessment, without knowing exactly what financial benefits (input cost reduction, production expansion, product quality improvements, etc.) can be gained from doing so. The project team came across four types of economic constraints:

1. **Prevalence of production quantum over production costs:** This continual preference of output production over cost reduction tends to carry great weight when trying to obtain management commitment and involvement in the execution of a waste minimisation assessment.

2. **Resource pricing and availability:** Prevailing low prices and abundant availability of natural resources such as water etc. in most areas dampen the impetus for identifying and implementing waste minimisation measures.

3. **Ad hoc investment policy:** Limiting economic analysis to obvious direct costs and benefits on the basis of direct financial returns and short term financial gains implies that the benefits accruing from reduced pollution control costs and electricity savings are given little significance. Furthermore, small scale entrepreneurs with a very limited supply of capital tend to prefer those measures that are least capital intensive, which, more often than not, are less likely to have much scope for the relatively expensive process of waste minimisation.

4. **Capital availability and costs:** Most financial institutions have not evinced interest in financing cost-intensive waste minimisation measures having longer pay back periods (over one year). Even if financing were available, high interest rates (market rates vary from 15 to 20 per cent) do not render major waste minimisation investments as viable options.

2.6.1.1 Catalysts

The extent to which each of the above economic constraints actually played a role in each company depended to a large extent on the financial position of the company at the start of the project and the ability of the waste minimisation team to identify financially attractive options. In the company selection and in the assistance to the companies, attention has been given to exploit each of these economic catalysts:

1. **Financially sound companies:** Since it is evident that financially sound companies are less vulnerable to the economic constraints, the perceived financial soundness of the companies has been used as one of the criteria for the company selection. Accordingly, in each sector at least two companies participated in which capital viability for implementation of waste minimisation would not be a major problem given the proven economic feasibility of the proposed waste minimisation measures.

2. **Financially-attractive options:** Since it had been recognised in the preparation of the project that the implementation of financially-attractive waste minimisation options could be a strong catalyst for waste minimisation, the assistance to the companies has been focused on the identification of waste minimisation options requiring low to medium investments and having obvious financial returns. The implementation of such low– and no-cost, highly cost-effective waste minimisation options is thought to pave the way for the implementation of selected higher cost options in the near future.

2.6.1.2 Enabling Measures

The experience in the project lead to the identification of the following measures to enable companies to deal with the economic constraints for waste minimisation:

1. **Proper cost allocation and planned investments:** Awareness of costs due to waste seems to be a crucial starting point for any company level waste minimisation effort. To be able to illustrate the potential for savings from waste minimisation, one needs to prepare an estimate of the costs of various components in a waste stream (e.g. energy, raw materials, water, product). Once different components and their cost have been allocated, it becomes easier to assign cost to a waste stream. Estimating the savings arising out of minimising or eliminating the waste stream becomes simpler. Such an exercise also helps in making the entrepreneur realise how much he is losing through the drain. In addition, it may be useful to merge waste minimisation in the overall investment plan, because the additional costs for waste minimisation might be much lower once waste minimisation is included in an overhaul or capacity expansion plan than when implemented on its own.

2. **Long-term industrial policies:** The Government should avoid making frequent changes in the industrial policies, because such changes sustain short-sighted investment planning in SSIs. Declaration of long-term industrial policies would help the industries in merging waste minimisation into the investment planning and in taking suitable steps to be more and more competitive without artificial fiscal protection.

3. **Financial incentives:** Special financial schemes might have a huge impact on the capital cost and availability of SSIs for waste minimisation investments. To foster the implementation of high-cost waste minimisation options, financial schemes could be developed by government or donor agencies which give priority to waste minimisation proposals over end-of-pipe proposals. To suit SSIs, such schemes should be procedurally simple and easily accessible. In addition, fiscal incentives can be created for waste minimisation. These might include automatic capacity enhancement, preferential purchase in the government sector, a 100 per cent depreciation allowance on investments in waste minimisation etc.

2.7 Governmental Constraints, Catalysts and Enabling Measures

Government policies affect company decision-making, and might thus either hamper or incite companies to adopt waste minimisation. With a view to fostering waste minimisation, industrial and environmental policies are expected to be most effective. In each of these policy areas legislative initiatives are developed which require training and institutional capacity building – both within the industrial community within various governmental organisations – in order to be effectively implemented and enforced. Although neither industrial nor environmental policies have been assessed in full detail as part of the project, a preliminary inventory of government constraints and incentives has been made on the basis of the experiences within the companies. The following summarises the major findings, which to some extent overlap with the results discussed above on each of the themes within the companies.

2.7.1 Industrial Policies

Frequently changing industrial policy is not conducive to waste minimisation efforts. With such uncertainties, industries are not willing to implement long- or even medium-term waste minimisation measures. In addition, incentive schemes like concessional corporate tax, a 100 per cent depreciation allowance for pollution control measures etc. are not yet available for waste minimisation.

2.7.2 Environmental Policies

Regulatory authorities still emphasise exclusively achieving stipulated environmental discharge standards. No weight is given to reduction of the generation of waste. The entrepreneurs, therefore, prefer using conventional end-of-pipe control practices which satisfy the regulatory authorities rather than adopting waste minimisation practices which are open to question by the authorities. Another area not yet covered by environmental regulations is utilisation of ground water, which is a major industrial resource for numerous industry sectors. The price of ground water is based on the pumping cost and a nominal tax. This is far too low to justify financial returns even from low-cost water conservation measures.

2.7.2.1 Catalysts

Given the limited pressure from governmental authorities on industries to reduce their environmental waste, it was very promising to note that a number of the participating companies had already taken self-responsibility and showed serious commitment to improve the environmental performance of the operations. The reasons for such self-responsibilities differed from company to company. In the participating textile dyeing and printing companies, the self-responsibility was most profound and based on concerns for future supply of soft water for the sector and the growing concerns among foreign consumers about possible residues of health-threatening chemicals in clothing. In pesticides formulation, the environmental concern seems to be a positive spin-off from occupational health and safety concerns. In the pulp and paper industry, the location of the industry played a major role, with the mills located in residential areas showing more commitment to environmental improvement than those located outside residential areas.

2.7.2.2 Enabling Measures

In the preceding sections some guidance has been given on how to develop governmental policies favouring waste minimisation in SSIs, such as the improvement of managerial skills etc. In addition, the following measures could be adopted by the Government to encourage waste minimisation:

1. **Area-wide, voluntary waste minimisation groups:** The Government could set the stage for area-wide voluntary waste minimisation groups by providing funds for the expenses to run such groups and creating conditions to exploit their achievements. The expenses include, for instance, the cost of publication of newsletters and other documentation, contribution to the costs of implementation of innovative waste minimisation options, the costs of technical support, the cost of study tours etc. In order to avoid undertaking similar initiatives by different waste minimisation groups in different parts of the country, there exists the need for a national coordination and information exchange mechanism, which in turn could be used by other agencies, like industry association, small industry service institutes, professional organisations and schools, banking and financing institutes and pollution control boards.

2. **Enforcement of environmental legislation:** Since numerous SSIs do not yet feel the need to undertake action to protect the environment or bear any pollution control cost, there is a serious need to improve the enforcement of environmental legislation. Although numerous suggestions can be made to improve environmental legislation in order to make it more waste minimisation oriented, it is felt that enforcement of existing environmental legislation will be more effective in fostering waste minimisation in the short term. Unless enforcement is taken seriously, entrepreneurs will not perceive the need to include environmental concerns in their business activities.

3. Financial and Environmental Dividends in Companies

3.1 Introduction

This chapter contains the comparative analysis and evaluation of the results – the concrete waste minimisation measures identified and implemented – that have been achieved in the sanitary fittings manufacturing sector covered by the project. The results will be reviewed against the hypotheses put forward at the start of the project. These were:

- There are *many opportunities* for waste minimisation in SSIs. These can be detected by making an integral analysis of the company, including – but not limited to – its production processes, input materials, waste streams and emissions.
- Many of these waste minimisation opportunities can be implemented by SSIs within the *short term* (within 1 to 2 years).
- Waste minimisation goes *beyond technical modifications*; it can also be achieved by improvement of operating practices, changes of input materials and recycling practices.
- The implementation of waste minimisation will *benefit the company*; these benefits will include monetary savings as well as less tangible benefits, such as improvement of working conditions, improvement of product quality and improvement of the local environment around the facility.

In the following section, process description of sanitary fittings, participant of the project and specific waste minimisation measures relevant to this sector and their potential impacts are discussed in brief.

3.2 Sanitary Fittings Industries

Nearly 75 per cent of the metallic raw material comprises scrap brass. The remaining one-fourth consists of brass sheets, rods and pipes; copper pipes; zinc ingots and nickel plates. The principal source of waste in the sanitary fittings manufacture is the electroplating process. Liquid effluent from the plating shop contain nickel and chromium metal in substantial quantities. Apart from causing a financial loss to the industrialist, the effluent is also a serious threat to the environment. Extended exposure to nickel and chromium metals is known to be injurious to human and animal health, and crops. Another environmental and health hazard is posed by the mist rising from the chromium plating bath. In addition, the industry is highly energy and water intensive. Air emissions include dust from raw material preparation and stack emissions from the furnaces.

Sanitary manufacturing consists of the following process areas:

Raw Material: Scrap brass is available from several sources. One form, commonly known as *Jahazi Purza,* is obtained from the ship-breaking yard at Gadani Beach in Baluchistan. Another source is ammunition scrap from Wah Ordinance Factory located approximately 50 kilometres from Islamabad. Brass is also purchased from local scrap dealers which consists of machinery parts, utensils, sanitary ware and other junk pieces. Given this variety of sources, the quality control of brass is a common problem faced by the casting unit. No facilities for testing the alloy composition are available in Gujranwala. The company has to rely on the experience of the casting supervisor for obtaining the desired composition. Another problem associated with the use of scrap brass is the metallic contamination of electroplating baths.

Moulding: Raw brass is moulded into shape in steel and sand casts. Zinc is occasionally added to improve quality. Brass filings from later stages are recycled. Charred sand is the major waste product.

Brass Extraction: Settling tanks are used to extract brass chips from the charred sand. The residual sand is sold to the local dealers for further extraction of brass.

Refining: Products from moulding shop are refined by trimming and machining. Other machining processes such as threading and boring take place during this stage.

Surface preparation: Grinding, polishing and buffing of the surface takes place in this stage. Emery powder and organic polishing compounds are used. Principal waste is the dust containing emery, glue and brass.

Electroplating: Nickel, chromium and copper electroplating takes place in this stage. Inorganic and organic plating compounds are the principal inputs to this process. Effluent from the shop contains heavy metals.

Acid treatment: Surface appearance of the brass products which are not electroplated are improved by dipping them in successive tanks of nitric, sulphuric and hydrochloric acids. Rinse water from the shop is drained into the local sewage system.

Packaging: Finished products are assembled, and cleaned and packed for shipment. Wooden crates, thermopore material and paper are used in the process.

Waste minimisation can be applied to each of these process areas, as illustrated in **Exhibit 3.1.**

The following industries were selected for participation in the project:

1. M/s. Faisal Sanitary Fittings Industries (Private) Ltd.;
2. M/s. Anwar Industries (Private) Ltd.;
3. M/s. Bajwa Industries (Private) Ltd.;
4. M/s. Super Asia Hi-Class Sanitary Fitting; and
5. M/s. Master Industries (Regd.).

Master Industries did not participate in the project despite initial confirmation. The unit was, therefore, left out from subsequent project activities. Although they initially agreed, Bajwa Industries and Super Asia Hi-Class Sanitary Fittings did not show interest in the project and were hesitant to provide any information about their production and material consumption. However, they were motivated again to participate in the project and draft reports for these two units (with a lot of data missing) were prepared and presented to these units. The remaining two plants, namely Anwar Industries and Faisal Industries, finally became the focus of the project because of their enthusiastic technical staff and the financial soundness. Therefore, final reports were prepared only for these two units and implementation of the proposed recommendations were carried out, mainly because of the visible successes in these units. The key findings at these two participating units are summarised in **Appendix A** and **B** of this report.

In each of the four participating plants, a total of 15 waste minimisation options were identified and evaluated. The nature and complexity of the options ranged from comparatively simple improvements of housekeeping practices and repair of leaks to relatively radical technology changes as shown in **Exhibit 3.2. Exhibit 3.3** reveals some basic facts about waste minimisation measures, implementation status, payback period and the environment and financial impacts on the sanitary fitting manufacturing industry. These measures have been classified into two main sections, i.e. raw materials/chemical and energy.

The environmental impact[2] of the raw material/chemical section is significant (57 per cent categorised 'High') when compared to the energy section (none categorised 'High'). In addition, the payback period for the raw material/chemical section is lower (0.6 years) than that for the energy section (1.18 years), which implies a higher return on investment in case of raw material/chemical options making them more financially attractive in comparison with energy options.

The present implementation status of all options is also depicted in **Exhibit 3.3**. Only 20 per cent of the options identified were implemented during the life of the project. A significant number of the options (46 per cent) are still in the planning stage and the management at the participating plants is considering incorporating them into their expansion plans. A comparatively small number of the options (13 per cent) were rejected due to management concerns, such as labour issues, non-availability of funds, etc. Finally, for about 50 per cent of the options planned for implementation, either more detailed technical and financial viability studies are needed or the management has yet to take them up for inclusion in the implementation programme.

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[2] The basis for classification of environmental impacts are:

High: Identified options have a direct and significant impact on prevention of environmental pollution
Medium: The options identified do not contribute significantly to prevention of pollution, but have associated hazards
Low: The options identified have very limited impact on environment and health

The categorisation of the options according to waste minimisation techniques is shown in **Exhibit 3.4a.** A large portion of these options (27 per cent) falls under the category of good housekeeping. Therefore, even an awareness of waste minimisation can play a significant role.

The waste minimisation efforts identified concentrated substantially on water-related environmental concerns: 40 per cent of the options are associated with minimisation of waste water discharges (see **Exhibit 3.4b**). Most of these options have other related environmental benefits, such as better raw material, chemicals, water and energy utilisation. The second largest share belongs to options aimed at minimisation of air pollution (33 per cent), and these reductions in air emissions can be achieved through improvements in the moulding process. Solid wastes have a small portion (27 per cent), as the recycling of solid waste is already being practised.

3.3 General Evaluation

In this section, some distinct features of the implementation of waste minimisation will be discussed as well as some general conclusions drawn.

3.3.1 Total Achievements

The participation in the project enabled all four companies to identify many different waste minimisation options which, to a large extent, could be implemented over the course of the project. A large share of the options could be implemented within 12 months of the start of the plant-level waste minimisation activities.

The implementation of these waste minimisation measures has contributed significantly to environmental improvement in areas such as the following:

- Minimisation of waste water discharges (both in volume and pollution load);
- Minimisation of air emissions (from furnaces as well as fugitive emissions from materials handling and processing);
- Minimisation of solid waste generation;
- Conservation of materials, energy and water;
- Reduction of the use of toxics;
- Minimisation of health and safety hazards (both at the shop floor level and in the direct vicinity of the plants).

Most options contribute to environmental improvement in several areas, such as material conservation and waste minimisation or water conservation and minimisation of waste water discharges.

Exhibit 3.1: Illustrative Waste Minimisation Measures for Sanitary Fittings Manufacturing Industries

	Waste minimisation technique	*Illustrative examples with associated benefits*
1.	Good housekeeping	▸ Closing water taps not in use in order to conserve water. ▸ Switching off extra lights to conserve energy ▸ Proper inspection and maintenance of machines, motors and pumps to avoid the breakdowns during operation. ▸ Efficient use of moulding furnaces through better management to optimise the production.
2.	Input material change	▸ Proper selection and thorough inspection of scrap brass to avoid rejections during machining and electroplating.
3.	Better process control	▸ Consistent use of the Hull cell can be the most useful for monitoring additive and contamination levels as well as overall performance characteristics of electroplating solutions provided their results are correlated with production experience. ▸ About 25% of total energy is consumed in pre-heating of the furnaces and 10% of total energy is consumed in holding of the molten metal within furnaces. Additional savings in fuel could be achieved by rescheduling of operations to operate the furnace for longer continuous periods.
4.	Equipment modification	▸ Addition of waste heat recovery unit on brass melting furnaces can minimise the input heat energy.
5.	Technology change	▸ Rinsing in the electroplating shop can be modified by incorporating vigorous agitation with the help of a pump to ensure the quality of the final product.
6.	On-site recycling	▸ The moulding sand should be reused. Sand can be recycled with an alternate composition consists of sand, bentonite clay, wood flour, graphite and water. ▸ Installing a simple scrubber on the top of the chrome bath in a hood can reduce the chrome waste up to 50% that can be recycled.
7.	Product reformulation	▸ Nitric, sulphuric, chromic and hydrochloric acids are used to improve the surface appearance of the brass products which are not electroplated. The rinse water containing heavy quantity of these acids and copper compounds are also discharged into the sewage system. This process should be stopped as it is not required essentially but is generating a lot of hazardous waste.

Exhibit 3.2: Waste Minimisation Measures for Sanitary Fittings Manufacturing Industries

Waste Minimisation Technique	*Option No.*	*Description*	*Associated Benefits*	*Type of Waste Generated*
Good housekeeping	1	Closing water taps not in use	To conserve water	Liquid
	2	Proper inspection and maintenance of machines, motors and pumps	To avoid the breakdowns	Gaseous, liquid and solid
	3	Cleaning of windows	To reduce the use of artificial light	Nil
	4	Rescheduling the furnace operating hours	To minimise the furnace heat losses	Gaseous
Input material change	5	Proper selection and thorough inspection of scrap brass	To avoid rejections during machining and electroplating.	Solid
	6	Rewinding of electrical motors with standard specification wire	To minimise the energy consumption of motors	Nil
Better process control	7	Consistent use of Hull cell	To purify and clean electroplating solution	Liquid
	8	Installation of sub-meters for major energy consuming equipment	To optimise the energy consumption by calculating the specific energy consumption	Gaseous, liquid and solid
	9	Modified rinsing in the electroplating shop	To recapture the metals and to reduce the water consumption	Liquid
Equipment modification	10	Installation of waste heat recovery unit on brass melting furnaces	To minimise the input heat energy	Gaseous
Technology change	11	Replacement of failed electrical motors with high efficiency motors	To reduce the electrical consumption	Nil
	12	Replacement of incandescent lamps which are used for more than 8 hours per day with the new energy saving lamps	To minimise the lighting load	Nil
On-site recycling	13	Recycling of moulding sand	To reduce the consumption of moulding sand	Solid
	14	Installing a simple scrubber on the top of the chrome bath in a hood	To reduce the chrome waste by recycling it	Gaseous
Product reformulation	15	Stop acid treatment on the brass products which are not electroplated	Reduces hazardous acid waste	Liquid

Exhibit 3.3: Summary of Results in Sanitary Fittings Manufacturing Industry

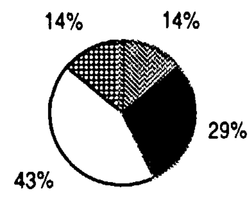
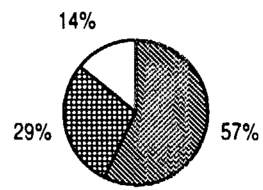
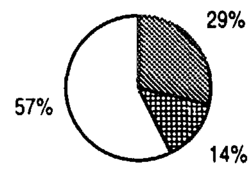
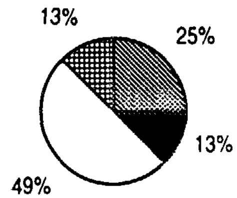
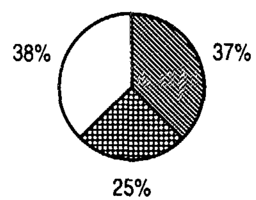
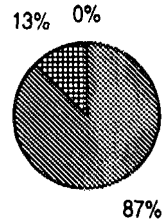
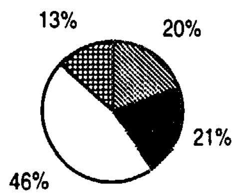
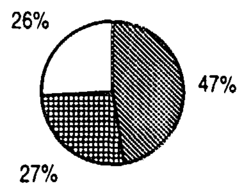
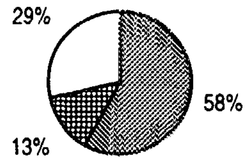
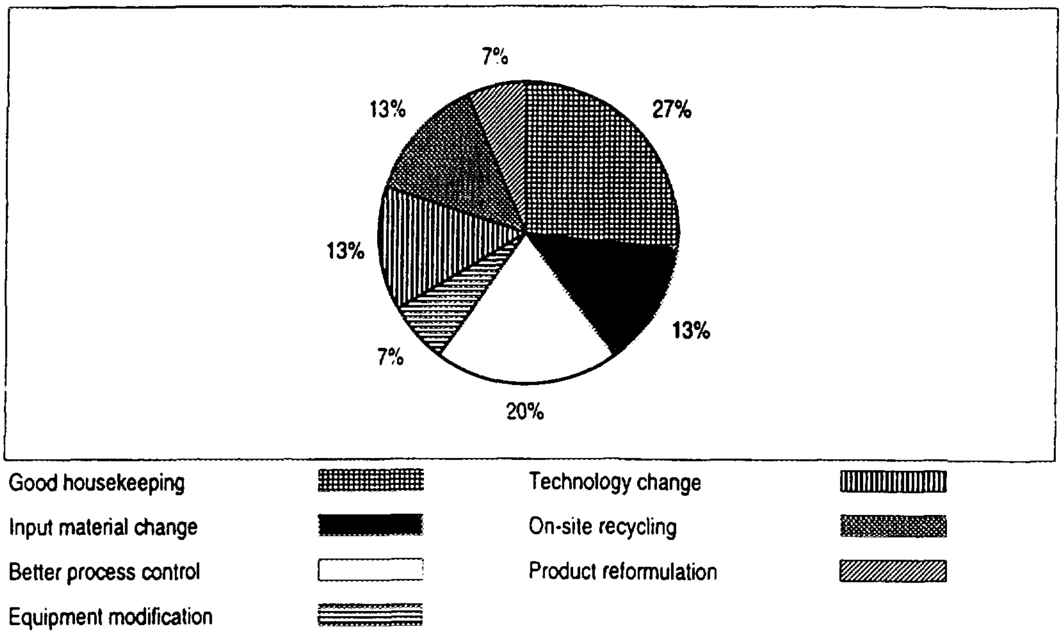
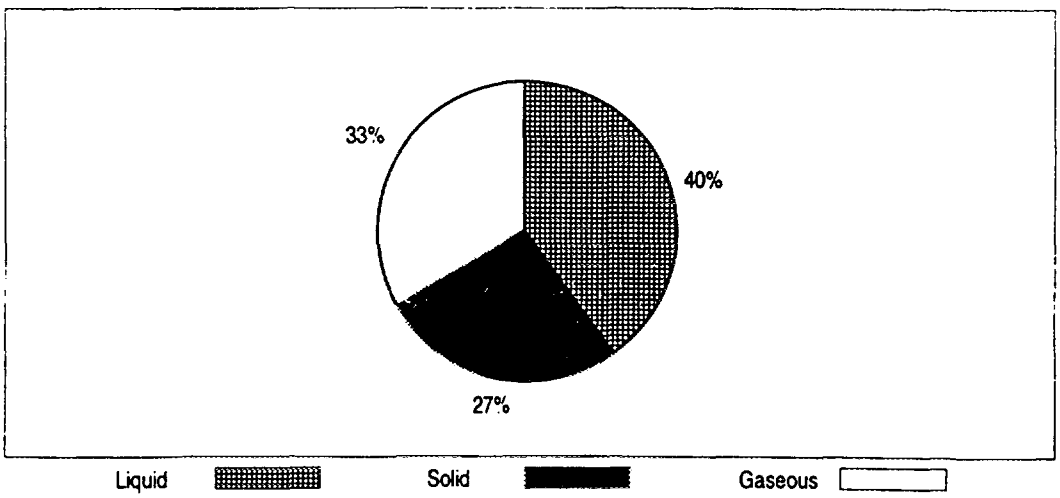
Area	*No. of Option*	*Implementation Status*	*Option Evaluation Payback Period*	*Environmental Impact*	*Total Impact*	
					Financial	*Environmental*
Raw material/ chemicals	7				I= 90,000 Rs. S= 150,016 Rs./yr. P= 0.60 yr.	BOD, COD and Toxicity reduction in effluent
Energy	8				I= 266,900 Rs. S= 227,074 Rs./yr. P= 1.18 yr.	CO reduction in air emission
Total industry	15				I= 356,900 Rs. S= 377,090 Rs./yr. P= 0.95 yr.	BOD, COD and Toxicity reduction in effluent CO reduction in air emission
		Implemented Started Planned Rejected	Low Medium High	Low Medium High	I= Investment S= Savings P= Payback	

Exhibit 3.4: Waste Minimisation Options

a) According to Techniques



b) According to Types of Wastes



4. Conclusions and Recommendations

Each of the constraints that were discussed in Chapter 2 reaffirm the importance of setting up waste minimisation policies that are capable of tackling the broadest possible spectrum of potential constraints. The experience of the project shows that intensive guidance and company-specific supervision by outside trainers cum consultants can eliminate a number of these constraints and thus foster waste minimisation.
There appears to be a set sequence in which the five topical groups of constraints normally appear when introducing waste minimisation in companies. The first constraints facing both companies and external agencies are normally attitudinal. These become evident in various misunderstandings as to the opportunities for waste minimisation and the financial as well as environmental benefits to be gained by the implementation of waste minimisation. This means that when encouraging waste minimisation in companies, a great deal of attention must be devoted to these attitudinal constraints. Once these are broken down – at least to some extent – and the management has decided to start a waste minimisation assessment, it is common to encounter systemic constraints (especially non-availability of information for conducting the assessment) and organisational constraints (especially towards the establishment of a properly functioning waste minimisation team in the company). In a subsequent stage, waste minimisation opportunities which might face technical constraints have to be generated and evaluated. In the last stage – the actual implementation of waste minimisation solutions – economic constraints might be most significant.

Moreover, there are *many opportunities* for waste minimisation in the sanitary fixture sub-sector and presumably in other sectors as well. These can be detected by making an integral analysis of the company, including – but not limited to – its production processes, input materials, waste streams and emissions.

Waste minimisation is much broader than technical modifications. It can be achieved by improvement of operating practices, changes of input materials and recycling practices.

Many of these waste minimisation opportunities can be implemented by the sanitary fixture sub-sector and presumably by other sub-sectors within the short term (one to two years).

The implementation of waste minimisation options will benefit sanitary fixture plants. These benefits include monetary savings as well as less tangible benefits, such as improvement of working conditions, improvement of product quality and improvement of local environmental conditions around the plants.

For a waste minimisation effort to be successful, it must systematically and comprehensively address potential constraints. The experience of the project shows that intensive guidance and company-specific supervision by outside trainers cum consultants can eliminate a number of constraints and thus foster waste minimisation.

The above conclusions are far-reaching. The concerted action of the companies participating in the project and the technical study team assisted by the project consultants has resulted in preventive measures being implemented and the start of ongoing waste minimisation activities in the companies. These results can, according to the audit team, also be achieved in numerous other small-scale industries. Company decision-makers do, however, need to create favourable conditions and allocate resources to the systematic identification, evaluation and implementation of waste minimisation options. Government decision-makers should, in turn, encourage and facilitate industrialists to do so. This brings us to the opportunities for waste minimisation fostering policies.

4.1 National Cleaner Production Centres (NCPC)

To reduce emissions and wastes and to minimise the use of raw materials, energy and water, it is best to start at the stage when the processes and products are being designed. This simple truth, now being realised by more and more industrialists and environmentalists, forms the basis for national cleaner production centres (NCPCs) being established jointly by UNIDO and UNEP. The NCPC programme is a capacity-building project to ensure the development and implementation of the cleaner production strategy at the national level. NCPCs can play a coordinating and catalytic role to achieve these objectives. The NCPCs are designed to do several things:

- Promote the cleaner production concept by disseminating information;
- Organise demonstration projects in industrial establishments;
- Conduct audits for industrial emissions and wastes;
- Produce technical publications;
- Promote good working relations in the various sectors;
- Offer training in cleaner production practices;
- Offer technical assistance;
- Identify obstacles to the implementation of cleaner production techniques and technologies;

- Collect information on their experience and store it in an information management system so it can be exchanged with other NCPCs and made available to programme management for wider distribution.

To promote this programme, UNIDO and UNEP are working with industry-oriented institutions, such as national productivity councils, chambers of commerce and industrial NGOs. The programme will support NCPCs in approximately 20 countries for five years, after which they are expected to be self-sufficient. Phase I, started in 1994 by the UNIDO Environment and Energy Branch and the UNEP Industry and Environment Programme Activity Centre, provides funding for eight centres for three years. The support is for demonstrations and training, the services of national and international consultants, the personnel costs of least one cleaner production promoter at each centre and premises. Each NCPC is matched with a cleaner production institution in an industrialised country which can provide expert services.

NCPCs can be managed by experienced nationals of the countries concerned and can be located at and supported by existing institutions.

4.2 Centralised Laboratory for Testing of Metals

One of the major issue in SSIs is non-availability of testing facilities. Brass is purchased from scrap dealers in lots of a few tons. The purchasing officer relies on his experience to determine the quality of brass. In the absence of any measuring equipment only visual checks are performed before the purchase of scrap brass. Therefore, the metallic composition of the lot is not known precisely to the casting department. The caster relies on his experience to set the composition of the brass to produce desired properties. However, it is found that the lack of quality control at this stage is the main source of rejection during later stages such as grinding, polishing and electroplating.

Therefore, it is essential to establish a laboratory for testing of metal. One such testing facility in the public sector exists in Lahore. However, it was reported by the participating plants that it is not practical to send samples of purchased brass to this laboratory because the laboratory usually takes 3 to 4 weeks to complete the analysis.

Establishment of a metal testing laboratory requires huge investment which no single industry can bear. The industries are prepared to share some portion of cost. Therefore, it is recommended that a metal testing laboratory should be established in Gujranwala. The government and the industry should collectively bear the cost of the facilities.

5. References

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5. *Study on Cleaner Production Techniques and Technologies covering Clusters of Small-Scale Industries in Selected Areas*, UNIDO report DP/ID/SER.D/19 (February 1996)

Appendix A: Faisal Industries (Pvt.) Ltd

Faisal Sanitary Fittings Industries (Private) Ltd., Gujranwala was established in 1975. It is one of the major producers of bathroom and kitchen fixtures. The total annual output is estimated at 275 metric tons with an approximate value of Rs. 20.5 million. Nearly 2-3 per cent of the production is exported. The workforce of the company comprises nearly 175 skilled and unskilled workers.

Consultants from Hagler Bailly Pakistan (HBP) and UNIDO made the first visit to this plant in December 1993. During this visit, meetings were held with the plant's top management and technical staff. A Waste Reduction Audit (WRA) team consisting of Manager (Research and Development), Incharge (electroplating shop), a senior operator (electroplating shop) and a representative of account and sales departments was formed.

Initial visit entailed a walk through analysis of the manufacturing plant. In the following months more visits were undertaken by the HBP staff to collect data from the WRA team and to conduct experiments in the electroplating shop. For data gathering a questionnaire was designed for the management; interviews were conducted with plant personnel; available company records were inspected; effluent samples were collected and analysed; and on-site measurements and experiments were conducted.

To quantify the raw materials consumption and production, the WRA team was requested to extract relevant information from the plant records. Unfortunately, this was not readily achievable as the company maintains very little data on its operation. The chemical analysis of the electroplating bath has rarely been done in the past. Therefore, records of laboratory analysis and the amounts of chemicals added to each bath could not be obtained. Water consumption is not metered at the plant. Gas and electricity are metered for the entire industry and there are no sub-meters. In view of these difficulties, indirect methods of estimation were adopted.

HBP prepared a waste reduction audit report under the guidance of a UNIDO consultant in October 1994. The focus of the WRA was the electroplating shop of the sanitary fitting manufacturing plant as agreed earlier between the WRA team, UNIDO and HBP staff. This choice was justified from the environmental point of view since the liquid effluent from the plating shop is the principal waste generated from the plant which is both a health hazard and is also in violation of the National Environmental Quality Standard (NEQS) for Municipal and Liquid Industrial Effluents enacted by the Environmental Protection Agency. However, after review of this report, it was realised that there are very little saving opportunities in the electroplating shop. After the visit of the UNIDO consultant to Gujranwala in September 1995, the scope of the project was expanded to include every shop of the sanitary fittings.

The basic approach adopted in the survey was to reduce the waste at the source and to examine recycling options to make the manufacturing operations more profitable, and to reduce adverse environmental impacts.

Findings

1. *There is significant chrome loss in the form of mist. It is estimated that about* 10% *of* the metal is being lost in the mist, which amounts to 7.8 kg per month.

2. The dragout rate for both nickel and chrome was calculated and found to be 1.60 ml/dm^2 for nickel and 1.012 ml/dm^2 for chrome.

3. The wastage of water was very obvious from the continuous flow in almost all of the rinsing tanks. An estimated flow rate for the waste water of electroplating shop was found to be 150,000 litres per day.

4. Samples of waste water were collected and analysed. Results of these samples showed that metal concentrations in the waste stream are much higher than the standards enforced by the Pakistan Environmental Protection Agency.

5. Brass is being melted in pit furnaces. The melting process is inefficient and there are no instrumentation and controls on the furnaces. It is estimated that only 8 per cent of the input energy is utilised in melting the brass; the rest is wasted in the form of radiation, convection and flue gas losses. A large amount of gas is used for pre-heating of furnace in the morning as the furnaces are closed at the end of the day.

6. Moulding sand is not re-cycled. Normal practice is to waste the sand after one time use.

Recommendations

Specific recommendations to reduce the losses are listed below:

1. Wastage of chrome is generally in the form of mist. It was calculated that about 7.8 kg of metal per month is being wasted in the form of mist. Installing a simple scrubber on the top of the chrome bath in a hood can reduce waste up to 50 per cent.

2. Minimum amount of water should be used for the first rinse. This can be done by using recirculating spray rinses. The rinse water should then be used as makeup water for nickel and chrome tanks. Dragout losses for nickel and chrome were calculated and found to be about 21.74 kg per month for nickel and 24.16 kg for chrome bath. Installing spray rinse can cut dragout losses by 50 per cent. Wastage of nickel in dragout and miscellaneous waste can be reduced up to 50 per cent resulting in savings

of Rs. 5,200 per month and similarly wastage of chrome in dragout, mist and miscellaneous waste can be reduced up to 50 per cent resulting in savings of Rs. 7,300 per month.

3. For the purification and cleaning of solution, continuous filtration equal to 3-5 turnovers per hour is recommended. Consistent use of the Hull cell can be the most useful for monitoring additive and contamination levels as well as overall performance characteristics of electroplating solutions provided their results are correlated with production experience.

4. Rinsing can be improved by incorporating vigorous agitation. This can be done by using a pump that can recirculate the water (from bottom to top) in the tank.

5. The temperature of flue gas of brass melting furnaces is as high as the melting point of the brass i.e. around 1710 °F. Approximately 37 per cent of the input heat to furnace can be recovered and can be used for pre-heating of brass in an insulated waste heat recovery unit. Annual savings of over Rs. 76,500 can be achieved by doing so. Pre-heating of brass will also reduce the average time required for heating and melting the brass. This will increase the production capacity of the furnaces. Large amount of gas is being wasted in pre-heating of furnace and in holding of molten metal within the furnace. Based on experience, a very conservative estimate is that about 25 per cent of total energy is consumed in pre-heating of the furnaces and 10 per cent of total energy is consumed in holding of the molten metal within furnaces. Additional savings in fuel could be achieved by rescheduling of operations to operate the furnace for longer continuous periods.

6. Rejections during casting, polishing and electroplating can be reduced with proper quality inspection of brass raw material. This can be a very effective way to reduce the wastage and improve the quality of the product.

7. The moulding sand should be reused. Steps should be taken to change the formulation of moulding sand. An alternate composition consists of sand, bentonite clay, wood flour, graphite and water.

Some general recommendations are listed below:

1. All windows should be cleaned regularly. Prepare a plan for periodic cleaning and a staff member should be given the responsibility of implementing the plan.

2. All incandescent lamps which are used for more than 8 hours per day should be replaced with the new energy saving lamps. These lamps consume 80 per cent less energy than incandescent lamps of comparable light. The cost is about 15 times higher; however, the life of the lamp is 10 times more. This gives a payback period of 6 months.

3. To make the maximum use of natural light, the possibility of installing new windows should be studied in all workshops.

4. In case of failure of electrical motor of 5 kW or above, replacement of standard motors with high efficiency motors made by reputable manufacturers should be adopted as standard practice.

5. For rewinding of electric motors standard specification wire should be used to reduce energy consumption and to enhance the life of the motors.

Additional recommendations that can yield further savings are listed below:

1. In order to avoid wastage of aluminium metal in casting process, instead of cast iron crucible, silicon carbide crucible is recommended.

2. The documentation and computerisation of data on incoming material, out-going products and by-products can lead to reduced wastage and improvement of quality.

3. If the modification of furnaces is not carried out, then insulation of the furnaces alone may result in reducing the wastage of energy due to reduction in wall losses.

Appendix B: Anwar Industries (Pvt.) Ltd.

Anwar Industries (Private) Limited (AI), Gujranwala, was established in 1944. It has two independent divisions which manufacture brass sanitary fittings and electric fans. Steel Castings (Private) Limited, located adjacent to AI, is a sister company under the same ownership. Part of the metallic waste generated at AI, including low grade brass, cutting waste of electrical steel sheets and nickel waste from electroplating baths, is sold to Steel Castings (Pvt.) Ltd.

The sanitary fittings division of AI started production as a small unit in 1955. Today, with an annual total output of about 65 metric tons, it is one of the leading manufacturers of sanitary fittings in the country. It employs more than 350 skilled and semi-skilled workers.

Anwar Industries was selected as the demonstration plant for the inaugural workshop of the project. A preliminary WRA was conducted by Hagler Bailly Pakistan (HBP) during a three day visit to the plant in December 1993. The audit covered both the sanitary fittings and the fan manufacturing divisions of the company. A visit to the plant was also made by HBP staff and UNIDO consultants during the same month. During these visits a Plant WRA team was formed in consultation with the management and the technical staff. In the following five months, HBP staff paid monthly visits to the plant to assist the WRA team in collection of data for the audit.

For data gathering a questionnaire was designed for the management; interviews were conducted with plant personnel; available company records were inspected; effluent samples were collected and analysed; and on-site measurements and experiments were conducted.

To quantify the raw materials consumption and production the WRA team was requested to extract relevant information from the plant records. Unfortunately, this was not readily achievable as the company maintains very little data on its operation. The chemical analysis of the electroplating bath has rarely been done in the past. Therefore, records of laboratory analyses and the amount of chemicals added to each bath could not be obtained. Water consumption is not metered at the plant. Gas and electricity are metered for the entire industry and there are no sub meters to monitor water consumption in the respective manufacturing divisions. In view of these difficulties, indirect methods of estimation were adopted.

HBP prepared a waste reduction audit report under the guidance of a UNIDO consultant in October 1994. The focus of the WRA was the electroplating shop of the sanitary fitting manufacturing plant, as agreed earlier between the WRA team, UNIDO and HBP staff. This choice was justified from the environmental point of view since the liquid effluent from the plating shop is the principal waste generated from the plant which is both a health hazard and is also in violation of the National Environmental Quality Standard (NEQS) for Municipal and Liquid Industrial Effluents enacted by the Environmental Protection Agency. However, after review of this report it was realised that there are very little saving opportunities in the electroplating shop. After the visit of the UNIDO consultant to Gujranwala in September 1995, the scope of the project was expanded to include every shop of the sanitary fittings and fan manufacturing plant.

The basic approach adopted in the survey was to reduce the waste at the source, to examine recycling options to make the manufacturing operations more profitable and to reduce adverse environmental impacts.

Findings

Due to the lack of documented information, it was not possible to establish a complete material balance for the plant. However, based on the analysis of selected operations, the following estimates were deduced:

1. There is significant chrome loss in the form of mist. It is estimated that about 10 per cent of the metal is being lost in the mist, which amounts to 1 kg per month.

2. The dragout rate for both nickel and chrome was calculated and found to be 2.53 ml/dm^2 for nickel and 1.63 ml/dm^2 for chrome. Total nickel and chrome in dragout is 1.5 times greater than the industrial standard.

3. The wastage of water was very obvious from the continuous flow in almost all of the rinsing tanks. An estimated flow rate for the waste water was found to be 12,000 litres per day.

4. Samples of waste water were collected and analysed. Results of these samples showed that metal concentrations in the waste stream are much higher than the National Environmental Quality Standards (NEQS) enforced by the Pakistan Environmental Protection Agency.

5. Brass is being melted in pit furnaces. The melting process is inefficient and there are no instrumentation and controls on the furnaces. It is estimated that only 8 per cent of the input energy is utilised in melting the brass. The rest is wasted in the form of radiation, convection and flue gas losses. A large amount of gas is used for pre-heating of furnace in the morning as the furnaces are closed at the end of the day.

6. The brass foundry uses scrap as raw material. There are no checks in place to control the quality of raw material used. Poor quality or inconsistent composition of the scarp brass can increase the rejection rates during moulding, polishing and electroplating process.

7. Moulding sand is not re-cycled. Normal practice is to waste the sand after one time use.

8. The paint section offers large material waste reduction and health and safety improvement opportunities.

9. The performance of the powder coating facility is not satisfactory and can be improved further to reduce the material wastage.

Recommendations

Specific recommendations to reduce the losses are listed below:

1. Wastage of chrome is generally in the form of mist. It was calculated that about 1 kg of metal per month is being wasted in the form of mist. Installing a simple scrubber on the top of the chrome bath in a hood can reduce waste up to 50 per cent.

2. Minimum amount of water should be used for the first rinse. This can be done by using recirculating spray rinses. The rinse water should then be used as makeup water for nickel and chrome tanks. Dragout losses for nickel were calculated and found to be about 5 kg per month. Installing spray rinse can cut dragout losses by 50 per cent resulting in savings of Rs. 500 per month.

3. For the purification and cleaning of solution, continuous filtration equal to 3-5 turnovers per hour is recommended. Consistent use of the Hull cell can be the most useful for monitoring additive and contamination levels as well as overall performance characteristics of electroplating solutions provided their results are correlated with production experience.

4. Rinsing can be improved by incorporating vigorous agitation. This can be done by using a pump that can recirculate the water (from bottom to top) in the tank.

5. The temperature of flue gas of brass melting furnaces is as high as the melting point of the brass i.e. around 1710°F. Approximately 37 per cent of the input heat to furnace can be recovered and can be used for pre-heating of brass in an insulated waste heat recovery unit. Annual savings of over Rs. 18,000 can be achieved by doing so. Pre-heating of brass will also reduce the average time required for heating and melting the brass. This will increase the production capacity of the furnaces. Large amount of gas is being wasted in pre-heating of furnace and in holding of molten metal within the furnace. Based on experience, a very conservative estimate is that about 25 per cent of total energy is consumed in pre-heating of the furnaces and 10 per cent of total energy is consumed in holding of the molten metal within furnaces. Additional savings in fuel could be achieved by rescheduling of operations to operate the furnace for longer continuous periods.

6. Rejections during casting, polishing and electroplating can be reduced with proper quality inspection of brass raw material. This can be a very effective way to reduce the wastage and improve the quality of the product.

7. The moulding sand should be reused. Steps should be taken to change the formulation of moulding sand. An alternate composition consists of sand, bentonite clay, wood flour, graphite and water.

8. There are many paint application stations in fan manufacturing section. Approximate annual cost of the paint is Rs. 1,559,597. Paint shops are of conventional type and there is massive over spray and wastage of material. It is fair to assume that at least 50% of the paint consumption can be reduced by upgrading the whole painting facilities into a sequential, auto line with rotary atomiser spray guns, etc. A 50 per cent reduction in paint consumption can result in monthly savings of nearly Rs. 65,000.

9. The gun used for powder coating gives a poor pattern distribution. Its replacement and use of vibratory box powder feeder can accomplish a reasonable amount of savings.

Some general recommendations are listed below:

1. All windows should be cleaned regularly. Prepare a plan for periodic cleaning and a staff member should be given the responsibility of implementing the plan.

2. All incandescent lamps which are used for more than 8 hours per day should be replaced with the new energy saving lamps. These lamps consume 80 per cent less energy than incandescent lamps of comparable light. The cost is about 15 times higher, however, the life of the lamp is 10 times more. This gives a payback period of 6 months.

3. To make the maximum use of natural light, possibility of installing new windows should be studied in all workshops.

4. In case of failure of electrical motor of 5 kW or above, replacement of standard motors with high efficiency motors made by reputable manufacturers should be adopted as standard practice.

5. For rewinding of electric motors, standard specification wire should be used to reduce energy consumption and to enhance the life of the motors.

Additional recommendations that can yield further savings are listed below:

1. In order to avoid wastage of aluminium metal in casting process, instead of cast iron crucible, silicon carbide crucible is recommended.

2. The documentation and computerisation of data on incoming material, out-going products and by-products can lead to reduced wastage and improvement of quality.

3. If the modification of furnaces is not carried out, then insulation of the furnaces alone may result in reducing the wastage of energy due to reduction in wall losses.