

## Chapter 2

# Financial and Commercial Matters

### 2.1 Financial Costs

The following expenses are likely to be incurred for setting up a new unit:

- Appointment of a project team with technical, commercial, and administrative members,
- Expenses for market survey for shortlisting of products to be considered for manufacture,
- Appointment of consultants for getting basic engineering document (the fees will be about 2.5–4.0 % of project cost). The decision to go ahead can be taken if the BED indicates technical and financial feasibility,
- The consultants can now be requested to provide the detailed engineering document. Their fees could be about 5.0–10.0 % of project cost depending on the complexity of the technology (*please also see below*),
- Applying for various statutory licences and permissions for environmental clearance,
- Acquiring land, its levelling, fencing, and developing approach roads,
- Water supply and power connections (for construction as well as for running the plant),
- Further activities after a study of the *detailed engineering document* by the technical and financial teams are (i) floating inquiries for equipments and (ii) identifying suitable vendors (*on the basis of their technical knowledge, experience, and reliability*),
- Technical team members of the promoter may also wish to observe the actual working of similar equipments supplied by the vendor. The following activities are quite time-consuming and also involve costs to the promoters because the vendor's workshops may have to be visited to assess their fabrication capability:

- Obtaining offers and shortlisting of vendors,
- Technical and commercial discussions with shortlisted vendors,
- Placing orders on finally selected vendor(s).

*Advance amounts required by vendors are generally 15–25 % of cost of machinery (in case the cost of machinery is in the range of about 50–70 % of total cost of project depending on the complexity of technology). Vendors may ask for greater advance amount if costly materials of construction (stainless steel, titanium, or special alloys) are required for fabrication, pressure vessels are to be supplied or equipment designs are complicated such as special reactors or boilers.*

## 2.2 Cost of Procurement

This needs additional funds for the following:

- Stage and final inspections at vendor's shop/at project site if it is a big item,
- Payment of further instalments to vendors/fabricators before it leaves fabrication shop,
- Packing, loading, forwarding, transit insurance, shipping (transport to site), unloading at site, storing, and site inspection again on receipt.

## 2.3 Cash Flow Planning for Site Jobs

In the meanwhile, the following should be ready at the project site:

- Establishment of site infrastructure—project office, stores, security arrangements, and other facilities such as transport, approach roads, and living quarters for site staff.
- Levelling of land and civil foundations as per design of the layout.
- Placing of equipments on the foundations can now be done. Care should be taken to correctly orient all nozzles—*this can need heavy-duty cranes and skilled manpower*. These machineries are hired at heavy charges on hourly basis.
- There are many major jobs such as fabrication of big storage tanks and large-diameter process vessels, internal refractory/acid-resistant brick lining and their curing, electrical cable work, fixing electrical motors to the respective equipments, installing internals in process units such as distribution trays, partition plates, loading of catalysts in converter, tower packing in gas absorption towers.

- These are followed by balance jobs such as fabricating/fixing prefabricated supports for ducts and pipelines, fabricating and then connecting ducts and piping to process vessels, installation of instrumentation probes and connecting cables, thermal insulation of process vessels and ducts/pipes.

### ***2.3.1 Testing of Static Equipments***

- Filling up vessels by water to check for any leak,
- Pressure tests by compressed air or hydraulic pressure tests by water (boiler, steam coils in evaporators, air receivers, and pressure vessels to be used for process),
- Smooth operation of valves, safety devices, and level indicators,
- Purging of dust and pipe scales,
- Checking the heating and cooling systems.

### ***2.3.2 Testing and Mechanical Trial Runs of Moving/Rotating Machineries***

- Air blowers and compressors,
- All pumps,
- Crushing and grinding mills,
- Belt conveyors, bucket elevators, and screw feeders,
- Agitated reactors, electrical cranes, and cooling tower fans, etc.

### ***2.3.3 Statutory Inspections***

These are necessary prior to commissioning of the plant and are to be done as per procedure instructed by the inspecting authorities. The following equipments are to be necessarily tested. Fees are to be paid to the statutory authorities for such inspection. This list is only suggestive, and more items can be added by them.

Pressure vessels, boilers and steam lines, fuel and gas lines, electrical equipments, and plant layout are inspected by Factory Inspectors from safety point of view.

### **2.3.4 Pollution Control Facilities and Waste Disposal Arrangements**

Inspection of the facilities for treatment of liquid effluents and gaseous emissions; and disposal plants (with air pollution control) for solid wastes is carried out by State Pollution Control Authorities before granting consent to operate.

## **2.4 Cash Flow Planning**

### **2.4.1 Typical Start-up Expenses**

- Higher charges are to be paid for construction power till regular production starts (*please see more details in chapter on electrical installations*),
- Cost of obtaining fuels—making necessary safety enclosures and other arrangements for fulfilling statutory requirements for storage of fuels, transport to site, and unloading into storage tanks,
- Arranging for testing, transport, and storage of sufficient quantities of raw materials,
- Chemicals, lime, and alkali for the treatment of effluents,
- Some more typical items required for starting a chemical plant are—Filter cloth pieces, active carbon, storage of raw and treated water, starting lots of materials like sulphuric acids *and oleums for establishing initial circulations in absorption towers*.
- To keep additional spare parts and lubrication oils ready,
- *Fees to erection and commissioning engineers and their teams may be included in orders for equipments,*
- Additional labour will have to be employed (for the duration) till plant is commissioned and performance guarantee terms are fully met.

### **2.4.2 Sale of Products**

It is generally seen that products from the trial runs and from the first few days of plant operations are not as per specifications given by clients. These cannot be supplied to them or sold in open markets. The initial quantities of such product need to be recycled/purified to make them saleable quality or disposed off at very low price to some party who may be able to use them.

During such times, very little revenue is obtained, while money is being spent continuously for getting raw materials and other necessary inputs. **The cash flow must be planned for such situations also.**

*Blackish sulphuric acid with some suspended matter may be produced in a new plant for first few days due to the dust and scales in process units and pipelines even after they are flushed out. This acid can be sold to manufacturer of single superphosphate or alum (to be used for effluent treatment).*

## 2.5 Investment of Own Funds by the Promoters

These could be up to 20 % of project cost before financial institutes agree to release loans. There will be certain processing fees (0.5–1.0 % of loan amount) charged by the financial institutes. Certain other expenses will also be there for:

- Mortgaging immovable properties for obtaining loans,
- Legal documentation and fees by legal consultants.

Venture capital may be obtained if it is a novel technology or a scheme with high technology. This investment provides the seed capital or an initial fund for getting further capital from financial institutes. It is for new companies which are not well known, have limited operations earlier or are too small to raise capital in the public markets and may not be able to get bank loans or raise capital through public offering for shares.

Venture capitalists usually try to get significant control over company decisions and a large share of the company's ownership because the parties giving venture capital are taking a higher risk of business failure in case the project fails (since the investments are being made in smaller and less known companies—*who may not be able to generate the expected return on the investment*).

- Raising funds from public as equity shares, preference shares, and debentures.
- Getting loans from financial institutions and banks (government/private)—the promoters are generally required to invest their own funds to the extent of 20–25 % of the project cost as seed money.

Cost of production per unit will be high till plant operations are stabilised and rated capacity is reached. Fine-tuning of operations is to be carried out carefully to establish all procedures of material feeding, starting the plant, operating various controls, and maintenance procedures. The cost of production per unit output will start coming down after this.

## 2.6 Hooking up with Running Plant

When new equipments are to be installed in a running plant, most of the infrastructure is already in place; however, very careful planning is required to erect the new equipments along with accessories (some of which can be supplied by the

vendor, some may have to be arranged by the purchaser, while certain items may be already available in the premises). It is advisable to take mechanical trials of as many as possible new machineries and complete the inspections of new equipments before hooking up to the old plant.

## 2.7 Depreciation

Process equipments and machineries in a chemical plant are subjected to corrosive conditions. Protective linings and external paints are generally provided, but these do get damaged earlier as compared to units in other industries.

Replacements become necessary sooner as compared to the units in mechanical workshops or civil structures for offices/residential buildings.

It is a thumb rule that almost all the reaction units and machines handling chemicals will have to be replaced every five years as they would be quite corroded or become unserviceable. Hence, managements shall keep aside an amount equal to at least 20 % of their costs every year.

This is a practical allocation from the profits and is generally allowed as a legitimate expense for running the industry by government taxation departments of many countries. The taxable income of the industry is reduced by this amount accordingly.

Efforts shall, however, be made to increase the useful life of the items by a few more years. This can create little surplus funds which shall be carried forward to the next financial year to meet any sudden major breakdown or some unforeseen mishap.

## 2.8 Government Assistance and Tax Concessions

These are given by certain countries:

- For establishing the industry in special geographical areas where more unemployment may be prevalent in the local population,
- In certain specially established export promotion zones where the government wants to promote export business,
- For certain research activities,
- Lower rate of taxation or deferred taxation (applicable taxes to be paid later on).

*However, the feasibility and satisfactory return on investment shall be independently established even without such government assistance.*

## 2.9 Marketing of Products

### 2.9.1 *Production for Export/Prestigious Clients*

The sale of products to prestigious clients or in export markets can create good reputation for the organisation and generate more business in future. It is very necessary that the goodwill must be maintained for further progress. The intended use of the product must be clearly understood by discussing with the client so that special precautions can be taken while procuring the raw materials and packing in suitable sized containers.

### 2.9.2 *Selling the Product*

Free samples of the product or trial runs with the products may be offered to the client for generating confidence. Some of the products could be pour point depressant for oils, anti-caking agent for salt, and descaling agents for heat exchanger tubes.

The selling price may include the loading and transport charges, cost of containers, taxes and other levies, and insurance charges (the price then becomes the *delivered cost at site* to client).

Sale on credit—clients may be asked to pay only partly for the consignment and allow payment of balance amount after confirming that the product was found useful indeed.

*Methyl violet dye can be sold as crystals which need to be weighed and dissolved or as a solution in suitable solvent which is easier to handle and feed in controlled doses at the point of use.*

*Papermaker's alum can be sold as solid or as 8–10 % solution (the latter is easy to use).*

### 2.9.3 *Instruction Manuals*

- Instructions for unloading and opening the containers (e.g. *do not use sharp tools or hammers for opening*),
- Instructions shall be given how to properly wash and clean the drums/small cans before returning in case the drums (100/200 litres capacity) or smaller cans (10/20/50 litres capacity) are supplied on a returnable basis (in order to save cost to the clients)—*no water shall remain inside when they are returned*,
- In case the drums are not to be returned, advice shall be made available for their safe disposal,
- Instructions for correctly and safely using the product:

*How to handle the cans or drums, how to dissolve the product, and how to add slowly to the process unit at point of use while standing at a place not to inhale the vapour/dust.*

Visits may be undertaken to explain the above matters for creating more goodwill and to answer any queries by clients on the spot.

The essential matters which should be taken care of/be addressed are as follows.

### **2.9.4 Confirmation of Product Quality**

All batches/lots being sold must be thoroughly checked by quality control laboratory in order to confirm that the specifications given by clients are fully met or even exceeded (the product can be even better than asked for).

The minimum purity level must be met by all consignments. In addition, the maximum level of impurities shall never exceed the limits set in the order.

A particular physical form is sometimes required by the client such as:

- Absence of big lumps—*since these do not dissolve quickly,*
- Requirement as a free flowing powder,
- Granules of a particular size or coated with anti-caking agents.

The test certificates for such analysis should mention the reference of order (name of client, order number, a copy of original specifications), production batch number, date of manufacture, and manufacturer's code—for ease of identification of the reaction units, process plants, operation sequence, or conditions maintained during production on the date of manufacture in future. These will be useful if any communication (complaint or compliment) is received about the product.

Taking care of quality—*Raw materials shall be thoroughly checked before using them for manufacture. The process streams shall also be checked at all stages of manufacture such as after calcinations or filtration of raw materials before charging into reactors; at exit of reactors, after every purification stage (settling–filtration–distillation) so that any process problems can be pinpointed and corrected.*

### **2.9.5 Internal Records (For Manufacturer)**

**Internal records (for manufacturer) are as follows**—date and shift of manufacture, reactor/unit used for production, process conditions maintained during production, and source and analysis of raw materials used.



The following are the documents to be provided while dispatching the products:

- Containers must be correctly labelled with name and analysis of the product.
- Material safety data sheets giving all important properties such as boiling and melting points, miscibility with water and other solvents, inflammable nature, toxicity, precautions to be taken for safe handling, and how to collect and make a spillage harmless (absorb in ash/washing by copious amounts of water).
- If there is a possibility of material spillage due to wrong handling, write antidotes and steps for first aid prominently on the packages in as many languages as possible with at least two internationally known ones. This is to suggest remedial action if material is accidentally inhaled/spilled on body.
- Precautions for handling glass containers shall also be written prominently on the packages in as many languages as possible with at least two internationally known ones. Stickers with standard symbols shall also be fixed, and symbols shall be printed.
- Information should also be given if the product is not compatible with any other material so that clients can take proper precaution during storage (not exposing to sunlight or rains) and using it (specially the feeding sequence to process reactors).
- Antidotes/first aid to be given to affected persons in case of a spillage must be prominently mentioned on every package/container.
- Confirmation of quantity packed in each container.
- Size of packages shall be as required by clients: these should be easy to fill, load, shift, unload, store, and open for use. The tare weight, net contents, and total weight of the packages shall be clearly marked on each package and also mentioned in the documents.

*Small bags carrying sulphur powder generally have a net content of 50 kg material and a tare weight of 1.0–1.5 kg; thus, the total weight of the bags may be 51.0–51.5 kg.*

- Some precautions may be specified by the authorities for transport by railway tankers or road tankers before the consignments are accepted for carrying them. It may be necessary to pay higher insurance charges and declare all details about the products if required by statutory authorities prior to export consignments.

## ***2.9.6 Dispatch of Products and Storing at Client's Site***

### **2.9.6.1 Drop Tests and Stack Tests**

Drop tests and stack tests must be carried out on a sufficiently large number of carbuoys if they are to be used for carrying dangerous liquids. These tests are done by dropping a filled-up carbuoy from a known height—say from 3 to 4 m, to confirm that they will not leak during shipment. Likewise, stacks of carbuoys are

arranged one above the other to confirm that the lowest one will not buckle under the load and start leaking.

The requirements are to be worked out by the manufacturer of the product who is in a better position to take such trials in the plant before dispatch.

Provide lifting lugs or slings to the containers for loading to transport vehicles. This is to prevent the use of hooks or any sharp tools for lifting the bags/containers which can tear them and cause spillage.

### **2.9.6.2 Seaworthy Containers**

Seaworthy containers shall be used for shipments by sea since they may get corroded by salty ambient conditions in case they are carried on decks. These shall be provided safe enclosures with soft packing around and then finally packed in a strong container.

Special precautions are to be taken for packaging when transport of high-value materials is by air (samples/special chemicals/pharmaceuticals/perfumery products).

Advice shall be given whether the material (product) can be moved in the premises by belt conveyors/bucket elevators or screw feeders, etc. *It will depend on inflammable/toxic/hygroscopic properties and angle of repose of the material.*

### **2.9.6.3 Storage Precautions**

Storage precautions for storing the containers at the user end are to be given. Some of the precautions to be avoided are direct sunlight, exposure to rains, dusty conditions, proximity to hot surfaces, provision of earth connection to container (having aluminium powder, inflammable matter), and need to install smoke detectors and water sprinklers in the storage sheds.

Whether the material can be stored in bins or silos with a rotary discharge valve at the bottom?

*These precautions depend on the particular product, and clients shall be made familiar with them by giving training for handling the products if necessary.*

### **2.9.7 Delivery Schedules**

The delivery schedules shall be committed to the clients only after consulting the plant engineers who are operating and maintaining the production units, because some of the process units such as reactors, condensers, and filters may not be working to rated capacity or a plant shutdown might have been planned for their repairs or cleaning.

Therefore, the copies of delivery orders (finally accepted for supply to clients) shall be given to departments responsible for purchase of raw materials and other necessary items, production and maintenance staff, transport section, etc., to enable them planning of their activities.

*The following situations can affect the timely delivery of products:*

- Delay in procurement of the specified raw materials, catalysts, maintenance spares, and packing items due to any reason,
- Adverse weather conditions prevailing at present (heavy continuous rains can affect drying operations),
- Scheduled preventive programmes planned for process units,
- Any urgent repairs to be carried out to key process units,
- Statutory inspection of some key equipments has become due, and it is necessary to stop the plant, overhaul and repair (*wherever necessary*) and present to authorities for annual inspection as per the law, e.g. steam-generating boilers, pressure vessels, electrical installations, and safety devices.
- Shortage of water, power, fuel, or transport bottlenecks
- In rare situations—absence of key personnel
- Finance managers may ask for certain conditions to be met before products are dispatched to an overseas client. Some of these could relate to the performance guarantee terms (these must be finalised in consultation with technical persons), payment of an advance amount by the client, credit terms asked for by client, whether client agrees to pay the costs of packing, insurance and transport for the consignments, and any other taxes and levies to be paid to statutory authorities in supplier's country and client's country.

### **2.9.8 A Word of Caution**

The marketing department shall never insist the plant engineers to run the plant above the rated capacity in order to meet the commitments made to the clients for the total quantity and delivery dates.

This can force them to run the process units by occasionally overloading them—which can be dangerous and cause environmental pollution or inefficient operation of the plant.

In rare cases, the equipment life may get reduced (e.g. charging excessive materials in a batch reactor and then running agitators at too high speed, **or** operating at too high SO<sub>2</sub> % to converter for producing more oleums from a sulphuric acid plant).

## 2.10 Agreements for Technical Consultancy

It will be found useful to get thorough professional advice (both technical and commercial) while setting up a new project, for expansion of a running plant or for revival of an idle plant. Technical advice may also be required if some problems are not getting solved by own technical teams and a fresh look is required. Managements may also enter into agreements for process know-how or engineering designs and then proceed to procure or fabricate the equipments instead of setting up a project on a turnkey basis in order to save costs.

The agreements for consultancy could be made for the following:

- Market survey to assess demand for a product and its availability,
- Obtaining only process know-how about a new modernised version of the existing process or a completely new process and then proceeding further on their own,
- Basic engineering package to get more details about the process description, major equipments required, raw materials and energy consumptions, an approximate requirement of funds, area, manpower for the plant, return on investment, and payback period. The management can now decide whether to go ahead, keep in abeyance, or abandon the project,
- Detailed engineering package (DEP) shall include but will not be limited to the following:
  - Full details of the process, equipments, and process piping,
  - Material and energy balances,
  - Details of safety devices and safety interconnections,
  - Electrical load data and wiring diagrams,
  - Civil and architectural drawings,
  - Effluent generation and treatment thereof by pollution control schemes,
  - Assistance for procurement (preparation of inquiry documents, evaluation of offers received from vendors, shortlisting, and final selection of vendors on technical basis), commercial discussions, and shortlisting are generally done by managements themselves,
  - Erection and commissioning of the plant equipments and machineries and reaching rated output from the plant,
  - The performance guarantee test runs are the most important part of such agreements as they represent completion of the project and the handing over to the regular operational team. Guaranteed maximum raw material and utilities consumptions (will not exceed these figures per unit output of saleable quality of finished product),
  - Operation and maintenance manuals shall also form part of the DEP. These shall include dos and don'ts for the specific guidance of the shop floor personnel.

- Training may also be arranged on a running unit or given on the plant being erected and commissioned. This may be charged separately on a man-day basis by the consultants,
- The consultants shall reply to any specific queries from the clients or from statutory authorities regarding technical matters, safety issues, effluent generation, and treatment thereof.
- Expansion of a running production plant:  
It is necessary to look into all the process units and the site infrastructure, including electrical installations, water supply, storage tanks for raw materials and products, and the handling equipments and systems. The consultants should examine all these very carefully and check suitability of the facilities for increased production (as per product mix decided). Specifically, the capacity of effluent treatment plant, main electrical transformers, refrigeration plants, cooling towers, fuel tanks, etc., shall be checked. All bottlenecks shall be identified and upgraded. It may become necessary to procure equipments/ machineries with higher capacity wherever existing units cannot be upgraded.

*Special care shall be taken to confirm that no pressure vessel will operate beyond its permitted pressure or electrical equipments (including distribution network in the premises) will get overloaded when the plant capacity is expanded. Moreover, no unsafe condition shall be created anywhere in the plant due to expansion of the capacity.*

- Diversification of a running production plant:  
In this case, the agreement with consultants shall include a clause that as much of the existing process units and machineries will be used for the manufacture of additional (new) products. The material of construction shall be carefully looked into so that there will be no contamination and corrosion issues for the new products. Only a minimum of additional units and machineries shall be added, and this shall be done with a minimum interruption of production run of the plant. As before, the capacity of effluent treatment plant, main electrical transformers, refrigeration plants, cooling towers, fuel tanks, etc., shall be specially checked.

No unsafe condition shall be created anywhere in the plant due to diversification of the plant to new products.

A performance guarantee test shall be included in the contract with the consultants.

### **2.10.1 General Conditions**

It is advisable to enter into a mutual secrecy agreement so that neither the consultants nor the plant management will disclose any of the plant design, operating data, or any other information to outside parties.

There shall be an agreement for regular visits to the plant by the consultants—say one visit per month for the first six months and once in three months thereafter. The first two or three visits shall be free of cost (except travel fare and arrangement of stay at site to be made by the plant authorities) to the consultants. All subsequent visits may be on a chargeable basis of per man-day. This will be convenient to both parties.

Any other conditions may be included in the contract after mutual agreement.

## **2.11 Running the Plant on Contract Basis**

It may be found convenient or even economical in certain circumstances to run the plant activities (either wholly or partially) by outside parties on contract.

Some of these circumstances could be when the purchaser does not have:

- Enough funds,
- Proper and sufficient manpower,
- Process and engineering know-how,
- Identify a project which will be profitable or is under statutory instructions to set up such a unit (e.g. effluent treatment plant),
- The purchaser has plans to raise funds in future to take over such a plant and is willing to pay a higher price for the same because the working has been established in the meanwhile.

### **2.11.1 Typical Options for External Assistance**

- BOT: Build, Operate, and Transfer. The plant is built and operated by external agency till performance guarantee terms are met and then transferred immediately to the purchaser. The purchaser thus gets a ready-made new running plant (e.g. effluent treatment).
- BOMT: Build, Operate, Maintain, and Transfer to purchaser. Major control on the plant remains with the external agency till it is transferred. Maintenance of the plant is also done by the agency. At the end of the contracted period—which *should not be too long*—it is to be handed over to purchaser. But it must be maintained in a good condition.

- **BOOM: Build, Own, Operate, and Maintain** for some years as per agreement between purchaser and external agency. The profits during these years could be shared or taken by external agency. It is then to be transferred to the original party for an amount (as per agreement made earlier) who has given the contract. Major control of the plant will remain with the external agency for the contracted period.

*The terms and conditions for sharing of profits and costs shall be worked out and written down in the agreements accordingly.*

### ***2.11.2 Agreement Between the Purchaser and External Party***

- The plant should be safely operable in the local geographical and climatic condition (ambient temperatures, rainfall, etc.) with the technology offered. Locally available (if cheaper) raw materials shall be used to the maximum extent in the plant. This shall be discussed between the purchaser and the contractor (external party) and confirmed in the agreement. Dependence on imported items shall be minimum.
- Consumption of raw materials, power, steam, and water shall be lowest or comparable with the best in industry. Specific consumptions of all inputs per unit of output shall be very economical over all operating capacity ranges. *This is the main requirement when the plant is being obtained on a turnkey basis from the external party.*
- A clause for operability of the plant in the range of 80 to 130 % of the capacity in an *efficient and safe manner* shall be written in the agreement. This is to safeguard when the demand for products is less (to run at 80 % capacity), or at overload of rated capacity (to run up to 130 %) if higher demand for product is to be met urgently.

### ***2.11.3 Important Jobs to Be Done by Purchaser***

These are to be done by purchaser themselves even after obtaining services of external agency on contract basis. Some of these are as follows:

- Obtaining all statutory permissions to establish and operate, and arranging land, power, water supply, and all necessary infrastructure. All statutory requirements and instructions shall be complied with by *the owner*.
- The purchaser shall appoint proper manpower who should be able to understand the process technology and able to operate and maintain it when it is handed over to them so that services of external agency are not required afterwards.

## **2.12 Organisational Resource Planning**

This shall be done for achieving the goal of developing the organisation as an efficient, reliable manufacturer which delivers quality products as per specifications and delivery schedules committed, while operating safely without causing environmental pollution.

Software shall be developed in-house in consultation with all concerned departments to address the important activities as below. The software shall have built-in alert signals to draw the attention of senior personnel in each department if any activity is not meeting the targets set. This will ensure timely action for properly planning the organisational resources.

### ***2.12.1 Fulfilling of All Orders Accepted by the Sales Department***

This involves the tracking of the following:

- Names of clients,
- Names of products and their specifications,
- Delivery schedules accepted,
- Availability in the storage tanks/sheds of these products (with certified quality),
- Approvals by clients for the samples given to them,
- Arrangements for dispatch and confirming acceptance by clients—*functioning of weighbridges, availability of special vehicles for transport of dangerous products, any transport bottlenecks, confirming receipt by clients, and payment of bills by clients.*

### ***2.12.2 Tracking All Purchase Orders Issued***

Track all purchase orders issued to suppliers of raw materials and inputs—approvals of samples received given by suppliers, any transport bottlenecks, actual quantities received, bills raised by vendors, payments actually made, balance payment amounts, and proper storage at site.

### ***2.12.3 Manufacturing/Production Operations***

- Confirming capacity of process units and reactors for each type of product to be manufactured and their actual availability for the production by discussing with senior production and maintenance engineers,



- Confirming availability of required quantities of all raw materials and inputs including additives, property modifiers, and packing containers for the products,
- Availability of water, power, and fuel as per amounts required,
- Tracking quantities of all items actually issued from stores and their balance stocks,
- Amounts of various products actually produced,
- Quality control to confirm the quantities of finished items which meet required specifications,
- **Statutory inspections** due in the meanwhile which may need stopping some of the units (specially pressure vessels).

#### ***2.12.4 Safety Issues***

Safety issues to be addressed urgently

- If there are chances of accidents when production rates *may have to be increased* beyond certain limits for fulfilling urgent orders from clients,
- Some minor leaks of acids/gases from reactor are yet to be attended,
- Some pending maintenance job (e.g. a support leg of process reactor has become weak and needs to be immediately reinforced).

#### ***2.12.5 Effluent Treatment***

Capacity of effluent treatment plant shall be confirmed to handle the effluent load generated by the product mix if extra amounts of effluents are likely to get generated. Temporary storage of additional effluents may be provided for properly treating them later on before discharge.

#### ***2.12.6 Maintenance***

Any plant stoppage is planned for carrying out preventive maintenance.

Any urgent equipment repair/replacement programme is planned.

#### ***2.12.7 Effect of Weather Conditions***

Drying operations may get affected or the dried product may absorb moisture if it is raining heavily or humidity is high.

Transport of highly volatile/inflammable products needs more precautions during severe summer.

There is possibility of pipelines of process plants or outlet valves of tankers getting jammed or choked due to solidification in severe winter.

### **2.12.8 Manpower**

Holiday season will have possibility of absenteeism or key personnel already gone on leave.

## **2.13 Resource Allocations for Increasing Revenue**

Resources are of various types such as installed machineries, infrastructure facilities, trained manpower, and cash funds. No resource shall remain idle as far as possible. It is suggested to consider how all of them can be utilised efficiently.

- Financial—cash, credit facilities, and advances paid to vendors,
- Manpower—qualified, experienced engineers and technicians who can be sent on deputation or for providing consultancy services to (similar) industries,
- Equipments installed in the premises which can be removed from position and sent outside, e.g. crushers, small packaged boilers, dissolvers, and centrifuges
- Spare capacity available in the installed equipments (which are fixed on position) for taking up outside jobs,
- Excess power, steam, hot water, hot air generated available from waste heat recovery units, and cogeneration facilities,
- Maintenance facilities and fabrication machineries,
- Laboratory facilities which can take up outside jobs,
- Materials in stock (excess quantity can be given on loan or sold),
- Utilities and infrastructure (water treatment plants, weighbridges, warehouse, transport fleet).

### **2.13.1 Cost of Idle Resources to the Organisation**

Investment is already made in acquiring various resources such as in production units, auxiliary equipments, and utilities by the organisation for certain rates of production. The unit cost of product is optimum when the plant is run at its rated capacity. However, if the plant is operated below its rated capacity, the consequences can be:

- Some processing units and machinery can become idle or redundant (the capital investment made for them remains unutilised; in addition, they have to be preserved for use in future and insurance premiums are to be paid to insurance companies). These equipments may even start getting rusted or jammed if they are kept stopped for long time.
- Power and water consumption per unit of output can be excessive when bigger machines such as crushers, big agitated reactors, boilers, pumps, and blowers are run much *below the lowest recommended point of operation by the manufacturer*.
- Trained manpower can become idle if they are already employed on a permanent basis or engaged on long-term contract if there is no work for them.
- If spare parts are already procured (corresponding to running of the plant at rated capacity), some of the spares can get rusted/jammed or obsolete due to long storage.
- Packing, bag stitching, and weighing machinery are underutilised.
- The transport fleet (which may consist of specially designed vehicles) becomes idle.
- Captive power generation or cogeneration facilities may have to be operated below their optimum efficiency point or may become partially idle.
- However, cost of purchase and taxes have already been incurred/paid on obtaining and installing these equipments (*but they may not be required now*) while licensing fees, royalties for process know-how, and catalysts charged in the reactors are to be paid on a recurring basis. The erection and commissioning expenses for the equipment have already been incurred.
- Various other inputs (power and water supply) have been arranged at considerable costs. In addition, the interest payment on borrowed funds becomes due as per repayment schedules (generally as monthly instalments).

All such expenses are now distributed over a *lower output* from the plant. This can increase the cost of production per unit and can be recovered only by raising the selling price.

### ***2.13.2 Some Typical Reasons for Resources Becoming Idle***

- There is not enough demand for the products (cheaper, better product has become available from competitors).
- Raw materials of required specifications are not available while the raw materials which are available need considerable purifications, drying, etc.
- Some key process unit or machinery is not working properly or stopped for maintenance for long time.
- Catalyst has got deactivated, and fresh supplies are not immediately available.
- Water supply is not available due to less rainfall and less storage in main supply reservoir.

- Fuel supply is delayed.
- External power supply lines have broken down.
- Transport fleet for outgoing products is under maintenance, or the road is blocked because some bridge has broken down.
- There are some pending demands from workforce.
- Plant is generating more effluent, and objections are raised by authorities/surrounding population forcing curtailment of production rates.
- Statutory authorities have instructed to stop the plant for some urgent corrective actions or inspections—**alert management should never allow such a thing to happen.**

### 2.13.3 Remedial Actions

Some corrective steps appear obvious and quite simple—but there could be practical difficulties in their implementation. Everyone in the organisation shall make sincere efforts to overcome the situation.

As a first step, all matters related to safety of personnel and plant machinery, environmental pollution control, and instructions from statutory authorities shall be attended immediately.

A programme for continuous innovation, suggestion schemes, etc., shall be in operation for improvement in the product and to bring down the cost of production. Condition monitoring of all key units and machineries and preventive maintenance will be able to minimise long stoppages of the plant. There shall be regular coordination meetings among operation and maintenance engineers to analyse reasons of breakdowns and to develop better methods of operation as well as more robust designs of equipments and machineries.

Auxiliary equipments for pretreatment of raw materials shall be in place to prevent deactivation of catalyst and fouling of heat transfer surfaces. Formats have been given elsewhere in this book for drawing attention to key equipments and consequences of their breakdown.

Stocks of all necessary raw materials and other inputs shall be monitored on a daily basis. Production planning engineers must know every day how long the available stocks will last to run the plant as per (current rates of production) the product mix. The reorder point for replenishment (the lowest stock level) of these items shall be clearly known with automatic warning available.

Grievance cells and other mechanisms for resolution of conflicts with workforce shall always be in force. No legitimate problem shall be ignored. Officers of this department as well as other senior engineers and managerial staff shall be alert to see that any discontent brewing in the organisation does not snowball into a major conflict.

Alternate arrangements for transport shall be made in advance in anticipation of heavy rains or for situations when there are chances of interruption. Managements may also look into the possibility to build up stocks of their products at the customer's plants or in warehouses at a convenient location near to the customer.

### 2.13.4 Allocation of Resources

Allocation from existing resources for new products and expansion/modernisation activities shall be done *only after observing that surplus* power, water, storage space, manpower, facilities for maintenance and fabrication in-house, and cash flow are available. This can be done by examining these resources in detail on the following basis. The list is only suggestive, and more criteria can be added for *establishing that these are surplus resources indeed*.

- The rated capacity of certain equipment/machine is more than necessary.
- The actual output from such machines/process units is also more than necessary when it is run all the time. Hence, it is required to run it only for some time in a shift.
- Required running time of the machine for processing the input is only a few hours per shift/day without disturbing the main plant being run at rated capacity. Hence, it is to be checked that can it be spared for a few hours every shift/day?
- Does this machine/resource have multiple uses (grinding raw material for feeding to many reactors/supplying steam to many reactors)?
- Raw material stock—Is this raw material used for making different products? In that case, the raw material shall be used for manufacture of products which will give higher profits or which are in stock in a very short quantity and an important customer has placed urgent orders. The raw material can also be used for a product where the reactor is in a ready condition for charging, while other reactors are undergoing maintenance or are being cleaned. Plant manager shall decide in consultation with marketing and maintenance departments and use the excess raw material in stock accordingly. Any further surplus may be sold outside.
- How much treated water can be generated per day and how much is actually required? Can the treated water be sold outside?
- How much steam is generated per hour and how much is required in the plant? Is a nearby customer willing to buy the surplus steam? Can some outside party be allowed to set up an evaporator in the premises for concentrating their dilute solution/to set up a dryer for drying wet material and then charged for the steam consumed.
- The steam consumption can be determined by collecting the condensate and measuring it. The condensate can be recycled to save cost of fresh DM water *provided it is not contaminated*.

- What is the total power required to run the plant at its rated capacity and how much power is getting generated through the steam turbogenerator? How much is the surplus? How much steam can be exported if cogeneration system is installed in the plant?
- Financial—Invest the surplus cash in important inputs/buying good-quality material in larger amount if available at off-season discount, and innovation and research activities.
- Procure items on credit if possible.
- Equipments installed in the premises which can be removed from position and sent outside, e.g. small crushers, small packaged boilers, dissolvers, and centrifuges if they are used sparingly. They may be used for two/three days continuously to build up stock of materials and then lent on hire.

### ***2.13.5 Spare Capacity Available***

- Taking up outside jobs by installed equipments (which are fixed on position)—crushers, grinders, dryers, and filters can be used to work for outside parties.
- Maintenance facilities can be used for repair or fabrication work for outside parties.
- Laboratory facilities can be used for certification work for outside parties.
- Outside parties can be allowed to use weighbridges, warehouse, and transport fleet for certain fees, and thus, some revenue can be generated.
- Are trained engineers and technicians available for sending them to assignments outside the premises (to other units for providing consultancy services on a per man-day chargeable basis).

## **2.14 Cost Reduction**

Records of total production and plant stoppages on a daily and monthly basis shall be maintained. Similarly, records of consumptions of raw materials, power, steam, water, and spare parts shall also be available. These shall be updated regularly for getting the latest figures at a glance.

### ***2.14.1 Factors Contributing to Variable Cost of Production***

- The above data shall be studied, and the quantity of acceptable grade products manufactured shall be determined by subtracting the quantity of rejected materials from the total production figures. The quantity of rejected products

(which may be reprocessed and sold thereafter) shall also be subtracted because they need additional inputs for making them acceptable in market. Consumptions of inputs shall be calculated on the basis of only marketable grade products.

- Generate the data for cost of consumptions of raw materials, power, steam, water, and spare parts on the above basis. Consider only the higher of the costs in the period under study *because some inputs might have become cheaper meanwhile*. Select the items for further detailed study which contribute about 80 % of the total costs. Remaining items are also to be looked into after corrective steps are taken for the above.
- Where same facility (e.g. grinding units) or inputs (e.g. steam supply) are used/consumed, allocate the consumptions in proportion of quantities of each item produced and quantity of effluent load attributed to such items.
- Compare landed cost of all raw materials at point of charging into reaction units—since *apparently* cheaper raw materials need lot of pretreatment such as filtration, drying, and screening before charging into process units. The procurement can be seasonal and in economic lots if lower rates or credit facilities are available.

### 2.14.2 Some Tips for Reducing Variable Cost

- If possible, direct unloading into process units shall be explored to save cost and contamination due to repeated handling in the premises (sulphur procured in road trucks can be unloaded directly in the melter, rock phosphate unloaded directly on to the grids of crushers, bauxite lumps into loading hoppers of belt conveyors, and alkali in day tanks) **or**
- Buy small bags or packets of additives which can be directly charged into reactors.
- Select the required fuel on the basis of *actually available heat* in Kcal per unit cost instead of gross calorific value and cost per unit weight.
- Use only treated water for cooling, making solutions, as aqueous medium for process reactions. Use spent water from one unit for next unit—blowdowns from cooling tower for flushing pipes, washing floors, gardening, cleaning drains, and basins.
- Compare the actual yield with expected yield. Investigate the loss of materials through effluent streams. Analyse samples of wash liquors from process units and spent scrubbing system liquors to check whether any product or reactants are getting lost.
- Examine weighbridges and recalibrate by using standard known weights in case of doubt.

- Sell the products in returnable packing/containers of bigger sizes (100–200 l instead of 5–10 l) to reduce workforce and time required for filling such small containers.
- Agitated reactors: Provide simple removable baffles of different designs. Run agitators at lower speed or less running time. Trials can now be taken to minimise power consumption.
- Maximise heat recovery from all possible sources. Use outgoing hot process streams for preheating of incoming cold process streams. (*Outgoing depleted hot oleum stream at 125–130 °C from oleum boiler is used to preheat the incoming concentrated oleum stream at 50–55 °C into the oleum boiler by an oleum/oleum heat exchanger in a liquid SO<sub>3</sub> plant*).
- Avoid unnecessary high pressure for the generation of steam unless cogeneration is to be done. Since the saturation temperature of high-pressure steam is high, the flue gases can exit at high temperature from the boiler—few degrees above the saturation temperature. This may cause loss of heat unless additional heat recovery units are provided.
- Provide variable-frequency drive motors for pumps and blowers wherever possible instead of throttling the delivery valves for flow control.
- Reuse spent scrubbing liquor for the regeneration of alkali/floor washing/cleaning drains.
- Implement inventory control programme through standardisation of spares and detailed analysis of reasons for consumptions by joint consultation among chemical, mechanical, electrical teams and purchase officers from engineering stores.
- Automation will lead to rationalisation of workforce and reduce excess manpower.
- Internal audits shall be done regularly. Test the plant performance every 3–6 months as if it is the performance guarantee test. This will point out inefficient units in the plant.
- Own transport fleet may be used for reliable and safe transportation of special, costly, or dangerous materials.
- Use metering tanks for feeding raw materials and for selling products.
- Prolong production run of the plant to minimise the proportion of the start-up, stabilisation, and shutdown periods in the total cycle time as the production rate is less during these days.
- Depute sales teams to client's works to explain handling and using the products to minimise rejection of products. Arrange direct sales from works to clients to eliminate middlemen.



## 2.15 Total Quality Management (TQM)

Progressive managements follow a total quality management (TQM) approach to build up reputation of the organisation for consistent good-quality products and credibility for meeting the delivery schedules. TQM indicates the culture, attitude, and organisation of the company which is making a serious continuous effort to provide products as per specifications given by the customers.

It shows the organisation approach that quality is the main goal towards which the activities for design, planning, and improvement are directed.

### 2.15.1 *Quality and Other Goals*

However, apart from quality, the goals of the chemical industry shall be safety, pollution control, energy efficiency, product quality, and to maintain rated production capacity with improvement in market share and customer satisfaction which is *reflected in repeat orders for the products*.

All plant engineers must therefore pay adequate attention to the following matters: safety, maintenance, pollution control, careful operation of the plant and machinery (which can increase equipment life), innovation, research and development, compliance with all statutory instructions and regulations, correct specifications for raw material, and inputs as these can contribute significantly to meet the goals of the company.

The culture requires quality in all processes and operations (which shall be done according to standard operating procedures) *right at the first time itself* while making maximum efforts to meet the above goals and eliminate off-spec products and minimise the generation of effluents.

### 2.15.2 *The Key Elements for Successful Implementation of TQM*

**Leadership** by the top management is most important. They shall lead by personal involvement to set example and shall inspire all members of the organisation (seniors and juniors) to meet the goals of the company towards TQM approach and should instil values for safety, pollution control, and quality. The leadership shall provide guidelines and directions to subordinates that are understood by all and create well-defined systems, as well as methods for their implementation and performance measures for achieving those goals.

Targets shall be set to operate the plants without any accident, while always meeting norms set by state authorities for effluent characteristics and generation, and meeting specifications for the products. Standard operating procedures shall be

well defined and explained to all concerned. Important parameters shall be displayed prominently on notice boards and as standing instructions. Any deviations shall be immediately investigated and corrective actions carried out (e.g. repair to safety valve; to scrubbing system; to process control instrumentation).

The top leadership, seniors, and juniors shall work as a team for success of TQM. The seniors must understand, believe, and practise TQM. They should make sure that strategies, values, and goals are well communicated throughout the organisation to promote focus and clarity.

Management shall create an environment where there is no fear to share knowledge (which is obtained from experience in the production plant) and suggestions for innovations. All team members shall be motivated to trust each other—due to ethical work culture.

The seniors must give credit where credit is due. This can further motivate juniors to carry out their jobs more sincerely and attentively and results in a successful TQM organisation.

**Ethical working:** Code of conduct (guidelines) that all employees should follow while carrying out their work. If a mistake is committed during operation by anyone, he/she should not hide it but try to correct it and inform coworking persons and seniors. It develops openness, fairness, sincerity, and involvement by everyone. *It will prevent recurrence of the same since the experience shall be shared with others.*

**Integrity:** Everyone in the organisation shall perform their tasks honestly and sincerely while being fair and adhering to the facts. *A customer will respect and place repeat orders on a company which has integrity in its workforce.*

TQM is built on **trust** which is generated by integrity and ethical conduct.

It promotes involvement and commitment of all members and hence the cooperation among them which is essential for TQM.

Team members shall trust the integrity, honesty, and sincerity of each other and decisions which are for continuous improvement of the process and products.

**Communication:** The success of TQM depends on clear communication among all the departments, seniors and juniors, and technical and non-technical personnel in the organisation and external suppliers and customers. Persons receiving the message must clearly understand the ideas the sender intended to communicate—when they are specially related to the required product quality and delivery schedules. Only correct information shall be communicated by the sender to the receiver to maintain the trust.

**Example:** Suppliers shall understand the need for urgent supply of items such as catalysts, spares for a process control instrument, and stabilisers for the finished product when a purchase order (*actually it will be an urgent communication*) is sent to them. They shall **act fast** because these items are required for ensuring proper reactions, and process and quality control, preventing deterioration of finished products.

Supervisors must listen carefully whereby employees can send about the TQM process. There are different channels of communication such as:

- The seniors shall make the junior employees understand clearly about TQM by providing guidelines and directions for meeting goals of their organisation. These shall be safety, pollution control, energy efficiency, product quality, maintaining rated production capacity, improvement in market share, and customer satisfaction (which is reflected in repeat orders for the products).
- The junior employees should be able to provide suggestions to seniors/higher management suggestions for improvement or inform genuine difficulties faced by them (during operations). Supervisors must listen to such constructive criticism, carefully and sympathetically. It can be useful to correct the situation that comes about. This forms a level of trust between supervisors and employees.

### **Communication between departments**

There shall clearly understand each other's requirements and difficulties and should listen to suggestions given for improvement in working to make it easier. Marketing shall understand the limitations of production engineers if they express inability to overload the plant units; production engineers shall cooperate with maintenance crew by more carefully operating the plant or arranging to stop the plant for some urgent repairs; stores department shall make available spares in time for repairs. This can help achieve safety, pollution control, and product quality. An environment of TQM is thus built up and maintained in the organisation.

**Training**—Training is very important for employees to be highly productive. Management and seniors are responsible for implementing TQM within the organisation and their respective departments and hence should organise professional training programmes—which are the key by which the TQM succeeds in an organisation.

- Orientation of new employees and to explain how they can contribute to the goals, the processes, and operations they will have to carry out and building trust among all by honest, sincere, and ethical working,
- Refresher courses for old employees,
- Mock drills for all employees to train them for response to emergency,
- Familiarise working of different departments. Persons should be trained to be able to work at different workstations if required. This training also helps them understand difficulties faced by others; they may offer some useful suggestions for improvement since they will be looking from a different angle.

Employees should be trained in technical skills, analysis of problems, generating new methods and ideas, estimating benefit–cost ratios, improvement in performance, and requirement of costs and time to implement any suggestions/ideas and to work as a team by mutual trust.

**Teamwork:** Discussions and cooperation among operating and maintenance personnel (chemical, mechanical, electrical, material purchase and marketing) can bring about permanent improvements in processes and operations. The problems can get highlighted, and practical solutions can be found out. The organisations can

build up teams of specialists and experienced personnel for continuously improving the working which contributes to the success of the TQM approach:

- Quality improvement teams—for addressing some recurring problems.
- Troubleshooting teams—to solve certain problems by identifying their causes and to minimise them.
- Working group teams—these could be small groups of skilled workers who share tasks and responsibilities. These can be quality circles also.

### **Recognition**

It should be given for both suggestions and achievements for teams as well as individuals. Giving due credit to deserving person as early as possible for good efforts, ideas, and suggestions is important job of a senior. It improves productivity, quality, and the employee morale. Recognition can be as:

- Special increment in salary,
- Promotion to higher post,
- Letter of appreciation from senior management,
- Praised in front of colleagues, in-house journals, in general notice boards, also in front of very senior personnel, and in staff meeting,
- Special award in annual company functions.

### **2.15.3 Suggestion Schemes**

Provide sealed boxes in every department where suggestion for safety, pollution control, Energy efficiency, better product quality, reducing breakdowns, reducing cost of production, increasing productivity of process equipments and machinery can be dropped in. These boxes shall be opened once every month and the best three suggestions can be implemented after making a benefit—cost analysis. Persons making these suggestions can be suitably rewarded.



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