Chapter -10

Summary & Conclusions

10.1.0 Overview:
“Systematic Comprehensive Study” on “Application of Operations Research in Mechanical Engineering” with major stress on TQM & TEM in different selected industrial sectors was undertaken. Various aspects related to TQM and Energy Conservation were investigated in five sectors - i) Casting / Foundry Industries, ii) Cement Industries, iii) Thermal Power Plants, iv) Mini Cement Plants – SSI and v) Chemical Industries inclusive of refineries.

Various Industrial units in the above mentioned five sectors were visited for case study purpose. Field visits were arranged for relevant Data Collection for more than 55 industries consisting of Eight Foundries, Seven Cement plants, Sixteen Thermal power plants, Nineteen Mini Cement Plants and Seven Other industrial units.

10.2.0 Summary & Conclusions for Industrial Sector: Casting / Foundry Industries

Improper process selection can lead to increase in complexity of production, increase in production time as well as increased cost of production. These drawbacks of Manual process selection can be overcome by using the fuzzy logic technique which is more suitable in selection methodology for casting process. In case of casting there are large numbers of processes to select from. Choosing the right manufacturing process for making a component is required at early stages of design. The casting processes have different characteristics. Similarly the component to be produced also has its own characteristics that are user defined. A novel approach can be to create the database for various process parameters for each process. The requirements of the product can then checked against the process parameters of each and every process and then we can have on our hand the compatibility of various processes for the given component. Weightage can be given to various parameters in terms of their importance and the best process can be identified for a particular component. The database can be fed in to a computer program and what we get is computer assisted process selection using fuzzy logic, which will save the time, improve the quality and reduce the cost of the casting. The queries are based on the application of fuzzy logic approach to determine the degree of compatible for each process. By using fuzzy logic approach based on mechanical parameters any alloy raw material that have values out of the range of absolutely limits will be eliminated. Then search for process that satisfies design requirements will enter to the next step of determining the optimal casting process and this process can be determined according to the degree of compatibility between product specifications and the capability of process. Thus it can be summarised that in this work, a systematic approach for casting process selection and design improvement has been proposed. This is based on evaluating and maximizing the compatibility between product requirements and process capabilities. The database is independent of the program and can be easily customized to any particular foundry. Fuzzy logic has been used to capture the imprecise nature of process characteristics, and Analytical Hierarchy Process has been employed to objectively assign weights to evaluation criteria. The approach can be implemented in a computer program and successfully used for selection of process and materials for industrial parts.

Using Taguchi method as discussed in this investigation can help in formulating a strategy to find optimum factors affecting the casting process and their interactions with a small number of experiments. Sand casting is used to manufacture complex shapes of various sizes depending upon the customer requirements. The basic requirements casting are pattern making, preparing a mold, pouring a molten metal, cooling of mold, shakeout, fettling. The main causes of rejection in castings are due to improper pattern, improper gating system, improper control of sand parameters, improper molten metal composition. The objective of this study was to optimizing the process parameters of sand casting process. The factor levels when optimized will result in reduction of casting defects and increase the yield percentage of the accepted castings without any additional investments. A usage of quality tools like Pareto chart is useful for finding the major defects in the daily operations of foundry. Quality of castings can be improved by aesthetic look, dimensional accuracy, better understanding of noise factors and the interaction between variables, quality cost system based on individual product, scrap reduction, reworking of castings and process control.

Lastly various steps have also been discussed which if implemented will result in energy conservation in the foundries. The most commonly used furnace in foundries is Cupola followed by the Induction furnace. Up to 50% of the foundry’s total energy consumption is accounted by Cupolas only. For efficient cupola operation guidelines and tips have been given for making the bottom sand base of the cupola, preparation of the coke bed, charging, melting, tapping and slagging.

Similarly the important energy saving measures in Induction Furnaces have been discussed.

Energy saving measures in other important operations have also been discussed for the following:

• Energy Savings in the Mould and Core-Making Process and Heat Treatment
• Energy Savings in the Machine Shop
The cement industry is an example of the continuous industry sector and this research demonstrated that the lean philosophy is applicable to all different organization types. There are numerous challenges facing the cement industry in today’s competitive environments; one of the major challenges is the capability of the cement industry to adopt and introduce the improvement approaches and techniques by which the overall enhancement can be achieved. The problem is that the cement industry is under pressure to reduce the downtime, cycle time, inventories and batch sizes. The cement industry is characterized by intensive energy and raw materials, large Work-In-Progress inventories, high breakdown levels, and the need to increase the productivity in order to meet high demands. The situation of not achieving the expectation of high machine utilization and production rates, low breakdown rates, and trouble free operation processes within the cement production line has motivated the undertaken research to design an integrated framework by which the cement production line will be improved and enhanced. The need for improving the efficiency of the cement production line is widely acknowledged in order to reduce the downtime rates, and satisfy high levels of market demand where the demand for cement is mostly second substance behind water. In response to this respect The research has used the cement industry which is accounted as the typical representative of the continuous process industry where the mass production system is adopted using inflexible and expensive machines to produce, transport, and accumulate tens of thousands of materials within each working area. The research has contributed to the body of the knowledge by studying and identifying the non-value added activities and attempted to implement lean within the cement industry. The cement industry is ideal example of the continuous process manufacturing; however the research has studied the cement industry through dividing the cement production line into three main processes such as raw milling process, thermo-chemical process, and finish grinding process. The research has handled each process as discrete or single process aiming to identify the interrelationships between the variables that associated with each process, and to determine the effects of these variables on the chosen performance parameters for each process. The research has highlighted some of the barriers that may cause the gap between the desired and the actual results, and prevent the cement industry from achieving any improvement. Based on the research findings the misconception and absence of open communication and commitments are among the most effective roadblocks within the cement industry. Furthermore the research has contributed to the knowledge through proposing standard steps which can be used as road map for implementing the lean philosophy within continuous industries and other organisations. The proposed transition steps are simple, direct, and understandable by the all people at the different organisation levels. The proposed transition steps can be summarised as:

- Achieving a fully understanding of the system through applying of the process mapping technique.
- Identifying the main variables and factors that control the system.
- Identifying different types of interrelationships between the variables and their effects on the performance parameters.
- Validating the obtained results. The main novelty of the proposed steps was the combination of the simulation model with the Taguchi Orthogonal Array aiming to improve the cement production line’s

10.3.0 Summary & Conclusions for Industrial Sector: Cement Industries (Large Scale & Medium)

Implementation of lean helps many industries to improve their productivity and efficiency. However the today’s challenge is to implement the lean philosophy within continuous manufacturing industries and different industries regardless to the type, size, or mission of the applicant organization. The cement industry is ideal example of the continuous industry sector and it this research demonstrate that the lean philosophy is applicable to all deferent organization types. There are numerous challenges facing the cement industry in today’s competitive environments; one of the major challenges is the capability of the cement industry to adopt and introduce the improvement approaches and techniques by which the overall enhancement can be achieved. The problem is that the cement industry is under pressure to reduce the downtime, cycle time, inventories and batch sizes. The cement industry is characterized by intensive energy and raw materials, large Work-In-Progress inventories, high breakdown levels, and the need to increase the productivity in order to meet high demands. The situation of not achieving the expectation of high machine utilization and production rates, low breakdown rates, and trouble free operation processes within the cement production line has motivated the undertaken research to design an integrated framework by which the cement production line will be improved and enhanced. The need for improving the efficiency of the cement production line is widely acknowledged in order to reduce the downtime rates, and satisfy high levels of market demand where the demand for cement is mostly second substance behind water. In response to this respect The research has used the cement industry which is accounted as the typical representative of the continuous process industry where the mass production system is adopted using inflexible and expensive machines to produce, transport, and accumulate tens of thousands of materials within each working area. The research has contributed to the body of the knowledge by studying and identifying the non-value added activities and attempted to implement lean within the cement industry. The cement industry is ideal example of the continuous process manufacturing; however the research has studied the cement industry through dividing the cement production line into three main processes such as raw milling process, thermo-chemical process, and finish grinding process. The research has handled each process as discrete or single process aiming to identify the interrelationships between the variables that associated with each process, and to determine the effects of these variables on the chosen performance parameters for each process. The research has highlighted some of the barriers that may cause the gap between the desired and the actual results, and prevent the cement industry from achieving any improvement. Based on the research findings the misconception and absence of open communication and commitments are among the most effective roadblocks within the cement industry. Furthermore the research has contributed to the knowledge through proposing standard steps which can be used as road map for implementing the lean philosophy within continuous industries and other organisations. The proposed transition steps are simple, direct, and understandable by the all people at the different organisation levels. The proposed transition steps have the answer to the possible questions and requests of the decision makers within the cement industry or other organisations. The proposed transition steps can be summarised as:

- Achieving a fully understanding of the system through applying of the process mapping technique.
- Identifying the main variables and factors that control the system.
- Identifying different types of interrelationships between the variables and their effects on the performance parameters.
- Validating the obtained results. The main novelty of the proposed steps was the combination of the simulation model with the Taguchi Orthogonal Array aiming to improve the cement production line’s
efficiency. The cement industry has all the features to be very thriving sector through adopting lean thinking. The successful implementation of the lean strategy ensures the achievement of the maximum efficiency in combination of simultaneous reduction of lead time and production costs within the cement production line.

The successful lean implementation will be achieved when:

- The right training and education program is provided to the people aiming to misconceptions about the lean philosophy.
- The right support and commitments of the management are obtained.
- The right motivation system is established

**Energy Conservation through Design Modifications and Technical Advancement:**

The production of cement is an energy-intensive process. Increasing energy prices are driving up costs and decreasing the value added. Successful, cost-effective investment into energy efficient technologies and practices meet the challenge of maintaining the output of a high quality product despite reduced production costs. This is especially important, as energy-efficient technologies often include “additional” benefits, such as increasing the productivity of the company.

A generalized overview of the various energy conservation measures considered in the seven cement plants has been discussed in the case study. The main modifications are as listed below.

- Coal Mill /Modification of the furnace grate bars to 25 mm from existing 50 mm
- Coal Mill: Electrical power saving by increasing coal mill drying chamber lifters height and angle
- Improved Drying of Coal through Insulation and Additional Hot Air Duct from the Coal Mill Furnace
- Increase of Inlet Duct Diameter of Circulating Air Fan to Reduce Flow Velocity and Pressure Drop
- Prevention of False Air Entry across Coal Mill Circuit
- Reduction of Velocity in Coal Mill Outlet Duct
- Reduction of Motor Size in Limestone Primary Crusher
- Reduction of Speed of Circulating Air Fan in the Coal Mill through Replacement of AC Motor with DC Motor

Despite the historic progress, there is ample room for energy efficiency improvement. Leakage, furnace and the drives have the greatest opportunities to save energy. Waste air also transfers a very important amount of energy, so the inlet air should be controlled and dust and stack gases can be used in pre-heater or other sections. Dry process will reduce the energy consumption (30% less than wet process). So programs for supporting the development of new dry process kilns must be continued. Promoting recycle economy, facilitating technological progress reduce consumption and protect the environment. Applying standards will help the industry to reduce energy costs in coming years.

**10.4.0 Summary & Conclusions for Industrial Sector: Thermal Power Plants**

Detailed study on thermal engineering aspects in power plant and implementation of TQM + TEM in power plant reveal the following:

- Barrier to Efficiency Improvement in Power Sector
- Need of improving Efficiency
- Good Practices for Maintenance and Energy Conservations

Hence appropriate detailing for all the above aspects has been done.

Six Sigma methodologies have recently gained wide popularity because they have proven to be successful not only at improving quality but also at producing large cost savings. Antony, J. & Banuelas In process industries like thermal plants, no such convenience is available. Steam/ water, the main working fluid in these industries may not be visible and its quality is measured by various instruments mounted on the process hardware in the form of pressure, temperature and flow measurement. Normally, in manufacturing industries, production is already operating at 1–2 sigma level and by applying Six Sigma methodology it can be raised to 5–6 sigma level, whereas in the process industries there are many sub-processes that operate even at negative sigma levels because they are secondary in nature. Therefore, in the process industries, a significant increase in the sigma value through the application of Six Sigma tools cannot be expected and it is found that the improvement potential is a maximum of up to 2–3 sigma level, but as the process industries are huge investment industries, e.g. thermal power plants, chemical plants and refineries. The cost benefits of applying Six Sigma can be significant to these industries. Optimisation of cycle make-up water (DM water) consumption is one such process. Any saving in DM water consumption pattern is a substantial cost saving for the industry and a service to society. It is calculated that each 0.1% increase in cycle make-up increases the generation cost by Rs. 80.46 Lakhs per annum, which includes the cost of heat loss, extra water and consumption of chemicals. Keeping this in mind, optimisation of cycle make-up DM water was chosen as an initiation project of applying Six Sigma techniques to the thermal power plant industry.
The summary of important outcome of this case study is as under:

- The application of Six Sigma project recommendations increased the mean DM water to 0.573% (with a total improvement of 0.336% mean), which is equivalent to a monetary saving of Rs. 270.34 Lakhs per annum.
- The estimated saving from the project after the implementation of all the recommendations is expected to be Rs. 321.84 Lakhs per annum, with mean DM water expected to reduce below 0.5%, which is substantial for any organization.

The study also elaborates on the energy conservation steps to be taken in a thermal power plant. Case study undertaken on few equipments demonstrate substantial saving possibilities in thermal power plants as could be seen from following facts and figures:

- The total annual energy cost saving potential in case of ID Fans is expected to be highest being Rs. 137.0 lakhs per year with total investment of Rs. 450 lakhs thus having payback period of 3.3 years.
- In case of the condensate extraction pumps, total saving expected is Rs 21.65 lakhs with justifiable investment of Rs. 21.65 lakhs, thus having payback period of 1 year.
- In case of the compressors, the expected saving is Rs 12.75 lakhs per year against the investment of Rs 9.25 Lakhs thereby having payback period of less than one year.

10.5.0 Summary & Conclusions for Industrial Sector: Mini Cement Plants – Representative of SSI

Mini cement plants come under the category of S.S.I. units. Mini cement plants generally start manufacturing of cement from Clinker – supplied to S.S.I. units by big manufactures of cement. In Mini Cement Plants wherein all the operations after clinker formation like crushing grinding, mixing etc are identical with that of any big cement plant. However, sizes of these equipments also become mini depending on manufacturing capacity of the plant. Thus, Mini Cement plants are also “energy intensive plants” and TEM measures is as such also a necessity in these plants. However, these – one man manager enterprises simply do not bother about implementation of even TEM. Hence, TQM implementation is also ruled out. Further, stringent Pollution Control Measures put up by the pollution control Board are not being followed by these units. These units also do not bother about Implementation of Energy Conservation Measures (ECM). Overall result being, many mini cement plants are on the verge of closure. Detailed study on Thermal Engineering Aspects in Mini Cement Plants and Implementation of TEM was carried out by visiting 19 mini cement plant units:

By appropriate Mechanical Design of Pollution Control Equipments and utilizing only such certified equipments in the plant, these mini cement plants can solve their Pollution Control Board problem. Further, effective implementation of TEM via Design will only help these entrepreneurs. The approach appears to be costly as it involves increase in expenditure of fixed capital cost, however, ultimately after running a mini cement plant at least for a year, and implementing TEM measures collectively and simultaneously, will certainly yield a “favorable result”. However, during initial period of 1 to 2 years there may be no financial gain. Detailed engineering flow sheet for mini cement plant indicates that via design of plant equipments, cement of required quality can be obtained. Depending on plant capacity, sizes of different equipments get altered. Hence, computerized programme for design of pollution control equipments was prepared and accordingly detailed engineering drawings for these equipments were drawn. All these drawings are a function of mini cement plant capacity. As plant capacity changes design parameters do get change and accordingly design modifications are required in mini cement plants to implement TQM in plant.

Computer aided design of pulse jet bag filter and wet scrubber depending on the capacity of mini cement has been done and the relevant detailed dimensional drawings are incorporated in this chapter. All these drawings could be utilized conveniently by mini cement manufactures. It consists of a set of 10 different drawings depending on capacity of mini cement plant. Further, it may be noted that such type “Equipment Design and Drawing” related information is not available in the literature. It is expected that by using appropriate set of these drawings, pollution control equipments can be fabricated and lowest levels of pollution can be maintained in the mini cement manufacturing plan.

Techno-economic viability of two mini cement plants has been considered in detail and its summary is as under:

**Case Study – I: Toranto Cement Ltd:**
Justifiable annual investment required is Rs. 90.0 lakhs. Annual energy cost saving potential is of the order of Rs. 93.0 lakhs. Thus, simple pay back period is one year. It means after one year, Rs. 7 to 8 lakhs per month will be reduction in recurring expenditure which can be considered as a gain. And this amount can be invested in “Pollution Control Equipments”. Thus, techno-economically it is a viable proposition.

**Case Study – II: Raghuvir Cement Industries Ltd:**
Justifiable annual investment required is Rs. 55.0 lakhs. Annual energy cost saving potential is of the order of Rs. 45.2 lakhs. Thus, simple pay back period is one and half year. It means after one year, Rs. 4 lakhs per month
will be reduction in recurring expenditure which can be considered as a gain. And this amount can be invested in “Pollution Control Equipments”. Thus, techno-economically it is a viable proposition.

**Important Energy Conservation Measures in Mini Cement Plant:**

Following are important energy conservation measures which can be implemented in mini cement plant:

- Incorporation of a Screen to separate fines and small particles to avoid fine generation in crushing
- Incorporation of a magnetic separator to separate iron pieces in coal, which may damage the crusher
- Arrest leakages coming from crushers, hammer mill
- Enclosure for Belt Conveyor to be provided from Jaw Crusher to Hammer mill
- Energy Saving by installation of Variable frequency Drive's for Crushers, Grinders, Kiln, etc
- Energy Saving by using properly size motors
- Avoid use of rewound motors
- Energy Saving by replacement of inefficient lamps with energy efficient lamps
- Energy Saving by means of adopting Natural Lighting
- Coal saving by using alternative fuel in the Vertical Shaft Kiln
- Coal saving by Waste heat recovery from Flue Gas
- Temperature in various zones of VSK to be maintained by installation of Thermocouple followed by adequate monitoring
- Install online oxygen analyzer for the flue gas to control excess air and also to monitor the combustion efficiency of Vertical Shaft Kiln
- Providing better outer surface insulation to the burning zone of VSK
- Reduce the kiln stoppage time by better management practices

**10.6.0 Summary & Conclusions for Industrial Sector: Selected Chemical Industries**

Good scope exists to apply HENS & MENS to have heat recovery and energy conservation in thermal power plants as well as in refineries producing different feed stocks

**New Methodology for RCWS:**

Re-circulating cooling water system (RCWS) are widely used as the industrial waste heat rejection system. They offer the opportunities for conservation of water and energy as well as reduction of the pollution when compared to once through system as they do not re-circulate the water. In conventionally cooling water system cooling tower supplies the cooling water which goes through a network of coolers which are usually of parallel configuration. In this fresh cooling water is provided to the individual heat exchanger directly while hot cooling water returns to the cooling tower afterwards. Mixing water from individual heat exchanger decreases inlet water temperature and also increases the inlet water flow rate of cooling tower. This leads to decrease in the performance of the cooling water. Hence the better alternative can be changing the configuration to series arrangement as it will give the benefit of water reuse and also makes it possible for water with high temperature and lower flow rate at a lesser cost. In RCWS design, any possible changes in each system component should be predicted properly. To achieve this, directly interacted cycle components should be accounted simultaneously. Pinch technology, as the most common design tool, can be used. This technology is based on targeting prior to design and exploits conceptual understanding. Pinch technology in water system design has been developed through principle concepts to make opportunities for energy saving in process design, since it cannot be applied for energy conservational implications. Previous researches on RCWS focused on the cooling system components individually, not the system as a whole. However, the new methodology proposed i.e. simultaneous integration of RCWS components provides opportunity to achieve the optimum design.

During this research, an optimum cooling water system was designed to minimize the total cost while maximizing water and energy savings. To accomplish the objectives of this design, a cooling tower model is presented to predict the cooling tower performance parameters, water temperature and flow rate under various conditions provided by the heat-exchanger network. The model is then followed by the RCWS design, which is based on pinch analysis and mathematical programming. This designed model, called the “integrated ozone treatment cooling system (IOTCS)”, considers the cycle water quality by involving ozone treatment to the cooling water system. By using this method, an optimum heat-exchanger configuration was obtained by introducing a feasible area concerning the constraints that were dictated through the whole cooling system and exploring the optimum water supply line regarding minimum total annual cost. The optimization model was based on a relaxed approach value which considered the defined feasible region to accomplish the optimum water supply line and cost-effective heat-exchanger configuration.

Mathematical modeling of cooling tower has been undertaken for a counter-flow wet cooling tower with mechanical draft. For optimum design of the RCWS, three step methodologies has to be followed as below:

Define feasible region from cooling composite curve
Explore the feasible region to target cooling water supply line
Design the cooling water network for target conditions.
An example has been discussed to elaborate the above methodology which shows the benefit of this methodology compared to the conventional approach. The methodology can be successfully applied in the thermal power plants.

**Heat Exchanger Network for Crude Distillation:**
In crude distillation, a well-designed crude and vacuum unit (CDU/VDU) heat exchanger network is essential to meet product yield, product quality, unit reliability and crude processing flexibility objectives when processing heavy crudes. Preheat trains conceived with the wrong flow scheme or those with multiple parallel paths that are complex to operate rarely have the flexibility needed to handle a range of crude blends or even the variability of many heavy crudes. Standard shell and tube exchangers designed with low velocity are prone to rapid and heavy fouling. It is becoming ever more important to temper crude train design that has been developed from composite curves, optimal energy targets and pinch points with crude unit experience and know-how. Practical concerns include operability, reliability, exchanger type and minimal fouling design. A critical review of the practices followed for crude distillation w.r.t. to heat exchanger networking has been carried out and the scope of present research work has been restricted to “Establishing Guidelines” w.r.t. crude unit Heat Exchanger Network based on exhaustive literature survey already performed.

**Utilization of Non Conventional Energy Resource:**
For the production of different chemicals in Industrial Sector, Thermal Engineering Aspects (TEA) are of utmost importance because of the fact that all such production units are generally highly energy intensive. Hence, utilization of non-conventional energy resource – Hidden Energy (Heat of Reaction) in particular appears to be an area which has been generally neglected – because of non-availability of thermodynamic data for various parameters for different chemicals like raw materials, intermediate products and final product inclusive of co-products. Based on “exhaustive literature survey” and also based on “industrial visits” to different manufacturing units, various technological alternatives available for the manufacturing of a particular chemical - Formaldehyde have been critically surveyed. Then, using principles of MEB, detailed Material Balance Flow Sheets have been prepared. Simultaneously, detailed Energy Balance Flow Sheets have also been prepared for various technological alternatives. These MEB flow sheets can be analyzed critically from Thermal Engineering Point view. Though such a study is time consuming and tedious, it is the most essential requirement in this novel approach of “Effective Utilization of non-conventional Energy Resources”.

Effective Utilization of Non-Conventional Energy Resource in Chemical Sector via Energy Conservation” has been thus achieved in a plant manufacturing a petrochemical product: Formaldehyde by using combined route and by doing process design modification.

Formaldehyde can be manufactured by two different processes namely – dehydrogenation and oxidation.

**Route – I** refers to dehydrogenation reaction, basically endothermic in nature. **Route – II**, refers to oxidation reaction, basically exothermic in nature.

**Route – III**, proposed in this investigation, can be considered as more environmentally friendly route and least energy intensive route. As the new technological option, both the routes are carried out in a combined reactor – using Shell and tube heat exchanger as a reactor and carrying out both reactions simultaneously in it. Among three routes total energy requirement (kJ / day) in terms of preheating the raw materials and separation of products from other chemical spices in combined route (Route – III) is very low in comparison with the other two routes.

- In other words, Dehydrogenation route requires total energy $37.81 \times 10^7$ kJ / day, whereas combined route requires total energy of $27.42 \times 10^7$ kJ / day.
- Hence in this combined route (Route – III) approximately 27 – 28% of total energy can be saved. This is the good example of energy conservation.
- In comparison to Route – II and Route – III, the total energy required in Route – II is $61.7 \times 10^7$ kJ / day, whereas Route - III requires total energy of $27.42 \times 10^7$ kJ / day.
- Hence in this combined route (Route – III) approximately 45% of total energy can be saved.
- So, combined route can also become the good example of Energy conservation.
- Hidden Energy (Heat of Reaction) can be utilized effectively.

Thus, in a plant of Formaldehyde manufacture having production capacity of 50 Tons/Day by implementing Process-Design Modification – i.e. Conventional Tubular bed reactor to be replaced by Shell & Tube Heat Exchanger as a reactor – energy saving to the extent of $14.2 \times 10^7$ kJ / day minimum / $26.1 \times 10^7$ kJ / day maximum can be achieved depending on the route utilised for the production of Petrochemical – Formaldehyde. This is the most important unique feature of the Ph.D. Research Project. Production of some other Petrochemicals like Vinyl chloride, Acrylonitrile etc can also be under taken using this novel concept of Utilization of non conventional energy resource – Hidden Energy (Heat of Reaction) via Energy Conservation Technique.