A STUDY OF PETROCHEMICAL PROJECT MANAGEMENT AND DESIGN PRACTICES IN PETROCHEMICAL FIRMS IN CHINA, HUBEI CHANGJIANG PETROCHEMICAL EQUIPMENT CO., LTD (CJPCE) AS STUDY CASE

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ABSTRACT

Petrochemical Project management continues to develop methods and techniques in response to ever-increasing complexity in delivery of projects. Projects however continue to be described as failing, despite the management. Why should this be if both the factors and the criteria for success are believed to be known? Project management seems keen to adopt new factors to achieve success, such as methodologies, tools, knowledge and skills, but continues to measure or judge project management using tried and failed criteria. This study identifies and assesses the project design practices at Hubei Changjiang Petrochemical Equipment Co., Ltd (CJPCE) presented by Design Management Department (DMD). It assesses the degree of fulfilling the DMD design practices its client's requirements for their projects. The data of design practices was obtained from literatures and interviews with DMD key personnel such as senior design engineers and specialist design engineers in CJPCE and two Engineers in SABIC, Saudi Arabia Company. This study ends up with some recommendations to improve the current design practices at DMD and to fulfilling the requirements. The recommendations are: (1) introduce Quality Control System edited by third party, (2) introduce a contractibility plan and (3) prepares a feasibility study for proposed projects.

Keywords: *Petrochemical Project Management, Project design, Design Management Department, Project success, Total Quality Management, CJPCE.*

1. INTRODUCTION

Over the years Petrochemical Project Management is a carefully planned and organized effort to accomplish a specific one-time objective. It includes developing a project plan, which includes defining and confirming the project goals and objectives, identifying tasks and how goals will be achieved, quantifying the resources needed, and determining budgets and timelines for completion. In this study I m focusing on the petrochemical project since Petrochemicals are very important in our daily life. The scope of products manufactured from petrochemicals is broad range from, insulators, cable wrap, fertilizers, plastic, and rubber to everyday items like home furnishing, cloths and toys. The demand of petrochemical is increasing in the last three decades.

Petrochemical projects associated with the production of petrochemical products such as intermediates, polyester, polyolefin and fertilizer. Those projects are highly technical in nature and frequently built by large, specialized industrial contracting firms that do both design and construction. Beside main process related projects there are many support projects that of less complexity and can be designed and constructed by the petrochemical company itself or by local contractors. In both cases, design services are required. Petrochemical projects just as other projects need to be executed as per the high quality specification, within budget and on time. Moreover, each petrochemical project is unique because for each petrochemical product, there are industrial codes and standards which control the design and construction of related petrochemical product. In addition, petrochemical projects are high technology project and most of the technologies are patented. These patents make the process of design and construction much complicated. This research attempts to identify and assess the design practices in CJPCE and attempts to improve the current quality of design services practices provided by design management department (DMD).

2. STUDY RESEARCH

A. Research objectives

The main objective of this research is to identify and assess the design practices in petrochemical industry in China in general and in CJPCE particular. This assessment attempts to improve current design practices. To achieving this objective, the following questions will be answered:

1. What is the best design practice applied in the international petrochemical firms?
2. What is the common design practice applied in Chinese petrochemical firms?
3. What is CJPCE design practice for petrochemical projects?
4. How to measure the performance of design practice?
5. What is the role of local engineering firms in petrochemical projects?
6. How to improve the design services in petrochemical industry in China.

B. Scope of the research

This study is limited to study Petrochemical Project and design practices performed in Hubei Petrochemical Equipment Company (CJPCE) in China by Design Management Department (DMD).

C. Significance of the research

The significance of this study stems from its nature since it is related to the petrochemical industry, which plays a very important role in the World economy. Globally, the demand of petrochemical is increasing and China is considered one of the petrochemical Equipment suppliers. For this reason, petrochemical industry is expanding to meet the demand of clients. An essential ingredient in meeting this demand is to expand existing plants and to build new ones. Constructing new petrochemical factories and plants needs to be executed in very efficient manner to maximize the profit of the projects. Obviously, efficient construction depends on efficient design. As such, design plays an instrumental role to this critical industry.

3. CHARACTERISTICS OF PETROCHEMICAL PROJECT

1. Characteristics of Petrochemical Project

Petrochemical firms and Equipment factories are well organized and one of the most important departments is Engineering Department. Most of petrochemical firms have continuing construction projects either expansion or upgrading the existing facilities. Sometimes in-house design department capability is not enough to handle the projects due workload or due the complexity of the project. In this case, the owner outsources the engineering services. Outsourcing might by in form of manpower supply or as a contract with engineering firm (Clough and Sears, 1994).

The typical contracts types in petrochemical projects are: Engineering, Procurement and Construction (EPC), Engineering, Procurement, Construction and management (EPCM) and lump Sum Turn Key (LSTK). These types can be observed from reviewing the worldwide petrochemical projects profiles (Amison, 2005).

In EPC projects, there is one entity who is responsible to provide the engineering (basic design and detailed design), the materials and equipment, and the construction for the project. The attributes of EPC contract as the following:

- The design and construction are time overlapped where construction may begin before design is 100% complete.
- Procurement may begin prior to construction.
- Specifications are performance-based rather than prescriptive.
- Minimal owner involvement and decisions are required.
- Design and construction quality are controlled by the EPC Contractor.
- Costs are known once the EPC contract is awarded, and typically are fixed.
- Transfer of responsibility and most risk from the owner to the EPC contractor for the entire design and construction.
- Construction experience is integrated into the design process.

Other type of contract is EPCM where the contract includes the project management within the scope of the contractor. In LSTK there is little or no owner involvement in a project wherein the contractor essentially turns over the keys for the facility to the owner at the end of construction. In all EPC, EPCM and LSTK contracts, commissioning and startup are often included in the contractor's scope of work. (Masucci and Freidheim, 2005).

The history of petrochemical projects shows that, there are many players in petrochemical construction industry including owner, engineering firm, construction contractor, technology owner, licenser, vendor (material supplier) and project manger. Petrochemical projects started with the selected of the technology of producing the desired petrochemical product such as polyethylene or polypropylene for new plant projects. There are many agencies provide the different technologies to produce same product. The owner selects the appropriate technology based on his priorities and his ability. Technology owner may delegate the license to another agent. In this case project owner has to pay the licenser for using the technology. After the technology is selected and licensed, owner can selects the type of contract such as EPC, EPCM or LSTK to complete the project (Loudermilk and Stein, 2002).

2. Engineering services

Engineering services cover a wide range of services including design, project analysis and construction support services.

Project analysis services are those services related to the feasibility of the project. Feasibility study addresses the need of the proposed facility, the economic requirement, site accessibility, location suitability, legal requirement, operation manpower to operate the new facility, value engineering, disturbance of ongoing operations and market analysis. Project schedule is a major consideration in the project analysis since it needs to be selected in the right time to minimize shutdown time and disruption of ongoing production.

Project support services include bid evaluation, technical evaluation construction supervision, quantity survey, cost control and construction management.

3. Design and planning services

Design and planning services is the main function of engineering services. Developing design for a given project entails the preparation of the required engineering documents to build the project. Generally, the design package of petrochemical projects includes scope of work, drawings, specifications, required calculations, material needed, project cost estimate and hazard identification study. Design packages may include documents used for bidding and official communications (Clough and Sears, 1994).

Design Best Practice can be defined as a process or method that, when correctly executed, leads to enhanced system performance. Each firm has its own practices to develop the design works within the general agreed practice known in each industry. General agreed practices are issued by professional organizations such as the Construction Industrial Institute (CII), National Petrochemical and Refiners Association (NPRA) and American Chemical Society (ACS). However, there are different approaches to develop design services which vary from industry to another and from firm to another. Each industry has its norms and practices.

Generally, petrochemical design packages include project scope of work, specifications, design drawings, material required, cost estimate and process hazards analysis. Each of these items is explained below.

4. Scope of Work

Scope planning is "the processes of progressively elaborating and documenting the project works that produces the project" (PMBOK 2000, p.55). The scope statement forms the basis for an agreement of the project objectives and its deliverable.

Preparing scope of work is a crucial process because it impacts all later stages. In petrochemical projects the owner must define the scope of work precisely. Because vague scope of work leads to undesired results. For example, a vendor or a contractor may supply or construct something that owner does not need and may cost the owner unnecessarily.

The scope of required engineering services is subject to a considerable variation, depending on the needs and wishes of the owner. Basic to such services, are establishing the needs and desires of the owner, developing the design, preparing the documents required for contractor bidding or negotiation as well as for contract purposes, aiding in the selection of a contractor, and making an estimate of construction cost (Clough and Sears, 1994).

The scope of services provided to the owner by the designer during field construction depends on the needs and preferences of the owner. Responsibility of the designer to the owner may end when the contract documents are finalized and delivered. On the other hand, the owner may require full construction-phase services, including project inspection, the checking of shop drawings, the approval of periodic payments to the contractor, the issuance of a certificate of completion, and the processing of change orders. Although the designer is not a party to the usual construction contract between the owner and contractor, this contract often conveys certain powers to the designer such as the authority to decide contract interpretation questions, judge performance, reject defective work, and stop field operations under certain circumstances (Clough and Sears, 1994).

5. Design Drawings

Drawings are the most important part of the design package since they contain the major information needed for construction. Drawings show the location of the project site, location of existing utilities and access roads. In addition, drawings show the equipment layout and arrangement. Required quantities are usually shown in detailed drawings in addition to installation details. Contractors refer to the drawing most of the time during all project phases (Clough and Sears, 1994).

Drawings of any petrochemical plant undergo many changes due to the operation and maintenance activities. Typically this changes do not reflected in the existing drawings to form As Built drawings. The archived master drawings remained as it is without change. This action creates problems requiring long time and a lot of extra expanses. To avoid these problems, any petrochemical firm has to apply Engineering Drawings Update Program (EDUP). EDUP is a system to keep all important drawings updated due any change.

However, it is not feasible to update all drawings such as fabrication drawings and shop drawings. The critical and important drawings need to be updated such as Piping and Instrumentation Diagrams (P&ID), Process Flow Diagrams (PFD), design drawings (including location, equipment layout, plot plans and piping plans), electrical drawings (including Single line diagram, cable layout and schematics), underground facilities drawings, Area Classification drawings and equipment data sheets based on inspection records. The new change shall be highlighted by cloud or different pattern to be identified very clearly. Revision number must be shown with written description of the change to keep the record in the drawing itself (Goyal, 2002).

Vendors participate in the design process by supplying products data to the designer. Vendor data are the technical information provided prior to equipment delivery for the purpose of incorporation into design drawings and specifications. In some cases, the incorporation is made in as built drawing after the construction is completed. Vendor data can be a drawing, table, cross section or flow diagrams (Coucha and O'Connor 1996).

The computer production of construction design and drawings is now an important and growing area. Computer-assisted design and drafting (CAD) systems are now being used by engineers, owners, and contractors to design structures and produce finished, dimensioned working drawings for field construction use, a process that makes their operations much more productive and profitable. CAD systems facilitate the rapid development of the design and production of high-quality construction drawings that convey much more information than their manually created counterparts. With CAD the designer can draw, make changes, model, and experiment with speed, efficiency and precision. The most famous two CAD software used in the industry are AutoCad and MicroStation.

Electronic drawing makes the communication much easier especially in petrochemical industry where the designer office is apart from the owner office. Designer can send the design drawings to the owner for review and approval. Owner can review and comments the drawings and resend them back to the designer to issue final drawings.

CAD drawings can be continuously updated relative to changes and modifications made to plans and elevations. Many of these systems also determine the field quantities of work as the design proceeds, which make it possible for the designer to prepare a bill of materials for bidding purposes. Also available is software that generates isometric drawings from plot plan (ISOGEN). Advance CAD software has the capability to enhance all data required for the plant such as equipment data sheet and related calculations hyperlinked to the drawing (smartplant).

6. *Specifications*

Specifications describes in worlds of what is to be done and how it is to be installed. The term specifications refer to the description of a product or a method. Sometimes specifications refer to the complete design package that includes drawings and the written description bound in a book to supplement the drawings. The general practice is to refer to drawings as plans and to the book as the specifications (Clough and Sears, 1994).

Specifications are divided into three divisions: bidding documents, conditions and technical division. Bidding documents contains invitation to bid, instructions for bidders and proposal form. Conditions include the general and special conditions of the contract between the owner and construction contractor. Both bidding documents and conditions divisions are used for contracting management. Generally, both divisions are not changed except the special conditions are revised to suite each project. Depending on the owner policy's and rules, those two divisions may take different shapes. For public projects when the government manages the projects and the bidding is open for all qualified contracts to participate with same document format. In the case of petrochemical projects only few qualified contractors whose already familiar with owner's contracting system are bidding for the project. Thus, the bidding document and conditions can be customized.

Normally, big petrochemical organizations procurement department take care of bidding documents and conditions division. Contractors usually submit a prequalification to procurement department and if the contractor satisfies the minimum owner's requirements, the contractor is approved. Once a contractor is approved, he is eligible to be invited for bid. For that reason, approved contractors are aware about owner rules and conditions.

Technical division is purely engineering document. There is no unique method to write the technical specifications. However, there are six basic types of specifications: performance, description, brand name, closed, open and reference specifications. In addition, combination specification containing two or more type may be used in some cases (Clough and Sears, 1994).

Performance specification is one where the performance of the product rather than the product itself is specified. Example of performance specifications is when a pump is required for pumping 10 gallon per minute with 30 pound per square inch (PSI); motor power shall be five horsepower with 220 volts.

Descriptive specification is performance specification plus other criteria such as shape, size or color. In previous pump example, pump skid size or arrangement can be added to the specification to become descriptive specifications. Descriptive and performance specification are called open specifications.

Brand-name specification is where a specific product is specified by manufacturing name and model number. Brand-name specification is closed specifications. Although, in closed specification many brands may be specified as alternatives. In this case, the specification called multi-product specification. Also, this closed specifications can be made open by adding "or approved equal".

Reference specification is where the item desired is referred to by a number corresponding to a number in published specification. This type used when the owner print complete specifications on commonly used products. Usually this type used for specific owner projects only.

Combination of specifications types may be used in some cases. It used where a product is needed with specific mechanical characteristics and comply with certain standards. For example, a pump is needed with particular performance parameters plus compliance with API-610 (American Petroleum Institute, centrifugal pump standards).

In petrochemical projects, performance specifications are used most frequently. However, brand name specification is used too for two reasons: to match existing equipment and to reduce maintenance. Using same brand all over the plant leads to reduced spare parts inventory and maintenance effort. On the other hand using brand-name may cost the owner more since there are cheaper alternatives. Performance specification gives chance to select the best offer satisfying the requirement (Amison,2005).

Petrochemical processes are very advanced technology that innovated by a company or by research institute. The patent is issued for the innovator who may not involve in the marketing or business industry rather than research or producing. Therefore, innovator or patent holder firm may need a third party to market its innovation to the clients. In this case, the license is issued for the tired party who called the licenser. The new technology equipment is manufactured by approved manufacturer. Most of petrochemical process products market is monopoly market where unique product controlled by single firm (Amison,2005).

Consequently, project owner interference is very limited in process related projects and specification type is brand-name specification in this case. Usually owner is involved in utility and support projects where no patent or license available. For those projects, performance specifications can be used.

7. Cost Estimate

Cost estimate is part of engineering services. The cost estimate is an important document which assists in decision making and cost controlling processes. Cost estimate is defined as the technique that is followed in order to determine the amount in monetary terms necessary to undertake an activity. The determination accounts for materials, labor, equipment, and many other variables that affect conducting that activity. Owner figures out whether the available budget is enough to satisfy the project criteria or not after developing the feasibility estimate (Al-Thunaian, 1996).

A preliminary (Conceptual) estimate is developed as part of the project conceptual plan to set an approximate cost for the project. It is considered more sound than feasibility estimate and cost estimation methods such as range estimate, factor estimate, and parameter estimate are used. Detailed Estimate is developed for bidding purposes. It involves the development of quantity take-off, labor cost, equipment cost, and other cost affecting parameters. The owner may select to develop it in order to be able to compare and analyze bids (Al-Thunaian, 1996).

Detailed cost estimate is prepared after completing the detailed design. All required material is extracted from project drawings. Exact prices of equipment and installation can be taken directly from the vendors. Construction work cost can be estimated by using the previous similar project cost records (Al-Thunaian, 1996).

Economy theory of supply and demand states that, the price is affected by supplied and demanded quantities. For that reason and beside other reasons the prices are not fixed. Normally, each quotation has a validity period. The validity is varying from one month to three months. Price instability is a potential problem in cost control. The typical scenario is when the cost was estimate prepared based on a quotation and the purchasing of an equipment is made during construction at that time the prices has changed (Sturts and Griffis, 2005).

Contingency percentage is used to overcome prices variation problem. Contingency percentage depends on the organization cost policy and the nature of the products. Global economic stability leads to lower contingency percentage and vice versa.

Overhead costs (OH) are those charges that cannot be attributing exclusively to a single product or service or the costs that are not a component of actual construction work but incurred by the contractor to support the work. Overhead constitute very important portion of cost, which varies between 8% to 30% of material, labor, and equipment cost or 12% to 50% of labor cost. Because of this reason some of contractors who underestimate overhead lose their business (Assaf et al, 2001).

The best costing practice is to optimize (OH) level to accomplish its strategic goals at lowest possible general expense. Reasons why it is difficult to measure the effectiveness of OH costs includes:

- Uncertainty of defining the activities that generate OH cost.
- The importance of the indirect activities and its impact in the quality of the performance.
- Ambiguity of the cost of indirect activities.
- Defensive mechanism may occurred because of cutting OH cost.
- Lack of planning and determining the priorities.

In Saudi Arabia, the ratio of company OH cost to project direct cost on the average is about 13%, while the ratio of company OH cost to annual construction volume is 14.3 %. Causes of increased company OH cost include delayed payment, lack of new projects, cost of inflation and government regulations. Factors affecting Company OH costs are: automobile and equipment cost, head office expenses, labor related cost and financing cost (Assaf et al 2001).

In China, most of engineering firms use budgetary quotations from vendors to complete the cost estimate. Big companies such as CJPCE have their own material management system that provides latest prices of frequently used materials. In some projects the work involves repetitious activities such as providing communication towers a long a highway. Work activities are the same but the quantities vary for each location. In such case, designer predefines the work activities and asks contractors (on behalf of the owner) to bid for each activity. Once contractors submit their bids, the engineer evaluates these bids and hires the construction contractor. The contract is based on unit price and many contractors may be hired for same project. In this case the designer will determine the cost estimate after completing the design and preparing the required quantities for both material and labor by using the project cost index.

8. Process Hazard Analysis (PHA)

Petrochemicals by nature are potential for hazards since they are flammable, explosive and have toxic effects. Moreover, all petrochemicals operations are associated with high risk since all reactions take place in high pressure high temperature. For these reasons petrochemical process needs hazards analysis which formally known as process Hazards Analysis (PHA).

The main purpose of PHA is to identify high-risk hazards associated with a chemical process. Once the high-risk hazards have been identified, corrective action can then be taken either to eliminate them or to minimize their impact (Sutton 2003).

PHA has three goals: the first goal is to identify hazards, where a hazard is defined as the potential conditions that may cause a significant incident. The second goal is to identify the hazards that related to process. The third goal of a PHA analysis is to concentrate on high-risk hazards rather than high consequences (Sutton 2003).

The occupational Safety and Health Association (OSHA) provides an overview of the key PHA methodologies that include the following:

- Hazard and Operability Method (HAZOP)
- What-If
- Checklist
- What-If / Checklist
- Failure Modes and Effects Analysis (FMEA)
- Fault Tree Analysis
- Other Appropriate Methods (such as Monte Carlo Analysis)

None of the above methods is inherently better than any of the others. They all have their place, and are often used in combination with one another (Acutech 2006).

Generally, HAZOP method is the most rigorous and time consuming method. It is the most systematic and thorough type of PHA, the HAZOP technique is sometimes used simply to ensure maximum compliance with regulations, even though it may not be the best technical choice, and even though one of the other methods can be just as effective at finding the hazards in a particular situation. Frequently, company legal advisors recommend the use of HAZOP method because of its completeness and because of its acceptance by regulatory agencies (Acutech 2006).

HAZOP can be defined as "a structured and systematic examination of planned or existing process or operation in order to identify and evaluate problems that may represent risk to personnel or equipment or prevent efficient operation" (Acutech 2006, p 07.). Normally the HAZOP study is carried out when the detailed design has been completed. HAZOP recommendations and comments are incorporated to release the final design revision. The HAZOP is usually carried out as a final check. A HAZOP study may also be conducted on an existing facility to identify modifications that should be implemented to reduce risk and operability problems (Sutton 2003).

9. *Total Quality Management*

Quality management system is very essential in the design process. The general practice of design quality management is to use total quality management TQM system. TQM is a structured approach used to improve the design quality. It is a continuous process to identifying owner's requirements and ensures that the owner is satisfied with design services provided. Whereas quality assurance is a systematic action taken to provide confidence that the completed design will satisfy owner's requirements (Bubshait and Al-Atiq, 1999).

ISO 9001(Quality Management Systems Requirements) is implemented by most of design firms to be quality assurance certified. ISO 9001 determine the quality management requirements, responsibilities, resource management, procedures, and monitoring that necessary to establish quality management system (ISO 9001, 2000).

Al-Abdurazzak prepared a study about quality management activates in design and construction (Al-Abdurazzak, 1993). In this study 29 quality management activates during the design phase are identified and ranked as shown in the table below. The ranking is based on a survey conducted for 38 Saudi design firms.

Table 1. Ranking of Quality Management Activities

Factor	Quality Management Activity	Overall Ranking
8	Drawing checks/Review	1
16	Functionality Review	
27	Provision of clear, concise and uniform plans and specifications	
9	Specification checks/Review	2
11	Review of client's comments	
12	Review / check of standards	
14	Review/check of space allocation	
17	Capacity review	
22	Provision of technically qualified design team members	
23	Provision of cost estimate of the project	
2	Establishment of qualification parameters for persons whose activities affect the quality of work	3
7	Calculation checks of the design	
10	Formal drafting check/Review	
13	Review/check of regulations	
15	Review/check of aesthetics	
19	Frequent contacts between the project parties	
24	Submission of progress reports to the owner	
21	Communication to resolve conflicts	4
25	Standardization of office procedures	
18	Documentation of any documents related to the design team members	5
4	On the job training for employees	6
26	Office library facilities	
1	Definition of the interrelationship and responsibilities of the quality program management and direction	7
20	Communication program	8
3	Establishment of an incentive system to motivate persons to produce quality work	9
29	Arrangements for project peer review	10
5	Short courses for employees	11
6	Seminars for employees	
28	Arrangements for organizational peer review	

Source: Al-Abdurazzak,1993

Another study conducted by Farooq (1997) where he analyzed seventy quality statements measuring fifteen quality management areas. The summary of the importance of the fifteen quality areas and recommendations for their improvement are listed below. Quality areas are ranked as per their importance.

Table 2. Quality Mangaement Area Conclusions

S. No.	Quality Management Areas	Important Conclusions (Summarized)
1	Organizational Quality Policy	Need for more effort in establishing and updating the quality manual.
2	Designer Qualification	Strong need for establishment of a design code
3	Employee Training and Education	Second least prevalent QMA. High need for more job training and provision of short courses to train local workforce.
4	Design Planning	Need for more emphasis towards identifying design interfaces in preliminary design.
5	Design inputs	Slight need for identifying and defining responsibilities of transmission of design inputs.
6	Design Process	Need for more assignment of project work to a single team. Need for more trust and cooperation with contractor, to increase the prevalency of specifying important construction methods in design documents.
7	Interface Control	Need for greater interface control, and confirmation in writing of informally transmitted information between interfacing entities.
8	Design Review	The most prevalent QMA. A slight increase in the prevalency of aesthetic review is recommended.
9	Design Changes	The second most prevalent QMA.
10	Subcontractor Control	Very slight need for more emphasis in selecting and controlling subcontractor organizations.
11	Document Control	The third most prevalent QMA.
12	Design Maintainability	Slight need for ensuring ease of maintainability while specifying material in design documents.
13	Computer Usage	Need for more frequent use of CAD tools.
14	Working Relationship	Need for encouraging more client interaction. High need for building up more trust and cooperation with the contractor.
15	Performance Quality Audit	High need for end of the project studies for future reference. Urgent rectification of the current low prevalence of evaluation request from the client and the contractor at the end of the project.

Source: Farooq,1997

Generally, independent design offices or consultants in China are ISO certified because it is one of the contracting requirements. However, in-house engineering departments are not certified or audited by external third party. Even, products of in-house engineering services are checked and certified by internal quality control team but it would it be same quality as the external auditor**.**

10. METHODOLOGY

A. Required data

The required data for this research can be summarized as:

1. Characteristics of Petrochemical projects.
2. Best design practices for petrochemical projects applied by international petrochemical firms.
3. CJPCE design practices.
4. Local engineering firms role in design services for the petrochemical industry.

B. Data collection

The required data will be collected from two main sources: literatures and interviews. Literatures include design procedure and guides prepared by petrochemical organizations. Interviews will be made with key personnel involved in engineering services in CJPCE and with Design Management Clients project engineers.

C. Data analysis

The collected data from both literatures and interviews will be analyzed to measure the efficiency of petrochemical design practices applied in CJPCE. Affiliates satisfaction will be taken as a measurement of success of design management at CJPCE. Analysis is aimed to make recommendations to improve the design practices in CJPCE.

11. DESIGN PRACTICES AT CJPCE

Design practices at CJPCE includes the engineering process for preparation the basic design and detail design packages. Design package consist of engineering drawings, calculation, technical specification, cost estimate, schedule and list of project materials.

A. General

For regular projects where vendor's scope is limited, detailed design is either prepared by DMD or by a design office depending on the work loads at DMD. The detailed design package includes all necessary documents required to execute the project. These documents are classified into two types: technical documents and contracting documents. Technical documents are prepared by the DMD and include engineering drawings, construction scope of work, bill of materials and technical specifications. Contracting documents are prepared by Supplied Management Organization (SMO) and include: general conditions, special conditions and contracting formats.

B. Work Flow

After receiving approval and Site Project Engineer consent to proceed for detailed engineering. Once 90% Detailed Engineering Package (DEP) is completed and checked by the Technical Assurance Team (TAT) and approved by the section head, it is forwarded to the proponent affiliate through SPM. After the affiliate's engineer and the project engineer review the package they send it back to DMD with their comment if any. DMD incorporates all comments and issues the final package for construction. The detailed design package is forwarded for SPM for contracting and construction after bidding process.

C. Document Index

The detailed design package includes a detailed engineering document index which lists all deliverables, general scope of work and detail design documents for each discipline. It is sorted by discipline and indicates the type of document, size, title, number of sheets and progress status (percentage).Document index is used to control the package and record the status of each document during the design development process.

D. Detail Drawings

Most of the cases, detailed drawings modify existing ones. For new facilities or new equipment that made by vendor, DMD received vendor drawings for review. Then vendor drawings are converted or adapted to match with CJPCE drafting standards.

E. Technical requisition

In some cases new requirements or new modifications appear due design development process. As a result, technical requisition is revised accordingly to show the latest requirements.

F. Material takes off

Bill of materials show in details the required material since it is extracted from the detailed design drawings. For piping material for example, each pipe is illustrated in a separate isometric drawing that determines the required material for that line.

Detailed material lists are leading for accurate cost estimate that reach up to 5% accuracy. Bills of materials are utilized in the project material management.

12. Result and Discussion

The required data as mentioned earlier is collected from two main sources, literatures and interviews with key personnel involved in design processes. Some of the required data such as international petrochemical firms' design practices could not be obtained due the confidentiality and access problem. These practices are not published and it used within the company only. Saudi petrochemical firms (except SABIC) are either under construction or small plants with few projects. However, the general design practices used in petrochemical industry is illustrated in the literature review.

A. Design Management Department (DMD) Capabilities

Capability of DMD is measure by the size, experience, design quality and affiliates satisfaction.

B. Design Management Department Size

The size of DMD is measured by number of the employees. DMD has 158 employees including management, engineers, designers, CAD operator, document control and secretary as shown in Table-9. The total number of employees is 55. Engineers and designers are from four disciplines, civil, mechanical, instrumentation and electrical. Obviously, DMD does not have Process engineer. This because DMD does not handled process project more frequently. If the process engineer is required for any project, a process engineer from the proponent affiliate is assigned for that project.

Table 7. Design Management Department Size

Discipline		Number of Employees
Engineers	Civil	2
	Mechanical	2
	Electrical	4
	Instrument	5
Designer	Civil	4
	Mechanical	3
	Electrical	4
	Instrument	2
Cad Operator		10
Technical Assurance Team		5
Document Control		6
Secretary		2
Supervisors		3
Section Head		2
Manager		1
Total		55

C. DMD Experience

The experience of DMD is measure by design experience of its engineers, designers and CAD operators. Experience is categorized into five categories for each class as shown in the Table-11. 60% of the engineering personnel have 6 to 10 years experience and 20% have more than ten years experience. This level of experience is enough to handle the design services of the most site projects.

Number of Years	Engineers	Designers	Cad Operators	Total
0-5	5	-	6	11
6-10	6	2	4	12
11-15	2	-4	-	6
16- 20		-	-	

D. Recommendation

The main objective to identify and assess the design practices in CJPCE and attempts to improve the current quality of design services practices provided by design management department (DMD). Design practices have been illustrated. The efficiency of DMD design practices is measured by the degree of clients satisfaction. The clients are practically satisfied with the provided services but they are expecting more from DMD. To improve the existing quality of design services provided by DMD the following recommendation are made.

1. DMD shall introduce quality control system such as ISO 9001,(Quality management system requirement) to improve the quality of design provided to its clients.
2. DMD shall include Constructability plan for each project to ensure the possibility of construction with optimum change in the existing facilities.
3. Obviously the feasibility study is not prepared by DMD, instead the feasibility study is prepared by the affiliate's engineers since they are close to the daily operation and maintenance problems. The practices is that the affiliate's management is approving the project before sending the Conceptual design Package (CDP) to DMD. The feasibility study shall be conducted by DMD and all required data shall be provided to facilitate their job.
4. Process engineer is very important in process projects. DMD shall have process engineers within the design team and not from affiliate staff.

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