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CASE STUDY

Large-scale coal-chemical industry project preparation and construction: Case study of Kaiyang project

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Abstract: Coal-chemical industry is the foundation of producing industrial chemical products. The construction of a large-scale coal-chemical industry facility is a systematic project. Coal-chemical industry is along with high investment, high tech, and long construction period. Thus, the appropriate management and control is a necessity towards low cost and sustainability of the industry. The purpose of this paper is to provide a guideline on constructing a large-scale coal-chemical industry facility. The goal of the construction is to make the whole project be cost-effective, and quality and timeline guaranteed. Thus, the paper focused on three control aspects: cost control, progress control, and quality control. Each control aspect consisted of control components and followed by case studies. All case studies were derived from the construction of Kaiyang ammonia synthesis project. Although based on Kaiyang project, the paper generalized the control theorem in each control aspect. As a result, all methodology can be applied on any large-scale coal-chemical industry construction.

Keywords: coal-chemical industry, cost control, progress control, quality control

1 Introduction

Coal-chemical industry is a business that produces chemical engineering products from coals. Coal-chemical industry started in the late eighteenth century. The integrated coal-chemical industry system was mature in the ninetieth century. In the twentieth century, abundant organic-chemical products renovated their producing ingredient from plants to coals. The transformation flourished the entire coal-chemical industry and highlighted the significance of the industry.

In coal-chemical industry, coals could stay solid, or be liquefied and gasified. Coal-chemical industry contains the coal's primary, secondary, and deep treatment. The treatments can make coals carbonized, liquidated, gasified, and post-synthesized. Among all treatments, coal gasification is a major field. The gasification is producing combustible carbon gases, such as CO, from coals, but not the thermodynamic phase change. Coal gasification has been broadly used in modern coal-chemical industry. Most large-scale coal-chemical industry plants adopt coal gasification technologies in their production.

The constructional preparation for a large-scale coal-chemical industry plant is a systematic project. Coal-chemical industry is characterized with high-risk and high-tech. The construction process is comprehensive, interdisciplinary, and time-consuming. In addition, sustainability and ecological civilization is making new challenge to coal-chemical industry. Thus, coal-chemical industry construction has to be on the way of employing advanced technology and equipment, reducing cost, improving resource utilization efficacy, optimizing resource and human allocation, and preventing pollution.

Numerous amounts of research have forced the construction of coal-chemical industry projects. Si and Song presented a research on technology innovation of coal gasification technology in coal-chemical industry[1]. Wang and Wei summarized precautions on quality control in coal-chemical Industry. The precautions however, concluded from a particular area, i.e. automatic control instrument engineering[2]. Zhang described the effective management of fixed assets on operating a coal chemical industry construction[3]. Zhang and Hou expressed several thoughts for constructing a large-scale coal-chemical industry project. The thoughts were in the aspects of utilizing technology, allocating resource, and sustaining environment. All thoughts however, were restricted to natural gas projects[4]. Guo and Kluse emphasized the significance of optimization while constructing facilities[5].

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However, the researching approach and the case study was based on photovoltaics recycling[6]. Though, many research works have been published, the advice was too specific to be applied directly on a general large-scale coal-chemical industry project.

There have not been many coal chemical industry facilities constructed all over the world. Due to the high cost, large project, and heavy management workload, there are needs to provide successful guidelines in coal chemical industry facility construction area to be referred and followed. The purpose of this paper is to provide effective constructing procedures for constructing new coal chemical industry facilities. The paper analyzed the achievements in constructing a large-scale coal chemical industry project. While managing and supervising the whole construction project, the authors concluded the most significant parts in constructing a large-scale coal chemical industry facility is cost control, progress control, and quality control. Therefore, the paper provided the major achievements in cost control, progress control, and quality control while constructing a large-scale coal chemical industry facility in Kaiyang. All the guidelines and directions came from the real project constructing and managing experience and can be applied to real large-scale coal chemical industry projects. Although the analyses were based on Kaiyang project, the guidance can be applied on generic large-scale coal chemical industry projects.

2 Kaiyang project overall

Guizhou Kaiyang Chemical Industry Company (Kaiyang Company) is located in Yongwen city, Guizhou province, China. The company was invested by Yankuang Group and Guizhou Kailin Group. On August 16 2006, the company was registered with the registered capital of CNY 900 million. The proposed project was constructing Kaiyang Company to be a larger-scale coal-chemical industry facility. The facility shall include a synthesis ammonia production line with the 500,000 tonne annual capacity. The anticipated facility area was 1.57 km^2. The estimated annual sale was CNY 1,500 million. Until June 2012, the company has raised CNY3,210 million investment. The facility construction was complete in 2014. The achievement analyses on the facility construction was based on cost control, progress control, and quality control.

3 Cost control

Effective cost control can avoid investment losses, as a result, maximizing the investment efficacy. Appling existing cost control models is one of an effective ways on cost control. Though many cost control models exist, no certain model can fit perfectly into a real project. Cost control models shall be integrated together while performing cost control.

Cost control on large-scale coal-chemical industry construction is a dynamic process. The construction on the industry are usually along with long construction period, frequent material cost change, and fast labor cost growing. All the characteristics fluctuate the construction cost. Therefore, cost control is a tough process, but significantly important on the way of completing the whole project. The baseline of the cost control is the scenario that do not take any action and just let the project run in the easiest way. There are numerous perspectives and areas in cost control. In Kaiyang project, cost control was successful in emphasizing technology selection, collaborating with professional designers, cooperating with reputable suppliers, and strengthening verifications on initial design.

3.1 Emphasizing technology selection

Technology selection is vital on constructing larger-scale coal-chemical industry projects. Proper equipment and process selection influences the success of the project as a whole. When making the selection, one should consider the economic and local concerns.

Kaiyang project constructed a larger-scale ammonia synthesis production line. Gasification technology is the core of the project. In 2007, gasification technology alternatives in China included stationary bed gasification, oxygen-enriched continuous gasification, coal-water slurry gasification, British Gas: Lurgi (BGL) crushed coal gasification, SHELL: dry-pulverized coal gasification, and GSP: dry-pulverized coal gasification. In order to select the best-fit technology, Kaiyang Company personnel visited multiple existing larger-scale ammonia synthesis plants. The plants included Guizhou Fertilizer, Pingdingshan Fertilizer, Huainan Fertilizer, Yunnan Jiefangjun Fertilizer, and German Heishuibeng Gasification. The site visits focused on the processes of sulphur retreatment, ammonia synthesis, and sewage treatment. The attention was paid on performance reliability, technology matureness, and compatibility and coherence with other processes and equipment. As a result, GSP dry-pulverized coal gasification technology was selected considered the economical, technical, and local situation of Kaiyang project.

3.2 Collaborating with professional designers

A professional designing company has much more practical experience than others companies do. Total

experience enables the designer to consider the entire engineering system as a whole while optimizing resource allocation. The initial optimal design can significantly save the cost on future operation and maintenance. Therefore, it is recommended inviting a professional designing company to initialize the global facility design.

In Kaiyang project, a professional designing company, Tianchen Co. was contracted for the global facility design. The designing company had numerous experience on designing processes, equipment, electrical, control, pipes and ducts, HVAC, civil, and drainage. In Kaiyang project, the necessary modules of the facility included processes, electrical, instrumentation, civil, and drainage. All of the modules' designing work were contracted to Tianchen Co. for ensuring operability and practicability. Back and forth communication were conducted between Kaiyang personnel and Tianchen Co. throughout the entire designing process.

3.3 Cooperating with reputable suppliers

Reputable suppliers tend to provide quality materials and services. In large-scale coal-chemical industry projects, paying higher initial cost is worthwhile than spending time and money on downtime maintenance in the future. In addition, high quality materials have less quality issues, subsequently, saved the labor and the cost on processing exchanges and returns.

In Kaiyang project, 210 quality suppliers were selected based on their achievements, reliability, supplying capability, and material cost performance. The whole selection procedure complied with Kaiyang Company administrative documents. Those documents were "Administrative measures for bidding and tendering" and "Price comparison for material purchasing".

In addition, to save the cost on processing incoming-materials, a database was developed for transit-material quality documentation. The documented materials included not only those sending to the warehouse, but also the ones delivering to the construction site. All the 210 suppliers' performance were recorded in the database. Furthermore, Kaiyang Company formulated a quality inspection system with detailed inspecting procedures on each process and profession. The inspecting evaluations were conducted by specialists from each field. For the supplies that did not satisfy the requirements, a replacement or return request was triggered prior to making payments.

3.4 Strengthening verifications on initial design

All design scenarios must be validated repeatedly in both feasibility and economy before being implemented. Once approved, design scenarios shall not be changed. Every change is a piece of waste on resource and investment.

In Kaiyang project, two major flaws were discovered beforehand. The first was modified within the purification process in the gasification reactor. During the verification procedure, the team was aware that the original design could not satisfy the requirement of coal ash being less than 1 mg/m^3. The original gasification reactor applied a shower-based system in the synthetic gas purification process. As the modification, the bath-based dry pulverized coal synthetic gas purification process was employed. The bath-based purification process can purify the synthetic gas more thoroughly and therefore, reduced the future downtime maintenance cost in commissioning. The second modification was on the wall structure of the ammonia-synthesis tower. The original design proposed to use one 16cm-thickness alloy steel plate. The 16 cm-thickness alloy steel plate needed to be pre-ordered abroad and was very expensive. As the modification, one domestic 13 multilayer-clamping plate was utilized to replace the original single layer plate design. The modification saved the investment by at least CNY 10,000,000 and saved the construction period by at least one half year.

4 Progress control

Progress control ensures all tasks are completed in certain time with certain quality. Progress control shall start from the beginning of the project. Detailed plans and implementing measures shall be formulated on each subproject. Implementing appropriate project organization and formulating project progress plans were two aspects on facilitating the success of large-scare coal-chemical industrial projects.

4.1 Employing appropriate project organization mode

There are two major types of project organization modes: Engineering Procurement Construction (EPC) and the owner taking management responsibility. EPC means the owner paying a fixed cost to a third party on completing the whole project. It is the third party's responsibility on designing, making purchases, constructing, and delivering the complete project to the owner. As the opposite, the owner taking management responsibility means the owner manages all core work on its own. The owner taking management responsibility requires the owner to possess sufficient professional employees in all areas.

Kaiyang project applied the owner taking management responsibility mode. In order to do so, Kaiyang Com-

pany established a special committee called the constructing command leading committee. The committee connected designers, reviewers, owner representatives, and specialists as a whole, which helped on conducting cross-functional audits. During the audits, all major designing scenarios were optimized in diverse perspectives several times. The scenario optimization improved the designing quality and reduced the chance of making future changes.

The mode of the owner taking management responsibility made many positive impacts to the whole project. Take the thermal ducts and pipes system commissioning as an example. The committee members went to the site and verified the appropriateness of the beam and truss installation. The verification improved the reliability of the thermal ducts and pipes system, and subsequently, shortened the feed-producing time and boosted the progress of the whole project.

4.2 Formulating project progress plan reasonably

Formulating a progress plan is a repetitive procedure. The progress plan needs to be modified and detailed at all times. In Kaiyang project, all progress plans were formulated by the constructing command leading committee. All progress plans complied with local reality for ensuring feasibility. All progress plans were also detailed weekly, monthly, quarterly, and yearly. The weekly plan propels the monthly plan; the monthly plans propels the quarterly plan and so on.

While formulating plans, the constructing command leading committee invited the related engineering department, the auditing union, and the project contractor to participate. Those participators provided numerous valuable insights in the aspect of labor allocation, mechanical equipment, and material turnover. In addition, proper buffer times were set while formulating plans. Those buffer times were for overcoming the effects from uncertainties. Lastly, for ensuring the completion of each task, one superintendent was assigned to each plan.

5 Quality control

Quality control is supervising and monitoring processes, products, and projects for avoiding defects and fails. Kaiyang project was located in a rural, underdevelopment area. The area is characterized with severe environmental condition, poor construction equipment, low quality technology, and less labor skills. Despite all tough situation, the project was completed with full quality credits in facility construction and equipment installation. The success was attributed to holding quality control training and meetings, compiling measurable criteria, and performing on-site supervision.

5.1 Holding quality control training and meetings

Kaiyang project emphasized quality control from the beginning of the construction. Kaiyang Company required all contractors to take the initial quality control training before start any of the construction work. In addition, Kaiyang Company held regular quality control meetings with contractors. The meetings were dedicated to the quality control of ongoing construction. The training and meetings not only benefited ongoing construction, but also prevented future subpar quality potentials due to the defects from the beginning.

5.2 Compiling measurable criteria

Kaiyang Company established measurable criteria in quality control. The criteria varied with each individual construction work. All criteria were detailed in constructional processes, technical parameters, quality standards, and an acceptable range. Those criteria can be applied on most types of inspection and assessment activities. The internal criteria not only acted as a reference to constructors, but also provided a standard on quality assessment for Kaiyang Company.

5.3 Performing on-site supervision

Many gigantic equipment were utilized in Kaiyang ammonia synthesis project. The investment on equipment was as much as CNY 1600 million. Therefore, Kaiyang Company put much effort in equipment quality assurance. First, Kaiyang Company sent corresponding engineers living in the city where the equipment manufacturer is located. The engineers reported the manufacturing progress and equipment quality to Kaiyang Company. In addition, during the equipment on-site installation, the whole process was supervised by a professional committee. The committee consisted of project designers, the construction contractors, and the chief engineers from Kaiyang Company. As a result, most major equipment in ammonia synthesis project accomplished their expected quality level.

6 Conclusion

Large-scale coal chemical industry facility constructions usually come with high cost, high risk, and a long project cycle. Due to all those characteristics, there are not many large-scale coal chemical industry facilities worldwide. While constructing a large-scale coal chemical industry facility, the project management team has

the needs on seeking the past project experience, achievements, and caution to follow and refer. The paper targeted the preparation and construction of large-scale coal-chemical industry project. Three control aspects were focused, i.e. cost control, progress control, and quality control. Each control aspect was discussed in detail and followed by case studies from Kaiyang Company. In cost control, the paper focused on emphasizing technology selection, collaborating with professional designers, cooperating with reputable suppliers, and strengthening verifications on initial design. In progress control, employing appropriate project organization mode and formulating project progress plan were emphasized. In quality control, the importance of holding quality control training and meetings, compiling measurable criteria, and performing on-site supervision were interpreted. All the best practices were from the real project experience and can be directed applied to other large-scale coal chemical industry facility construction projects. The research work not only provided insights on constructing large-scale coal-chemical industry projects, but also prompted the sustainable development in the coal-chemical industry.

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