

Engineering Management and Cost Control of Petrochemical Projects

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With the increasing developing of petrochemical engineering construction market, China has accumulated rich experience in project engineering management and cost control, but has not yet established a complete cost control performance evaluation system, and the traditional project cost control method has been unable to meet the cost requirements under the new project management environment. For this, this paper studies the engineering management and cost control system theory of petrochemical projects, and builds one petrochemical project cost control system. The analysis results show that mature project management mode has been increasingly applied in petrochemical projects. The construction of the engineering cost control early warning system can achieve the objective of cost control. The related cost control performance evaluation system can greatly improve the actual engineering cost control level and realize the quantification and standardization of cost control performance evaluation.

1. Introduction

Petrochemical projects involve various fields in the country such as import and export, labour, capital, and economic politics (Liu et al., 2018; Bovsunovskaya, 2016). In terms of project management, due to different climatic conditions, technical standards and backgrounds of different countries, the management of engineering projects is faced with great challenges (Willems and Vanhoucke, 2015). At present, the petrochemical projects adopt the main mode of engineering, procurement and construction management (EPCM). According to the existing engineering experience, many management methods and techniques have been proposed (Abdi et al., 2018). Project cost control is an important branch of engineering management, and there are many factors affecting cost control, such as cost control performance and management factors (Ahlemann et al., 2009). Based on the current research, it is still impossible to clarify the mechanism of cost control factors on cost control performance, so the project cost control performance evaluation system cannot also be constructed (Lian and Zhao, 2012).

With the continuous development of China's market economy and the continuous expansion of market access, China's energy consumption has been accelerating, and more petrochemical projects have been put into construction with high engineering investment. But, constrained by such factors as resources, environment, and market etc., it has high investment risk (Korhonen et al., 2014; Aubry, 2011). China's project management model has also been continuously improved, realizing an effective combination of design, management and construction, and achieving good results in implementation progress, cost and quality control (Demeulemeester, 2015). In the EPCM model, the role of acquisition management, design management, construction management and risk management need to be considered (Aliverdi et al., 2013). This paper analyses the role of engineering management and cost control in petrochemical projects specifically, build one project cost control system, and improve the project management capabilities of petrochemical enterprises, thereby improving the enterprise competitiveness.

2. Engineering management and cost control system construction

2.1 Basic theory of engineering management mode for petrochemical projects

Petrochemical project management is committed to the harmonization of quality, cost and schedule in the management process (Doloi, 2013; Moradi et al., 2017). The petrochemical project management model includes engineering construction supervision mode, construction-based engineering contracting mode, project management responsibility mode, project management contractor mode, and BOT mode (Pajares and López-Paredes, 2011). It's characterized by decision-making, organization and coordination. The ultimate goal of petrochemical project management is to ensure the investment, schedule, safety and quality. Thus, the professional technical services are more optimized, and the perfect combination of effect and efficiency based on economic cooperation can be realized (Acikara et al., 2017; Kim and Reinschmidt, 2011). Fig.1 shows the schematic diagram of schedule management. During the implementation of the scheduled plan, actual progress data will be collected and analysed. Through the reason analysis, the schedule will be revised and adjusted. The project itself remains certain big risk. Before the project contract is signed, both parties will reasonably allocate the responsibility and risk in the project management process to reduce the risk of one-sided trend.

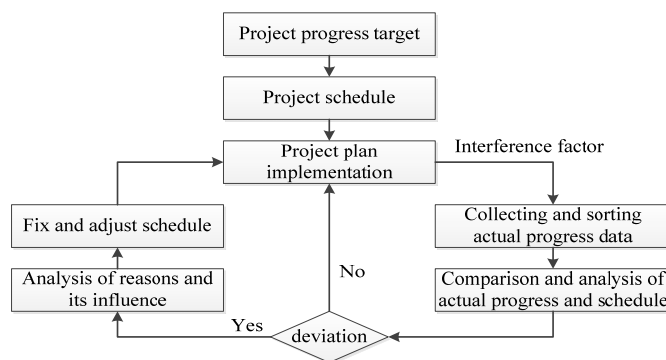


Figure 1: Schedule management diagram

2.2 Analysis for current status of cost control in petrochemical projects

The total cost of petrochemical project includes direct and indirect costs for the project. The research on engineering project cost in China has developed slowly, and the main research focuses on the whole life cycle cost control. The initial mode of engineering cost control is the use of network planning technology; with the factors affecting engineering cost determined, it is an important method to reduce engineering cost by studying these factors firstly. At present, there still exist many problems with the cost control of engineering projects in China, including the cost control concept, cost control objective, cost control method, and cost control content. As the project environment, laws, regulations and policies change, the traditional project cost control method cannot meet the cost requirements under the new project management environment.

3. Construction of petrochemical project cost control system under EPCM mode

3.1 Establishment of dynamic cost control system

Project cost includes the decision-making cost, bidding cost, survey design, and implementation cost, which are affected by the project characteristics, technical factors, control factors, management factors and market economic factors. At present, the cost management of petrochemical projects often uses the "earned value management (EVM) method". However, the EVM method only involves two factors: project duration and cost. Fig.2 shows the theoretical model of task uncertainty and management control system. The analysability of behavioural control and process control is high in the management process, while that of result control and personnel control is low; there are few exception events for behavioural control and result control, while there are many for the process control and personnel control. Fig.3 shows the in-process control phase. The in-process management includes electromechanical materials management, site management, labour subcontracting team management and cost dynamic analysis. The costs are controlled irregularly during the construction process through in-process management in various aspects. Fig.4 and 5 show the dynamic and static cost control curves. The cost control process by external factors and the cost deviation process are both

dynamic. It's necessary to make real-time control of the whole project process, continuously compare the target cost with the actual cost, constantly optimize the program, and correct cost deviations.

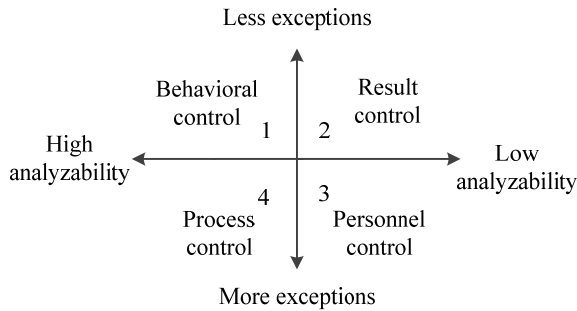


Figure 2: Mission uncertainty and theoretical model of management control system

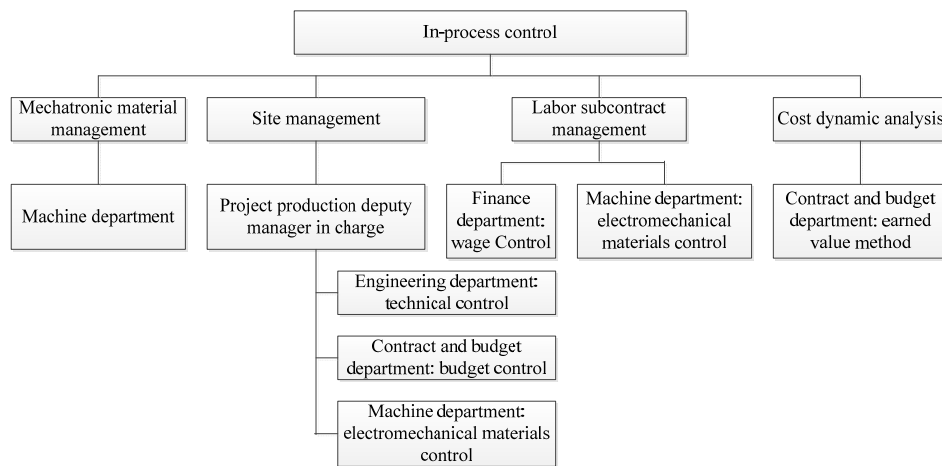


Figure 3: Process diagram of the control phase

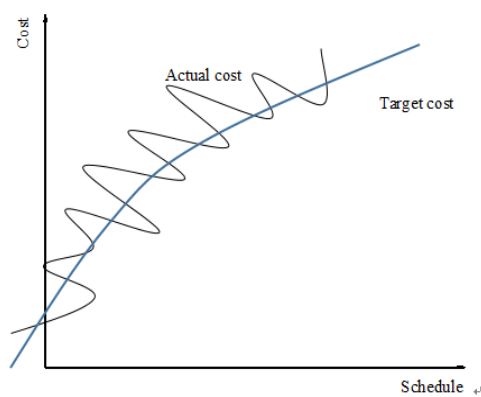


Figure 4: Dynamic cost control curve

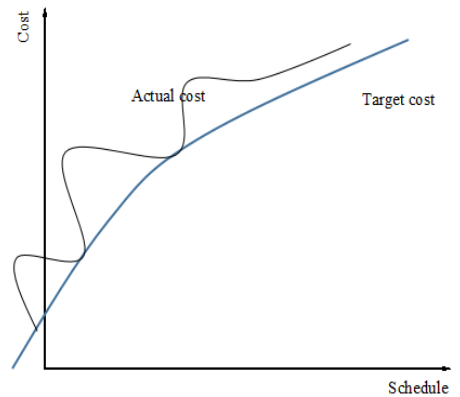


Figure 5: Static cost control curve

3.2 Engineering cost warning system under critical path

When the engineering cost deviates from the early warning line, the cost warning system of the project will issue an early warning signal. The structure of the early warning system includes the monitor, information, means, objects and results. The operation platform of the entire early warning system relies on the support and connection of various platforms. The early warning system of engineering cost includes early warning research, early warning preparation, problem identification and early warning, engineering problem handling,

and crisis relief and summarization. Fig.6 shows the chart of earned value analysis. The use of earned value indicates the actual cost of consumption in the actual workload state, and the cost control target can be achieved.

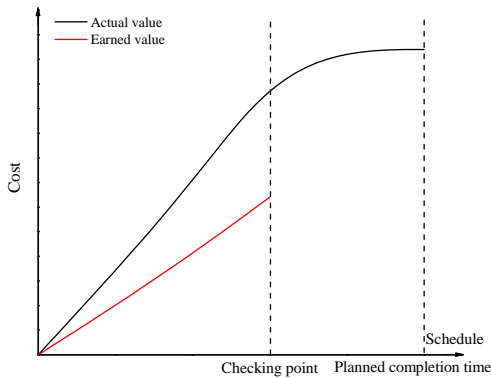


Figure 6: Earned value analysis chart

4. Cost control evaluation of petrochemical project

4.1 Construction of cost control performance evaluation system for petrochemical engineering construction projects

So far, China has not formed a complete cost control performance evaluation system for petrochemical engineering construction projects. The existing project cost control performance evaluation system includes excellent project excellence model, project performance management system, and logical framework method. Fig.7 shows the organization diagram of the engineering project construction headquarters, including the design management group, the contract planning group, the process equipment group, the construction management group, and the cost control group. The cost control group of the project is responsible for the cost control of the project process. Some research has applied the Partnering protocol to the project management mechanism, so as to achieve trust evaluation, trust training and long-term agreements. Fig.8 shows the pre-control process. The pre-control phase includes cost prediction and plan management, in which the cost prediction is mainly to prepare scientific and reasonable construction organization design, and the plan management mainly decomposes the responsibility cost and prepares the responsibility cost plan. Fig.9 is the framework diagram of the Partnering mode management mechanism. To achieve the target cost control, in addition to the Partnering protocol design, the cooperation mechanism, coordination mechanism, communication mechanism, trust mechanism and incentive mechanism are also implemented. Furthermore, the resource sharing system is established for achieving the cost control.

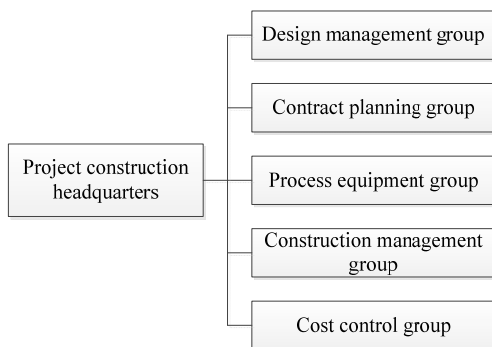


Figure 7: Engineering project construction headquarters

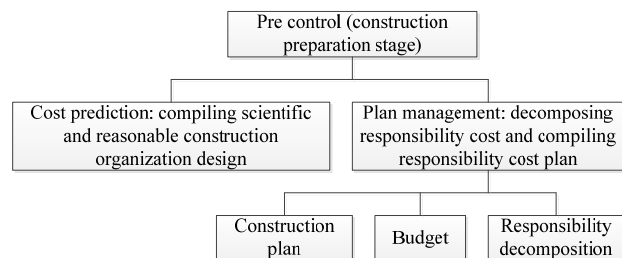


Figure 8: Ex ante control process diagram

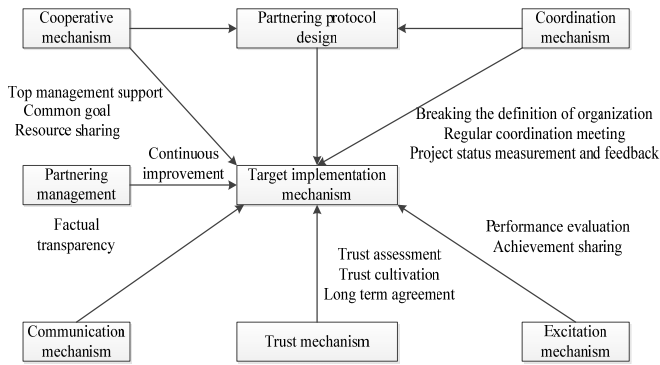


Figure 9: Partnering mode management mechanism

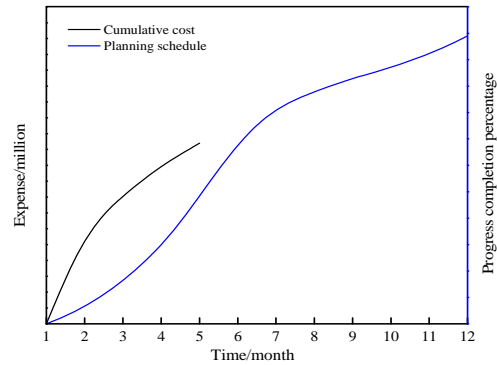


Figure 10: Project cost estimate and schedule

framework model diagram

plan

4.2 Examples of engineering management and cost control for petrochemical projects

Five typical petrochemical projects were selected as the examples in the experiments, to analyse the cost control performance evaluation system of the proposed petrochemical engineering construction project, and comprehensively evaluate the quality, cost, duration and benefits. Table 1 lists the evaluation results of five petrochemical projects. It can be seen that the total evaluation values of the five projects are 8.24, 7.79, 7.40, 8.04 and 8.67, with an average of 8.03, indicating good performance of the five projects; according to overall evaluation of experts, the scores of the five projects are 9.13, 8.57, 8.27, 8.93, and 9.20, with an average of 8.82, also indicating good performance. Based on the expert score, the performance contribution of each indicator item can be calculated, as shown in formula 1:

$$V_{pijk} = [\sum_{m=1}^M (V_{pijkm} \times h_m)] / M \tag{1}$$

where:

V_{pijk} is the weighted average of the k-index in the j subprocess at the i-stage of the project;

M is the number of experts evaluating the project P;

V_{pijkm} is the evaluation value of expert m for index k

According to the performance of each indicator, the performance of each sub-process and each stage can be calculated, as shown in formula 2 and 3.

$$d_{pij} = \sum_{k=1}^{10} V_{pijk} w_{pijk} \tag{2}$$

$$S_{pi} = \sum_{j=1}^J d_{pij} r_{pij} \tag{3}$$

Fig.10 is the comprehensive chart of the cost estimation and scheduled plan for the petrochemical project 1. The scheduled plan and cost are closely combined to achieve an effective integration of project cost and construction period, avoiding large deviations.

Table 1: Evaluation results of five petrochemical projects

	Expert comprehensive evaluation	Total project evaluation	Four-stage evaluation value			
			Early stage	Definition stage	Implementation phase	Completion acceptance
1	9.13	8.24	8.06	8.17	8.46	8.27
2	8.57	7.79	7.37	7.86	8.09	7.86
3	8.27	7.40	7.15	7.68	7.51	7.23
4	8.93	8.04	7.60	8.11	8.26	8.20
5	9.20	8.67	8.26	8.95	8.78	8.68
Average	8.82	8.03	7.69	8.15	8.22	8.05

5. Conclusions

This paper analyses the role of engineering management and cost control in petrochemical projects specifically, and builds one project cost control system. The specific conclusions are as follows:

- (1) The cost control process by external factors and the cost deviation process are both dynamic. It is necessary to control the whole process of the project in real time, continuously compare the target cost with the actual cost, constantly optimize the plan, and correct the cost deviation.
- (2) The operation platform of the whole early warning system relies on the support and connection of each (1) platform. The engineering cost early warning system includes early warning research, early warning preparation, problem identification and early warning, engineering problem handling, crisis relief and summarization.
- (3) In the cost control performance evaluation system of petrochemical engineering construction project, it is necessary to comprehensively evaluate the quality, cost, construction period and benefit, and closely combine the design schedule with the cost to realize the effective integration of project cost and construction period, so as to evaluate the cost and progress of chemical project.

Acknowledgments

The study was supported by “2017 Philosophy and Social Science Planning Project of Hebei Province, China (Grant No. HB17GLO87)”.

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