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Construction Cost of Chemical Plant Based on Dynamic Management Technology

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With the vigorous development of China's chemical industry, the scale of investment in construction projects of chemical enterprises has been expanding. Although China has accumulated rich experience in construction project cost, it has not yet established a relatively complete construction cost management technology system of chemical plant. Based on the dynamic management technology, this paper studies the construction cost of chemical plants. Then, through analysis of the factors affecting the construction cost of chemical plants, it establishes the technical system of construction cost management for chemical plants. The analysis results show that this management technology system can realize the control target in the construction cost of the chemical plant. The established dynamic evaluation model of cost can greatly improve the actual project cost control level. It has wide practicality and is worthy of promotion.

1. Introduction

The construction of chemical industry buildings is related to people's livelihood. As the national infrastructure, its good construction and stable operation not only affects the development of macro economy and chemical industry itself, but also has a significant impact on chemistry-related industry (Wang et al., 2016; Han et al., 2013). In recent years, with the rapid development of China's chemical enterprises, the construction of chemical plant has been greatly accelerated, and the scale of investment has been expanding (Jo et al., 2015). The forecast of cost control targets plays a very important role in the dynamic management of construction cost in chemical plants (Baker and Solak, 2014; Shrestha et al., 2017). Through analysis of the factors affecting cost dynamic management, the dynamic forecasting technology and optimum selecting mechanism are constructed; the dynamic forecasting model for construction cost of chemical plant is systematically and multi-dimensionally established, promoting the dynamic forecasting and scientific management for the construction project cost of chemical plants from the all-round and multiple perspectives (Marco et al., 2016).

However, along with the continuous development of China's market economy and the rapid development of chemical industry, it has become more and more difficult in the construction cost management of chemical plants (Nasirzadeh et al., 2014). The occasional occurrence of runaway investment in the construction project of chemical plant has caused huge economic losses (Chen et al., 2015; Peñamora et al., 2008). This is because the chemical industry is the technical and capital-intensive industry, and the project management of chemical plant construction is very complicated and different from the general civil construction projects. The construction cost of chemical plants is a very complicated system engineering (Ayub et al., 2016). Therefore, it is necessary to establish a scientific dynamic management system for the construction cost of chemical plants and implement cost control in the whole construction cycle (Ren et al., 2011). Based on the dynamic management technology, this paper studies the construction cost of chemical plant, and establishes the dynamic identification measurement model for the factors affecting the construction cost of the chemical plant. Then, based on the basic theory of engineering cost and the objective law of construction project in chemical plant, this model can make dynamic control and management of the construction project, so as to reduce the corporate costs and make good investment returns.

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2. Dynamic prediction model for construction cost control target of chemical plant

2.1 Dynamic prediction model design for construction cost control target of chemical plant

There are currently three main methods for construction cost prediction: the quota method, the analog method, and prediction algorithm (Papelniuk, 2016; Amusan et al., 2018). The quota algorithm is currently widely used, but it has a long time period for budgeting and is complicated (Belay et al., 2016); the analog method has lower computational accuracy, while the prediction algorithm is relatively scientific and intelligent, and it can make rapid calculation of construction project cost based on historical engineering data analysis (Paraskevopoulou and Benardos, 2013). Fig.1 shows the technical flow chart of the dynamic prediction model for the construction cost control of chemical plant. It can be seen that the model can be divided into four parts: cost decomposition module, model prediction module, cost integration module and feedback adjustment module. Fig. 2 shows the investment value of chemical plant construction in the past five years. It can be seen that since 2013, the capital investment of chemical industry construction has increased year by year, and that in 2017 has reached nearly 40 billion yuan.

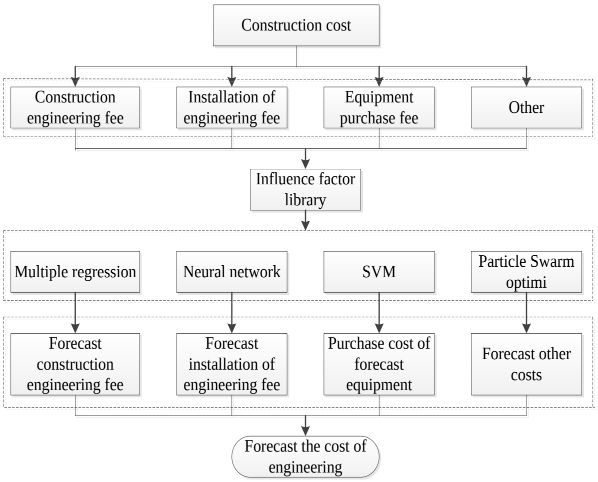


Figure 1: Technical flow chart of dynamic prediction model for construction cost of chemical plant

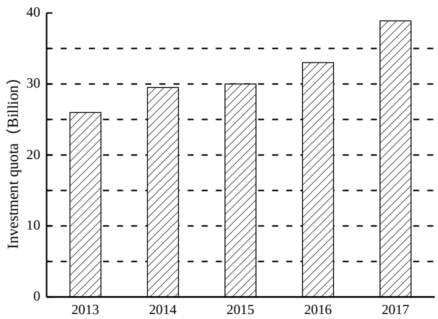


Figure 2 Investment in engineering construction of chemical plant

2.2 Dynamic analysis model for construction cost risk control target of chemical plant

For the cost risk analysis of chemical plant construction, the common analysis method is to build the relationship between independent variables and dependent variables, and use the highest value and average value to characterize the uncertain variables, thus calculating the analysis results. But its calculation results are relatively simple without fully considering the uncertainty of risk variables, so it is difficult to conduct reliability analysis of the results. When the type of research objects is cumbersome, the calculation amount will be increased, and the risk analysis be difficult to be completed. Fig.3 shows the ideas of cost-based risk assessment, analysis and control based on Monte Carlo simulation. The Monte Carlo simulation method is based on the relationship between variables and objective functions to use the probability distribution of variables for replacing the uniqueness of its input; it's an effective simulation method, compensating for the defects of risk analysis method. The principle is as follows:

It's assumed that the independently distribution functions are Y= $(X_1,X_2,X_3,\ldots,X_n$, for the known functions of random variables X1, X2, X3, ..., Xn, and the random group values ($X_{1k},X_{2k},X_{3k},\ldots,X_{nk}$) for random variables $X_1,X_2,X_3,\ldots,X_n$ are extracted, to obtain the Y value Yk=($X_{1k},X_{2k},X_{3k},\ldots,X_{nk}$) corresponding to the random group value. Then, the sampling data y_1, y_2, $y_3,\ldots,y_m$ of the function Y were obtained by repeatedly and independently sampling. After the sampling times reach a certain level, the cumulative probability distribution of the function Y can be given, so as to provide effective and intuitive information for decision makers.

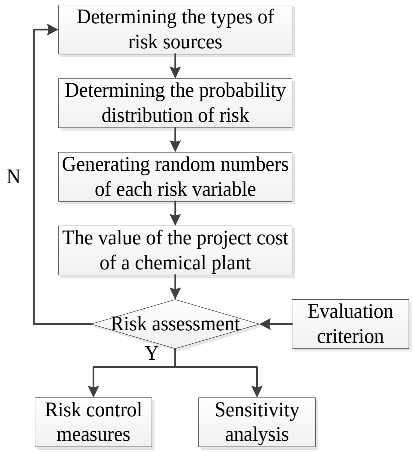


Figure 3: Cost risk analysis, evaluation and control based on Monte Carlo simulation

3. Cost-time-quality multi-objective dynamic optimization model of chemical plant construction project

3.1 Cost-time-quality multi-objective control analysis

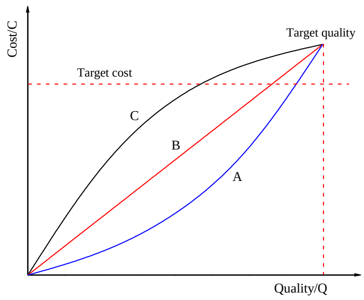
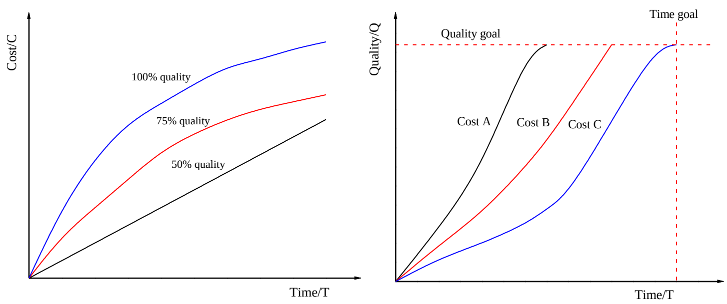


Figure 4: The relation curve between cost and quality under the established time



(a) (b)

Figure 5: The relation curve of cost-time-quality

Cost, time, and quality affect and restrain each other. If one element is modified, the other two will also be affected. Therefore, in the cost analysis of chemical plant construction, it is improper only to pursue the lowest cost but ignoring the adverse effects of project schedule and quality. Comparative analysis should be carried out in multiple aspects, taking the three as a whole into the consideration. Thus, the three elements can be effectively coordinated and unified so as to ensure the whole target system in the optimal state. Fig. 4 shows the relationship between cost and quality under the conditions of given construction time, in which the three curves A, B and C represent the different degrees of cost change with quality; it can be seen that under the conditions of given construction time, the most cost-effective cost and the best quality cannot be met at the same time. The pursuit of high quality must be accompanied by an increase in the cost; the increase should be analysed according to the actual situation. In the actual construction process of the chemical plant, it is more common to have uncertain project construction time, quality and cost. Fig.5 shows the cost-time-quality relationship curve. It is necessary to adjust the relationship between the three for determining their respective target. The component in one target can be classified firstly, and then the remaining two target components are marked on the coordinates. In sum, to determine the single target, the relevant constraints should be considered. On the basis of achieving the project reliability, safety, qualified quality and basic targets, it’s ensured to achieve the optimal overall project goal of the chemical plant construction project.

3.2 Establishment of multi-objective dynamic optimization model

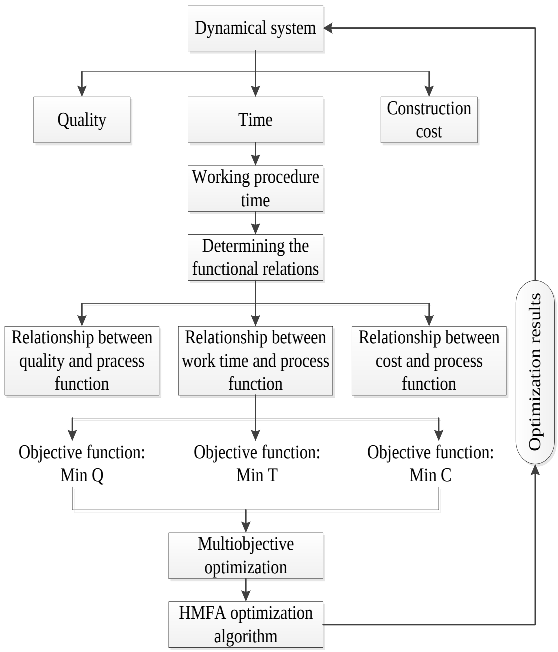


Figure 6: Research ideas of dynamic optimization model

Fig. 6 shows the ideas of dynamic optimization model. Based on the integrated analysis of the quality, cost and time of the plant construction project, the research of the dynamic system was divided into multiple steps: using the time as a link, the mathematical equations are established; then, the optimization control problem for the quality-cost-time of plant construction is transformed into multi-objective dynamic optimization problem, and the firefly algorithm is improved; finally, the modelling is completed and the established model is solved.

4. Dynamic evaluation model for the construction cost control effect of chemical plants

4.1 Construction of comprehensive evaluation index system for construction cost control effect of chemical plant

When establishing the dynamic evaluation model for the construction project cost control effect of the chemical plant, it is necessary to build the comprehensive evaluation index system for the construction project cost control effect of the chemical plant in advance. According to the actual situation of the project, this system can make comprehensive evaluation of the cost control effect in view of the complexity, long-term and dynamics of chemical plant construction project. Finally, the evaluation index is determined in five aspects:

cost, schedule, quality, safety, and satisfaction of all parties, so as to establish the performance evaluation index system for the construction project cost control of the chemical plant, as shown in Table 1 below:

Table 1: Comprehensive evaluation index system of cost control effect

Evaluation object	Primary indices	Secondly indices
Cost control effect	Cost	Investment control rate
		Unreasonable expense rate
	Schedule	Time limit control rate
	Quality	Process quality control
		Quality management level
	Security	The number of safety accidents
		Safety management level
	Satisfaction of all parties	Power grid enterprise satisfaction
		Construction unit satisfaction
		Supervision unit satisfaction

4.2 Dynamic evaluation model for construction cost control effect of chemical plant

Through analysis for the comprehensive evaluation index system of cost control effect, the particle swarm optimization-projection pursuit (PSO-PP) evaluation algorithm was used to analyse and verify the dynamic evaluation model of the construction project cost control effect in chemical plant. In the MATLAB environment, the target evaluation was carried out for the construction project of new-built chemical plant. Based on MATLAB, the PSO-PP program based on particle swarm optimization algorithm was compiled. Given the parameters of the particle swarm optimization algorithm, the program was debugged to seek the optimal function value. The degree of influence of the evaluation index on the dynamic evaluation of the construction project cost control effect can be expressed by the projection direction calculated by the projection pursuit model. Fig.7 shows the relationship between the projection values of each rank and the ranks. It can be found that the projection values and their rank values do not completely exhibit a positive linear relationship.

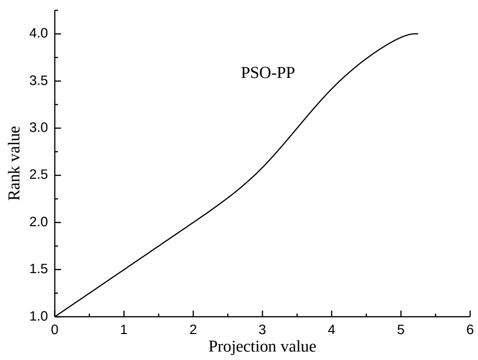


Figure 7: Simulation curve of scatter point distribution of projection value

The relationship between the projection value interval and the evaluation grade can be found in Table 2 below.

Table 2: The correspondence between the interval of the projection value and the evaluation grade

Grade Model	Very poor	Poor	Commonly	Good	Very good
PP	$(-\infty, 0.104]$	$(0.104,0.802]$	$(0.802,2.246]$	$(2.246,5.244]$	$(5.244, +\infty]$
PSO-PP	$(-\infty, 0.108]$	$(0.108,0.801]$	$(0.801,2.242]$	$(2.242,5.233]$	$(5.233, +\infty]$

5. Conclusions

Based on the dynamic management technology, this paper studies the construction cost of chemical plants, and establishes a dynamic identification and measurement model for the factors affecting the construction cost of chemical plants. The specific conclusions are as follows:
Through the analysis for the measurement model and dynamic identification of the factors affecting the construction cost of chemical plants, the causal relationship between the cost and influencing factors of the

chemical plant construction project was established on the basis of system dynamic. And all measurement analysis models were also verified, achieving more accurate and practical results.
The dynamic analysis model for the construction project risk control target of the chemical plant was constructed to identify the risk factors of the construction cost in the chemical plant; based on Monte Carlo simulation, the functional relationship between the construction cost of the chemical plant and the risk variable was determined.
The cost-time-quality dynamic optimization model was established, to determine the quantitative analysis function of the construction project cost, time and process time of the chemical plant on the basis of the project duration, and according to the characteristics of the construction cost control in the chemical plant, ten evaluation indicators were extracted in the five aspects of cost, schedule, quality, safety and satisfaction of all parties, to evaluate the cost control effect of chemical plant construction project.

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