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Resource Balance Optimization Method of Mechanical Engineering Project Considering Multi-objective Optimization

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Abstract: In the current project construction in China, it is an important work to coordinate and cooperate among various project departments. In consideration of the resource balance, full attention should be paid to the connection, cooperation and information sharing among various departments. Taking the field of mechanical engineering planning and design as an example, this paper establishes a scheme and strategy system for scientific and reasonable resource allocation from the perspective of external environment to achieve the overall goal. After optimization, human resource allocation and personnel structure arrangement can be used to improve the efficiency of staff in the shortest time. Then, based on the multi-objective optimization algorithm, the resource balance model of mechanical engineering project is designed and the model is tested. The test results show that the model has small variance and low range, which shows that the model has excellent optimization effect.

1. Introduction

In modern society, with the development of industrialization, various factors of production are showing a trend of diversification and complexity. For the resource allocation process of mechanical engineering projects, the core content is to coordinate and allocate various types of work [1-2]. However, at present, many small and medium-sized enterprises in China have problems such as confused human resource management and low personnel quality. At the same time, due to the lack of scientific and reasonable planning and arrangement within enterprises and incompatible post separation system, many conflicts and waste have occurred in actual operation, The impact on the normal implementation and progress control of the project may even cause a lot of idle or

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unnecessary loss of resources [3-4].

The research of foreign scholars on project management mainly focuses on theories and methods, while the domestic literature on resource balance and optimization of engineering projects is relatively few, so domestic and foreign experts and scholars have conducted in-depth discussions from different perspectives. Some foreign scholars believe that there is a certain degree of interdependence between various departments [5-6]. For example, production, service and other related enterprises have a win-win relationship with other related industries, and some enterprises may have adverse effects on them due to their own reasons during the implementation of the project. Domestic scholars started late in the research of multi-objective optimization problems, but have made some achievements in theory and practical application. Some scholars combine the sustainable development strategy with the balanced management of project resources, and from the perspective of stakeholders, discuss how to give consideration to the rights and interests of all parties, coordinate the relationship between various departments, and maximize the overall performance [7-8]. Some scholars pointed out that scientific design method is the basis to ensure the minimum target cost and the optimal decision-making when analyzing the factors affecting the integration degree in international engineering consulting enterprises, but we should not blindly pursue the optimal scheme and ignore the benefit problem. Therefore, based on multi-objective optimization, this paper studies the resource balance optimization of mechanical engineering projects.

With the rapid development of China's economy, higher and more refined requirements have been put forward for resource utilization. It is a very important content to consider the resource balance and cost issues in the process of project construction. The scientific and reasonable distribution of the relationship between departments and between personnel and equipment in each unit is of great significance for the smooth implementation of the entire project, while coordinating the contradictions between various production factors inside and outside the enterprise is also conducive to improving the overall efficiency, while it is very helpful for the sustainable development of social economy and promoting the overall progress of the country.

2. Discussion on Resource Balance Optimization Method of Mechanical Engineering Project Considering Multi-objective Optimization

2.1. Resource Balance of Mechanical Engineering Projects

When optimizing the resource balance of mechanical engineering projects, the first thing to consider is that there are mutual influences between various objectives, interactions and constraints between various factors, and the second is to determine an optimal value. This requires us to scientifically analyze its internal and external environmental factors. The most basic and effective way for a system is to use economic means to realize the rational allocation and full development of resources, so as to improve the level of total social output and the growth rate of national income, and reduce unnecessary expenditure [9-10]. When optimizing the resource balance of mechanical engineering projects, it is necessary to first determine the resource requirements, that is, the requirements for the quantity and quality of various materials required by the project. When optimizing the resource balance of the project, it is necessary to first analyze the actual situation of each participant and the engineering design requirements, and understand whether various schemes proposed by various stakeholders meet their needs. At the same time, it is also necessary to consider the project implementation progress, cost and other issues under the influence of various factors, and then determine a reasonable and feasible distribution target value according to these factors.

Secondly, it is necessary to take into account the coordination and cooperation between various departments, mutual containment and coordination costs. Finally, we should integrate the factors among the objectives to formulate specific feasible plans and implement the problems and shortcomings in the control management and operation process, so as to maximize the overall benefit and minimize the economy, and finally achieve the optimal goal of resource balance. The resource allocation of mechanical engineering projects is a complex, changeable and dynamic multi-dimensional process with uncertainty factors. Therefore, when building the system optimization model, it is necessary to introduce multiple constraint variables to conduct comprehensive simulation analysis and evaluation of the entire system [11-12]. Figure 1 is the resource balance framework.

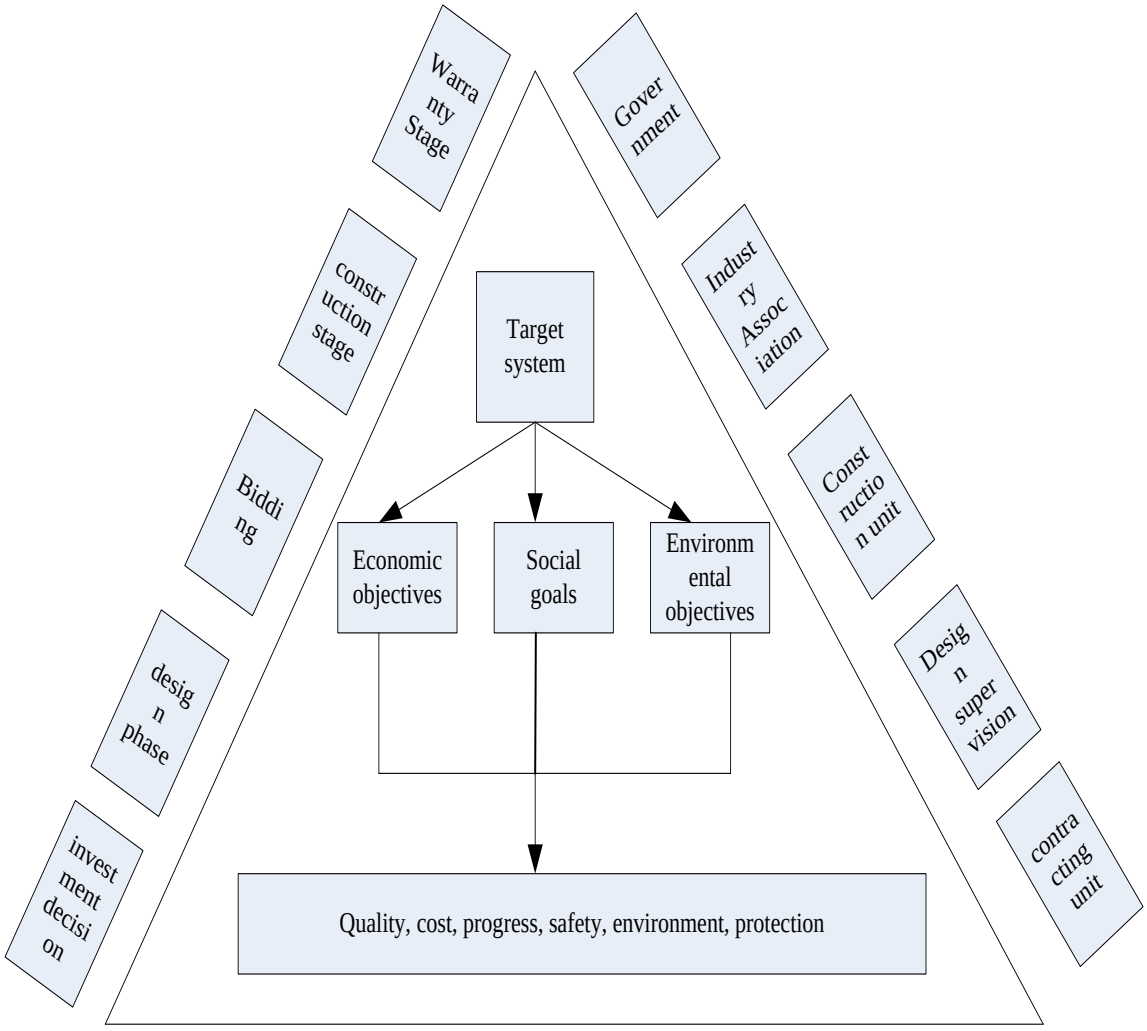


Figure 1. The resource balance framework map

2.2. Ranking of Resource Balance of Mechanical Engineering Projects

When optimizing the balance of project resources, it is necessary to fully understand the impact of various internal factors, and then establish the coordination relationship between subsystems according to the relationship and contradiction between various parts to determine the system functions [13-14]. According to the resource allocation scheme, project construction scale,

construction technology and other conditions in the studied area, consider the reasonable allocation of human resources, material reserves and quality indicators under the objectives of each stage. In the project progress control, fully evaluate the proportion of various resources input, and optimize and adjust it to achieve the purpose of optimal combination and minimum cost. In project management, sequencing is a very important part. It not only affects the changes of resource balance, schedule, cost and other factors, but also determines whether the project can be successfully completed and whether the expected goals can be achieved. The core content of the mechanical engineering project is to coordinate each stage during the construction period, measure the input of human and material resources and the output benefit during the construction process, and determine the optimal plan according to the actual results. In the process of optimizing the balance of project resources, it is necessary to comprehensively consider the objectives and contents of each unit or department to improve the overall efficiency. However, there is a certain degree of interdependence between the subsystems. Therefore, priority resources (such as equipment, raw materials, etc.) allocated to these departments or other projects will be given priority in this paper to minimize the total demand and the maximum total demand within the overall budget. At the same time, reasonable allocation should be made among units or departments on the premise of ensuring that the project implementation quality and progress meet the requirements. Through the reasonable allocation of resources in each part, and the establishment of mathematical functions, the total cost required by each project is calculated, and then compared with the actual budget results. During the implementation of mechanical engineering projects, various uncertain factors often occur. For example, the construction progress is delayed or delayed due to geological conditions, hydrological climate and other natural reasons, and the construction period is affected due to workers' work stoppage due to human error, Therefore, reasonable allocation and optimization of all resources is the basic guarantee to ensure the smooth progress of the project and achieve economic benefit growth [15-16].

2.3. Multi Objective Optimization

In the project construction, the optimal allocation of resources is a complex process, and many factors need to be considered. The most common are personnel, capital and material resources. Human resources include organizational structure, age distribution and work type relations. Technical level refers to the professional ability and comprehensive quality of workers themselves. The management system is mainly based on the enterprise itself to formulate reasonable measures and plans and implement them to achieve the goal of maximizing the effect. At the same time, it is also necessary to scientifically allocate resources to improve their utilization and ensure the smooth completion of the project. On the basis of considering risks and benefits, various resources are comprehensively used to optimize each subproject, so as to maximize the overall benefits [17-18]. However, when there may be multiple sub objectives (i.e. under different indicators) in a specific project, multi-objective allocation strategy or single variable linear function method can be used to solve the problem. Since the correlation, restriction and coordination among independent units is one of the most complex and representative factors in the dynamic evolution process of the system, after considering the two basic conditions of risk and benefit. During risk sharing, the goals used and undertaken by each member of each department or project team are different and have certain differences. Therefore, how to allocate limited resources to achieve overall optimal control and improve efficiency has become an important issue. Figure 2 is the multi-objective algorithm optimization process.

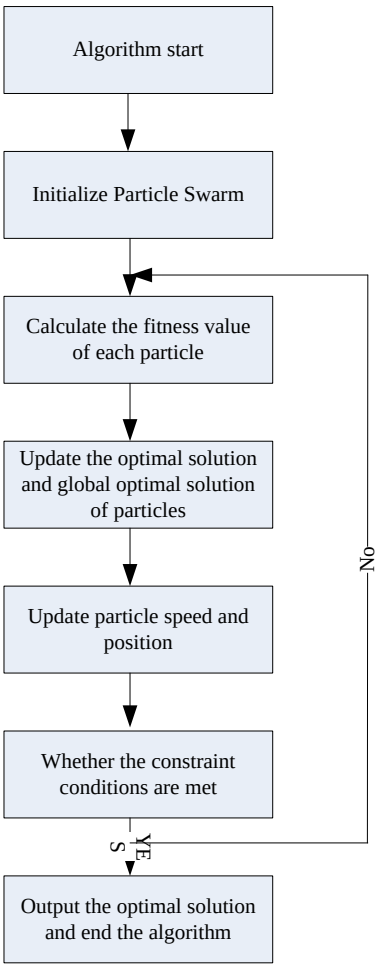


Figure 2. Algorithm optimization process

The scientific and reasonable use of multi-objective optimization problem solving methods to deal with conflicts can effectively reduce the internal contradictions of enterprises, thereby reducing costs and improving efficiency. At the same time, when sharing risks, factors such as the degree of pursuit of each participant's interests should be considered, and the best balance state and the optimal solution of the results should be achieved by weighing the advantages and disadvantages. In the process of optimization, the objective is often vague or difficult to achieve, which requires comprehensive consideration of the relationship between system variables and resource allocation and the change rule. For mechanical engineering projects, it is necessary to establish a scientific, reasonable, comprehensive and controllable structural system with strong effective binding force, global adaptability and dynamic characteristics. Secondly, it is used as a management mode and optimized. In this process, computer technology can be used to realize data processing, so that the system operation status and resource configuration can be known in time. In this way, the linear weighting sum solution model of the optimal configuration model of construction machinery and equipment based on multi-objective optimization is as follows:

$$C'(N,T) = C(N,T)/C_{max} \tag{1}$$

$$T'(N) = T(N)/T_{max} \tag{2}$$

Wherein, Cmax and Tmx are the maximum of all values of C (N, T) and T (N) respectively.

3. Experimental Process of Resource Balance Optimization Method of Mechanical Engineering Project Considering Multi-objective Optimization

3.1. Model for Resource Balance Optimization Method of Mechanical Engineering Project Considering Multi-objective Optimization



Figure 3. Resource balance optimization model of mechanical engineering project

The resource balance optimization model of mechanical engineering project based on multi-objective optimization (as shown in Figure 3) mainly includes three states: dynamic system, static and mixed. Under the scientific and reasonable consideration of uncertainty factors, the optimal solution can be obtained to achieve the optimal value of the time required in the whole process and the number of human resources required. In the traditional project management, the resource balance problem is usually divided into static and dynamic aspects. Static means that only the target function value, actual demand and other indicators are considered when evaluating a

target. For multi-stage or discrete systems, coordination refers to achieving the equilibrium state of each part of the project under certain constraints. In the scientific concept of development and sustainable development, the problem of resource allocation and utilization is particularly prominent. How to maximize the benefits of limited natural resources without affecting the healthy development of the environment, economy and society. While considering multi-objective optimization, it is also necessary to give consideration to stakeholders (i.e. decision makers) and resource constraints. Coordinated allocation refers to the realization of overall optimization through comprehensive tradeoff of multiple subprojects. For the allocation of a single sub project, it is necessary to treat and analyze the relationships and interactions among the subsystems as a system. The objectives of maximizing the benefits of each element at different levels are different. Therefore, a reasonable and feasible scheme can be determined after considering the stakeholders (i.e. decision-making subjects) and resource constraints. This paper constructs a multi-objective programming model based on the principle of "overall consideration and dynamic adjustment", modern mathematical ideas such as extension theory and fuzzy mathematics, and analytic hierarchy process. After considering these basic elements, they are decomposed into several small units (i.e. subsystems). Through this system, the resources of each sub project are reasonably allocated to achieve the balance and optimization of each sub project.

3.2. Model Function Test Process of Resource Balance Optimization Method of Mechanical Engineering Project Considering Multi-objective Optimization

In the process of project implementation, due to the uncertainty of resources, the distribution and consumption of resources are very different. Therefore, how to analyze the actual needs of each sub project is an important issue. It is particularly urgent, necessary and effective to establish mathematical models to solve these problems by comprehensively considering various factors. Then, it is transformed into a linear equation and solved to obtain the allocation scheme with the maximum mutual restriction and coordination among the objectives. Determine the principle of optimal allocation of resources within a reasonable range. When carrying out resource balance optimization, it is necessary to analyze the relationship between project objectives, project scale, duration and other factors. By considering uncertainty and multi-objective optimization problems, combined with theoretical knowledge, a fuzzy comprehensive evaluation system based on analytic hierarchy process is proposed. When building project evaluation indicators under multiple sub objectives (such as resource demand and price level) including strategic planning and resource allocation, it is necessary to first select appropriate variables with high quantifiable degree that can reflect the actual situation and dynamic changes. Secondly, each scheme is evaluated according to the weight coefficient in each sub criterion. Finally, each weight value corresponds to the total score of different sub items through matrix calculation, that is, each weight value represents the overall weight coefficient. During the comprehensive test, the next process is arranged and assigned to the task amount and progress control points of each sub item until the requirements are met.

4. Experimental Analysis of Resource Balance Optimization Method of Mechanical Engineering Project Considering Multi-objective Optimization

4.1. Effect Analysis of Model Function Test for Resource Balance Optimization Method of Mechanical Engineering Project Considering Multi-objective Optimization

Table 1 shows the function test data of the project resource balance optimization model.

Table 1. Test of engineering project resource balance optimization model

Test times	Crest value	Range	Variance
1	54	32	73
2	53	37	72
3	57	35	78
4	56	32	73
5	52	36	70

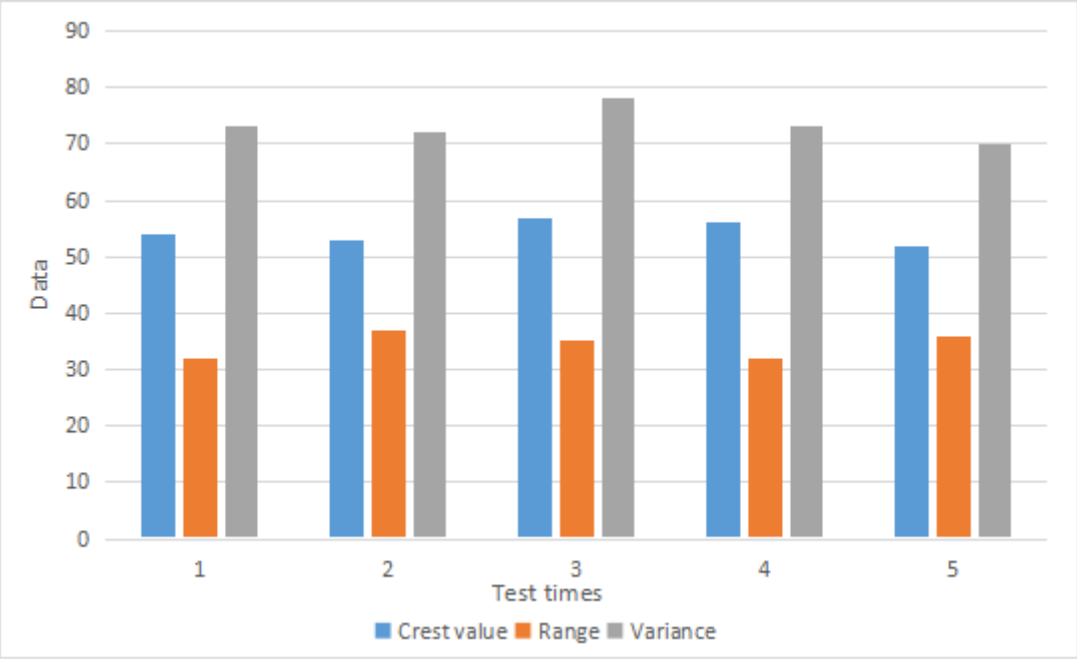


Figure 4. Optimization effect of the resource balance model

The resource balance optimization model of mechanical engineering project based on multi-objective optimization is mainly to further analyze whether its functions are perfect and how well each module is coordinated during the comprehensive evaluation. Through the combination of theoretical test and simulation experiment, dynamic simulation and system test, the method can achieve the desired effect. After the weight of subsystem indicators is determined, each sub item will be ranked in a single hierarchy. Each unit will complete the corresponding tasks according to the evaluation objectives and form a whole block. After comprehensive consideration of the contents of multiple sub items, the matrix calculation method will be used to determine that there is a mutual influence relationship between each sub task, The fuzzy comprehensive evaluation method is used to realize that various factors have a direct effect on the total income and total cost in the process of resource balance optimization of the project when the impact of multiple indicators on different weight values of the overall scheme is different and the weight changes. It can be seen from Figure 4 that the model has small variance and low range, which indicates that the model has excellent optimization effect.

5. Conclusion

With the continuous economic growth, China plays an important role in the international

community, but the domestic requirements for all aspects are also getting higher and higher. Mechanical engineering construction is a complex, systematic and advanced engineering project. This paper mainly studies and analyzes the problems related to the optimization of resource balance, and puts forward scientific and reasonable suggestions and countermeasures for reference. In addition, based on the summary and summary of the research results of domestic and foreign scholars on the theories and methods related to resource allocation and coordination, the corresponding solutions are formulated in combination with the actual situation of China, which will provide a certain guiding role in all aspects of work in the future.

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Data Availability

Data sharing is not applicable to this article as no new data were created or analysed in this study.

Conflict of Interest

The author states that this article has no conflict of interest.

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