Research Core Ideas Analysis of Intelligent Optimization Methods of Complex Equipment Multi-Pipe Road

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Abstract. In the process of complex equipment work, the piping system plays a very important role. The rationality and precision of the layout design results will affect the service life of complex equipment. This article analyzes the targets, laying principles, commonly used laying models, and laying obstacles for complex equipment with multiple pipelines in bundles. The author studied the key points of intelligent optimization of single-target pipeline and multi-target pipeline laying in bundles of complex equipment. The purpose of this article is to optimize the piping system layout and improve the safety of complex equipment during operation.

1. Introduction
Judging from the current application situation, the laying of multiple pipelines in bundles has the advantages of overall rules and beauty, easy installation, clear connection relationship, and convenience for the pipelines to be fixed in turn by double clamps. Therefore, it is widely used in pipeline systems. In the past, the pipeline layout research of complex equipment mainly focused on the single-pipe laying and multi-pipe laying sequence planning, and the research considering the laying of multiple pipelines in bundles was scarce. Based on this, in practical applications, an intelligent optimization method is proposed to optimize this problem. This not only improves the rationality of the pipeline layout content, but also has a positive meaning for extending the service life of complex equipment.

2. Discussion on Related Content of Multi-pipeline Bundle Laying of Complex Equipment

2.1. A subsection
In the existing theoretical basis, there are many factors that have to be considered for the multi-pipeline bundle laying of complex equipment, so it is a multi-objective optimization problem in the field of intelligent optimization algorithms. In different application fields, the laying goals and constraints involved in the complex equipment pipeline system are also different. Generally speaking, the main design goals of piping system bundle laying are as follows. Firstly, the total length of the pipelines laid in bundles should be as short as possible to achieve the purpose of saving costs, reducing the overall weight of complex equipment, and improving the utilization of the internal space of the pipeline system. Secondly, related workers should consider the smoothness of the overall trend of the bundled pipeline when avoiding obstacles, so as to reduce the flow resistance of liquid or gas inside the pipeline. Thirdly, the pipeline to be laid should be as close as possible to the inner wall of the laying space, the accessories inside the equipment, and other special areas to achieve the effect of easy
assembly and fixation. Fourth, the pipelines in the pipeline system that often need to be replaced, maintained, and repaired need to be installed in an area that is convenient for replacement, disassembly and maintenance.

2.2. Laying Principle
In order to ensure the reliability of equipment operation, the following principles need to be followed during the laying of multiple pipelines in bundles. First, the laying space of pipelines is often limited to a special space area. For example, the laying area of the internal pipeline system of an aeroengine is limited to the three-dimensional revolving space, and the laying range of the internal pipeline system of the ship is in the three-dimensional space. In the pipeline network for energy transportation of oil and natural gas, pipelines are laid in flat and curved spaces. Second, the bundled pipeline must avoid various areas inside complex equipment such as obstacle areas. Besides, the previously laid pipelines also need to be treated as obstacle areas to ensure that there is no mutual interference between the pipelines. Third, for safety and reliability considerations, pipelines laid in bundles should be designed to avoid special areas, such as electrical areas and high-temperature areas, as much as possible. Fourth, in order to facilitate the smooth development of subsequent maintenance work, it is necessary to reserve a maintenance area in advance during the pipeline laying period. At the same time, the relevant staff also need to reasonably control the pipeline laying spacing to ensure the convenience of the follow-up maintenance process. In addition, the length of the straight line section to be laid needs to exceed the expected design standard, leaving a certain amount of fault tolerance space. This can lay the foundation for the orderly development of subsequent construction activities.

2.3. Commonly Used Laying Models

When designing complex equipment pipelines, in order to ensure the closeness of the pipeline system connection and provide convenient conditions for subsequent equipment maintenance, the laying method often used is bundled laying. Meanwhile, this method is also an important measure to reduce system vibration failures. As shown in Figure 2, the pipeline is fixed with the help of double clamps, which improves the independence of laying pipelines and reduces the probability of failure during system operation. Under normal circumstances, some straight line segments are set at the starting point of the structure and the ending point during the bundle laying process. This facilitates the laying and assembly of bundled pipelines. In the meantime, relevant staff also need to do a good job in determining the starting point, target point, turning point and other content. Relevant staff can combine mathematical models to determine the spatial coordinates and spatial angles of each inflection point, and combine the corresponding calculation formulas to intelligently process the entire data content, thereby improving the use value of the analysis results.
2.4. Laying Obstacle Analysis

Based on past application experience, experts can use hierarchical modeling to improve the level of refinement of the obstacle analysis content when analyzing the laying of obstacles. In the specific modeling process, experts will complete the expansion of the pipeline content based on the space model. In this way, some application space can be reserved in advance, so that a relatively safe application distance can be maintained between the entire pipeline area and the high temperature area. Simultaneously, based on the mathematical model, it can be smoothly expanded into regular application graphics, which can be processed with reasonable algorithms, thereby reducing the complexity of the pipeline layout process and improving the application effect of the established model. Relevant staff need to extract some special coordinates for the sections that have been expanded. At the same time, the relevant staff need to store it in the txt application format, after completing the format conversion process. Related staff will also directly enter it into Matlab, and then complete the processing of three-dimensional coordinates, cylindrical coordinates, UV coordinates and other content to obtain two-dimensional coordinates for analysis and processing. This can also provide reliable application data for subsequent fault discovery and fault handling.

![Figure 2. Schematic Diagram of Expansion Model](image)

3. Key Points of Intelligent Optimization for Bundle Laying of Single Target Pipelines in Complex Equipment

3.1. Optimization Algorithm Analysis

The particle swarm algorithm is the main optimization algorithm used when carrying out the bundled laying of single-target pipelines of complex equipment. This algorithm is an evolutionary processing algorithm based on the unfolding of particles. When proposing such algorithms, experts usually refer to the regular movement of birds and fishes, adjustment of orientation, and search for destination trajectories, so as to obtain the best laying path. In the specific application process of the algorithm, experts will use it as a non-gradient algorithm. Experts will use iterative processing, attempted improvement, candidate selection and other methods to screen out the required solutions. In the actual application process, experts will use a certain type of candidate solution as particles, and use corresponding mathematical formulas to calculate the particle's moving position and moving speed. It should be noted that in the application process of the algorithm, the changes in the content of the coordinates are necessary to relate to self-cognition and neighboring particle information. Based on this, experts also need to do a good job in strengthening the particle search capabilities. This makes it possible to complete the content screening in a short time and get the best design scheme.
3.2. Algorithm Content Design

3.2.1. Particle Encoding Processing

According to the content in the above chapters, it is necessary to calculate the fitness function of each particle when using the particle swarm algorithm to process related content. Subsequently, the computer system uses iterative processing to find the optimal solution. It can be seen that establishing an appropriate fitness function in specific applications is a very basic and important link. When establishing the fitness function, it is necessary to encode the particle content according to the actual situation to obtain the node coordinate information with application value. As shown in Figure 3, relevant workers need to determine the starting point and end point of the single-target pipeline, establish a corresponding two-dimensional rectangular coordinate system around it, and use other layout coordinates as node coordinates. Nodes such as X1, Y1, Y2 in the figure will be recorded as node coordinates, and then these information will be substituted into the laying formula for comprehensive calculation. Next, relevant staff need to use iterative analysis methods to obtain the most appropriate coding content and improve the rationality of the design results.

3.2.2. Constraint Handling Essentials

In the process of algorithm application, it is also necessary to strengthen the constraint processing work to ensure the compliance of the node control quality. From the perspective of actual application, complex equipment will pass through electrical appliances dense areas, signal interference areas, external contact areas and other modules during the pipeline layout process. For this content, the constraint processing needs to be applied to analytical geometry and facades. Projection and other methods will be the constraints that need to be considered in the actual layout. Then it is transformed into the plane intersection problem existing in the mathematical model, so as to improve the practicability and reliability of the problem processing result. In the process of particle algorithm application, a penalty function will also be used to reduce the screening time of the scheme by 30%-50%. Meantime, this can also increase the constraint by more than 40%, find the obstacle content in the process of bundle laying in time, and achieve the effect of continuously optimizing the function calculation content [1].

3.3. Algorithm Implementation Process

Based on the above-mentioned related content, the collected data information will be adjusted to the TXT text format when the particle swarm algorithm is applied. This also laid the application foundation for the smooth development of subsequent data interaction activities. In the meantime, the Grip secondary development process will also be used in the optimization process of the control node, together with Simense NX to complete the collation of the particle model. Moreover, in specific applications, a comprehensive evaluation of multiple programs will be carried out to obtain reliable data analysis results. Otherwise, the following needs to be paid attention to in the process of algorithm application. Firstly, when deploying algorithm optimization based on the content of pipeline laying of complex equipment, the selected population size needs to be controlled within a reasonable range. In
this way, too large a population can increase the time cost loss. Combining previous practical experience, the population used is controlled within 300-500 to meet the requirements. Secondly, to properly select the search range, the content needs to be organized while establishing the two-dimensional coordinates of the space, so as to improve the retrieval efficiency by 10%-15%. Thirdly, considering the randomness of the particle swarm trajectory, it is necessary to increase the number of iterations in practical applications to obtain the most suitable solution [2].

3.4. Simulation Experiment Analysis
In the established simulation experiment, three pipelines can be laid in bundles as experimental objects, denoted as a1, a2, and a3, where the distance between a1 and a2 is 30mm, and the distance between a2 and a3 is 40mm. The total length of the laying is 1000m. During the processing based on the particle swarm algorithm, an iterative curve is also drawn. Among them, the abscissa of the curve is the number of particle iterations, and the ordinate is the value of the fitness function. According to the calculated data, it can be understood that after the number of iterations exceeds 30 times, the entire curve begins to converge. After more than 90 times, the curve starts to be in a relatively stable state, that is, the optimal combination target has been obtained at this time. We are supposed to put the obtained optimal scheme into the simulation experiment, check the pipeline avoidance area, the total length of the laid line, etc. It can be understood that the use of particle swarm algorithm can meet the intelligent demand for single-object pipeline laying, thereby improving the rationality and effectiveness of the laying plan [3].

4. Key Points of Intelligent Optimization for Bundle Laying of Multi-Objective Pipelines for Complex Equipment

4.1. Optimization Algorithm Analysis
The multi-objective particle swarm algorithm (hereinafter referred to as MOPSO algorithm) is the main optimization algorithm used when carrying out the bundled laying of single-target pipelines of complex equipment. This algorithm is an improved calculation method based on the particle swarm algorithm, which can handle more complex scheme selection problems. In the process of the specific application of the algorithm, the Pareto optimal solution set will be selected by means of iterative processing, attempted improvement, and candidate selection. Corresponding application models will also be established during the period, assuming that there are n decision variables and m targets to be optimized, based on which to complete the construction of the mathematical model, and discuss the data content of the Pareto optimal solution set. It should be noted that there are many calculations that need to be performed during the application of the algorithm. The system has higher requirements for the particle search ability, which also requires the analysis of the Pareto optimal solution set content law, so as to obtain the best design plan in a shorter time [4].

4.2. Algorithm Content Design

4.2.1. Particle Encoding Processing
When using the MOPSO algorithm to process related content, it is necessary to calculate the fitness function of each particle. Subsequently, the system will use iterative processing to obtain the Pareto optimal solution set, and find the optimal solution from it. It can be seen that establishing an appropriate fitness function in a specific application is a very important application link. During the establishment of the fitness function, it is also necessary to encode the particle content according to the actual situation, so as to obtain the Pareto optimal solution set data with application value. In practical applications, relevant workers need to determine the starting point and ending point of the multi-target pipeline, and filter out the corresponding value data. Simultaneously, the relevant staff also need to clarify the node coordinates of the function calculation process, scientifically calculate the value data involved, and convert it into data information that can be quantitatively analyzed. Subsequently, the
relevant staff need to substitute this information into the laying formula and perform comprehensive calculations on it. Relevant staff can use iterative analysis methods to obtain the most appropriate coding content. This can lay the foundation for the subsequent calculation work [5].

4.2.2. Constraint Handling Essentials
In the process of applying the MOPSO algorithm, it is also necessary to strengthen the constraint processing work to ensure the compliance of the node control quality. From the perspective of actual application, the area that complex equipment passes through in the multi-object pipeline layout design is more complicated, and more constraints need to be taken into account. This also requires the help of analytical geometry, elevation projection and other methods. Experts need to simplify the content of the constraints and transform them into the plane intersection problem in the mathematical model. Experts can use quantitative or qualitative methods to determine the content of constraints, thereby improving the reliability of the content of Pareto's optimal solution set. Besides, in the application process of the MOPSO algorithm, non-dominated sorting is also used to complete the iterative optimization work. Experts can directly replace the content that does not meet the requirements according to the clear constraints, thereby reducing the workload of 30%-50% and improving the value of the content of the areto optimal solution set [6].

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5.3. Algorithm Implementation Process
Based on the above-mentioned related content, Simense NX software and MATLAB software need to be used in conjunction with the application of the MOPSO algorithm. At the same time, when
establishing the application model, GRIP secondary development will be used to complete the particle model sorting and obtain the optimal solution. Moreover, in the process of algorithm application, also need to pay attention to the following. Firstly, when deploying algorithm optimization processing based on the content of multi-target pipeline laying of complex equipment, relevant staff need to clearly mark the special point information and process the content of the three-dimensional coordinate points. Moreover, relevant staff also need to use visualization functions to complete data sorting. Secondly, in order to facilitate the unified processing of the collected data, relevant staff need to convert the collected data into TXT text format. This also lays a solid application foundation for the rapid interaction of MATLAB information. Third, considering the randomness of the particle swarm trajectory, in practical applications, relevant staff need to do a good job in the optimization of the first generation of particle swarms. Meanwhile, relevant staff need to appropriately increase the number of iterations to obtain the most suitable Pareto optimal solution set [7].

5.4. Simulation Experiment Analysis
In the established simulation experiment, the MOPSO algorithm is used to process this, during which an iterative curve will also be drawn. Among them, the abscissa of the curve is the number of particle iterations, and the ordinate is the value of the fitness function. Simultaneously, experts also need to build a systematic clustering tree and Pareto non-dominated solution set to evaluate the application effect of the intelligent algorithm. According to the calculation data, it can be understood that after the number of iterations reaches a certain number of times, the dominance relationship of the obtained Pareto non-dominated solution set content is also continuously enriched. This can not only effectively reduce the distance reduction by 10%-15%, but also meet the needs of intelligent multi-target pipeline laying, and improve the rationality and effectiveness of the laying plan [8].

6. Conclusion
In summary, in the piping system design of complex equipment, taking into account the complex internal structure of the equipment, more irregular areas, high degree of dispersion, complex nonlinear relationships, etc., experts need to match the intelligent algorithm according to the actual situation. Deal with. This can improve the rationality of the pipeline design content and meet the actual application requirements.

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