Research computer numerical simulation on heat dissipation model of submarine data centre based on TOPSIS model

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Abstract. Due to the huge energy consumption of land-based data centers, it is necessary to establish undersea data centers as soon as possible in order to alleviate the problem of resource tension. In this paper, the uniformity of containers is assumed. Through force analysis, it is found that the stress of containers is uniformly distributed, so only the external stress should be considered. Hypothesis submarine data center in the 50 m deep seawater, calculate the container need to withstand stress is 76.417403 Mpa, common material in engineering field, then physical parameters of material to deal with the dimensional and normalization, and establishes a comprehensive evaluation model material, the Topsis method is adopted to solve, to solve the optimal evaluation of the results can be divided into: 7-4 PH Stainless Stee 0.7450 points, so choose it as IU server container material.

Keywords: Topsis model material, comprehensive evaluation, Submarine data center, IU server container.

1. Introduction
With the rapid development of the Internet era, the number of data centers on the Internet also increases. But the core of the data center cooling problem is to solve problems, in order to guarantee the normal operation of the data center, when the server is running will emit a lot of heat, is needed at this time of heat, and heat dissipation is expensive in the long term, in order to solve this problem, need to set up of the data center in the bottom of the sea, make data center cooling water for processing, but set up at the bottom of the sea, to solve some undersea problem such as equipment corrosion resistance, resistance to high pressure. Therefore, suitable materials need to be selected according to the seabed location, so as to handle the heat dissipation of the data center while ensuring the stability of the data center.

2. Status of research
Scholars have used different methods and from different angles to excavate seabed resources: For example, Huang Guocheng (2008) used the volume method in the calculation process of seabed natural gas hydrate resources. Experimental results show that volume method can well establish many parameters of natural gas hydrate [1]. Yuan Wenjuan (2014) used the barrier analysis method to build a multi-dimensional evaluation model for submarine pipelines. The simulation results show that the multi-dimensional evaluation accuracy of this model is higher than other models, and it can give good
feedback to the evaluation of submarine pipelines, and has a wide application prospect in the prevention of submarine pipelines [2]. Li Bing (2014) established the fuzzy comprehensive evaluation model of submarine power cable system by combining the mathematical methods such as fuzzy mathematics and analytic hierarchy process (AHP). The simulation results show that the model can well assess the risk level of the submarine power cable system, and also prove the validity and rationality of the model [3]. Qingyang Liu (2016) based on ABAQUS software established a finite element model for a transfault submarine gas pipeline that could take into account the large geometric deformation of the pipeline and the nonlinear coupling effect of pipe and soil. The final simulation results show that the finite element model establishes the accuracy of the equivalent boundary model and the optimal benign verification [4]. Zhang Haozhong (2017) took ABAQUS, a large finite element structure analysis program, as the platform, used X65 steel as the pipeline steel, and ramberg-Osgood model as the constitutive model to establish the nonlinear equivalent boundary beam element model of submarine pipeline. The final simulation results show that the Ramberg-Osgood model can effectively analyze the seismic dynamic reliability of pipelines compared with other models [5]. Tang Peipei (2017) used the finite element method to analyze the mechanical response law of pavement structure under different influencing factors by using dynamic modulus, explored the sensitivity of each influencing factor to the structural stress response, and established a multi-index control system for the thickness design of pavement structure of submarine tunnel in frozen sea. The final experimental results provide theoretical support for the design and application of pavement structure and material of submarine tunnel in frozen sea [6]. Most of the models used in the above literatures are based on the study of undersea tunnels, pipelines, cables, etc., which are not obviously helpful for the establishment of undersea data center, and the models are relatively complex. In this paper, the TOPSIS method is mainly used, and the comprehensive material evaluation model based on TOPSIS method is established. The material properties of the seabed data center are designed, and the material selection model suitable for the seabed data center is obtained.

3. Data Preprocessing
The pressure is different at different depths of seawater, and the chemical properties of different materials are also different. Therefore, this paper combines pressure resistance and corrosion resistance to select materials, and takes the cost into consideration. For containers under pressure, in mechanics of Materials: the same mechanical properties are assumed everywhere in a solid. Therefore, we also make the uniformity assumption for the cylinder, assuming that the mechanical properties of each position are consistent, and the container is in the seabed, its axis is parallel to the sea level, so the pressure state of the container is uniformly distributed load. We set the depth as 55m, calculate the stress that the container should bear through the pressure and pressure formula, and then select the material in the attachment according to the stress. The material parameter here is subject to the yield strength. At the same time, heat dissipation needs to be taken into account, so we choose from metal materials, eliminate the non-conforming materials from the attachment according to the server bearing stress, and then check the price of the remaining materials. Finally, dimensions were removed from the properties of the materials selected in the attachment. As for the corrosion, we found that the greater the potential difference, the greater the potential corrosion. Therefore, the potential column in seawater was converted into potential difference. For the interval value in the material parameter, we take the intermediate number. For price, the requirement is to reduce the cost, so the price data is converted into reciprocal. You end up with the following matrix
Table 1. Dimensity table of metal material parameters

| Material                        | Modulus of elasticity E (psi) | Yield strength Oy (KSI) | Tensile strength Ou (kSI) | Potential difference | Price |
|---------------------------------|-------------------------------|-------------------------|---------------------------|----------------------|-------|
| Copper alloy                    |                               |                         |                           |                      |       |
| Beryllium-Copper, CDA 172       | 18000000                      | 170                     | 197.5                     | 0.15                 | 0.04  |
| 70-30 Copper-Nickel             | 22000000                      | 79                      | 85                        | 0.06                 | 0.02  |
| Cast Aluminum Bronze           | -6000000.                     | 60                      | 102                       | 0.1                  | 0.03  |
| Nickel alloy                    |                               |                         |                           |                      |       |
| Monel 400                       | 26000000                      | 110                     | 120                       | 0.1                  | 0.05  |
| Inconel 625                     | 29800000                      | 201                     | 219                       | 0.14                 | 0.005 |
| Iron and steel                  |                               |                         |                           |                      |       |
| Ductile Cast Iron, -2000000.   | 95                            | 117.5                   | 0.12                      | 0.06                 |       |
| AISI 1040 Steel                 | 30000000                      | 86                      | 113                       | 0.1                  |       |
| AISI 1080 Steel                 | 30000000                      | 142                     | 190                       | 0.1                  | 0.05  |
| HY-80 Steel                     | 30000000                      | 90                      | 103                       | 0.0001               | 0.1   |
| HY-100 Steel                    | 30000000                      | 102.5                   | 114                       | 0.001                | 0.06  |
| Stainless steel                 |                               |                         |                           |                      |       |
| 17-4 PH Stainless Steel         | 28500000                      | 181.5                   | 200                       | 0.15                 | 0.1   |
| 410 Stainless Steel             | 29000000                      | 285                     | 185                       | 0.115                | 0.04  |

4. Force analysis of the server container

On the basis of data processing, the selection of appropriate materials and appropriate seabed depth should take into account the corrosion of seawater on containers. Analyze the physical property parameters of metal: material, metal proportion of alloy material, density, elastic modulus, yield strength, tensile strength, seawater potential, metal corrosion type, application and special reminder. Because it is in the sea floor, from the point of view of service life, the choice of material preferred metal material, and is in the sea floor, need to bear large water pressure, other materials are not competent. There is also the question of cost. Since the sea water tends to decrease by 1℃ with the decreasing temperature of 1000m, it is mainly considered from the perspective of pressure.

Firstly, we analyze the pressure:

Seawater pressure formula:

\[ P_{\text{sea}} = \rho_{\text{sea}} gh \]  \hspace{1cm} (1)

Sea water pressure at 55m:

\[ P_{\text{sea}} = \rho_{\text{sea}} gh = 1.03 \text{kg/m}^3 \times 9.8N/kg \times 55m = 555.17Pa \]

Pressure required for container at 55m:

\[ F = PS = 555.17Pa \times 39.25\text{m}^2 = 21790.4225N \]

Since the container is a cylinder, we regard it as a hollow shaft in the sea water, and first we analyze the force on it.

![Figure 1. Force analysis diagram](image-url)
As shown in the two above, because the load is uniformly distributed, the bending moment borne by the container is offset, so the bending moment can be ignored and not remembered. We only need to calculate the yield strength of the container at the bottom of the sea, we choose the metal materials: aluminium alloy, copper and copper alloy, nickel alloy, iron and copper, titanium and titanium alloy, stainless steel.

Yield strength calculation formula: \( \sigma = \frac{F}{S} \)

Where, F is the pressure and S is the cross-sectional area

Stress required for container at 55m:

\[
\sigma = \frac{F}{S} = \frac{21790.4225 \text{N/m}^2}{0.28515 \text{m}^2} = 76417.4031 \text{MPa} = 76.4174031 \text{MPa}
\]

5. Establish a comprehensive evaluation model of materials based on TOPSIS method

TOPSIS method: TOPSIS method is the ideal solution method, which is an effective multi-index evaluation method. The metal property parameter matrix obtained after data processing was substituted into the TOPSIS model. The steps are as follows:

**Topsis algorithm steps as follows:**

1. The canonical decision matrix is obtained by vector programming method. Let the decision matrix of multi-attribute decision problem, the normalized matrix, where \( A = (a_{ij})_{m \times n} \)

\[
b_j = a_{ij} \sqrt{\sum_{i=1}^{m} a_{ij}^2}, i = 1,2,\ldots,n
\]  

2. Construct the weighted gauge matrix. \( C = (c_{ij})_{m \times n} \) Let the weight vector of the attribute given by the decision maker be, then \( w = [w_1, w_2,\ldots,w_n]^T \)

\[
c_{ij} = w_j \cdot b_j, i = 1,2,\ldots,m; j = 1,2,\ldots,n
\]

3. Identify positive and negative ideal solutions. \( C^+ \) \( C^0 \) Let the value of the attribute of the positive ideal solution be, and the value of the attribute of the negative ideal solution be, then \( C^+ \) \( C^0 \) \( C^0 \)

\[
Positive \ ideal \ solution \ c^*_j = \begin{cases} \max_i c_{ij}, & j \text{ Efficiency attribute,} \\ \min_i c_{ij}, & j \text{ Cost attribute,} \end{cases} \quad j = 1,2,\ldots,n
\]

\[
Negative \ ideal \ solution \ c^0_j = \begin{cases} \min_i c_{ij}, & j \text{ Efficiency attribute,} \\ \max_i c_{ij}, & j \text{ Cost attribute,} \end{cases} \quad j = 1,2,\ldots,n
\]

4. Calculate the distances between each scheme and the positive and negative ideal solutions. The distance between the alternative solution and the ideal solution is zero \( d_i \)

\[
s_i^* = \sqrt{\sum_{j=1}^{n} (c_{ij} - c^*_j)^2}, i = 1,2,\ldots,m
\]
The distance from the alternative to the negative ideal solution is \( d_i \)

\[
s_i^0 = \sqrt{\sum_{j=1}^{m} (c_{ij} - c_{ij}^0)^2}, \quad i = 1, 2, ..., m;
\]

(6)

(5) The ranking index value (i.e., comprehensive evaluation index) of each scheme was calculated, i.e.

\[
f_i^* = s_i^0 / (s_i^0 + s_j^*), \quad i = 1, 2, ..., m
\]

(7)

(6) Rank the options in order of best to worst. \( f_i^* \)

5.1. Solution of material comprehensive evaluation model

The final results are as follows:

0.5809 0.3400 0.2859 0.4916 0.5637 0.4268 0.5735 0.4840 0.5316 0.7450 0.6536

Corresponding to a metal material:

| Table 2. Comprehensive score sheet of materials |
|-----------------------------------------------|
| Material nouns                  | Evaluation score |
| Beryllium-Copper, CDA 172       | 0.5809           |
| 70-30 Copper-Nickel             | 0.3400           |
| Cast Aluminum Bronze            | 0.2859           |
| Monel 400                       | 0.4916           |
| Inconel 625                     | 0.5637           |
| Ductile Cast Iron               | 0.4095           |
| AISI 1040 Steel                 | 0.5683           |
| AISI 1080 Steel                 | 0.5735           |
| HY-80 Steel                     | 0.4840           |
| HY-100 Steel                    | 0.4268           |
| Maraging 300 Steel              | 0.5316           |
| 7-4 PH Stainless Stee           | 0.7450           |
| 410 Stainless Stee              | 0.6536           |

The ranking from highest to lowest was: 7-4 PH Stainless Stee, 410 Stainless Stee, Beryllium-copper, Ductile Cast Iron, 70-30 copper-nickel, Cast Aluminum Bronze, CDA 172, AISI 1080 Steel, AISI 1040 Steel, Inconel 625, Maraging 300 Steel, Monel 400, HY-80 Steel, HY-100 Steel, Ductile Iron, 70-30 copper-nickel, Cast Aluminum Bronze

Therefore, for the selection of materials, we preferred 7-4 PH Stainless Stee as the material of IU server container.

6. The conclusion

Proposed in this paper, based on TOPSIS model data in the material at the bottom of the evaluation model, the physical parameters of materials is analyzed, based on the idea of statistics to solve material selection problem in the field of engineering, the model has the advantages of high accuracy, reliability, versatility, and for the choice of material in the undersea data center construction problem provides a new solution that can be applied to the practical, bring certain realistic significance for the construction of underwater data center.
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