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RESEARCH ON THE DESIGN METHOD OF PYROTECHNIC FORMULAE

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Abstract: In this paper, in view of the continuous emergence of new experimental methods and the continuous improvement of old methods, how to reasonably select so many design methods has become a major problem for the formulation designers, the three commonly used formulation design optimization methods are briefly described, their advantages and disadvantages as well as their applications, especially in the formulation design of pyrotechnic drugs, and through a comprehensive analysis of various experimental methods, it is hoped to help Through the comprehensive analysis of various experimental methods, it is hoped that it will help the formulation designers to choose the formulation design methods reasonably.
Keywords: Formulation design; Optimisation methods; Pyrotechnics

1 INTRODUCTION

Formulation optimization is an important research content in the field of materials, In order to obtain formulations with excellent performance and meet the requirements of use, it is necessary to select raw materials reasonably and determine the dosage of various raw materials according to the performance requirements of the product and process conditions through testing, optimization and identification, For such a complex multi-objective formulation system, the design of the test method is particularly important, In recent years, the applied research on the optimal design of formulations is very active, new test methods continue to appear, the old methods continue to improve, in the face of so many design methods, how to reasonably choose has become a major problem for the formulation designer.
The formulation design of pyrotechnics is an important link in the research of pyrotechnics, and its quality and performance largely depend on the rationality of the formulation, Since in most of the formulation research, it is necessary to consider the influence law of two or more variable factors on the performance at the same time, with the help of the mathematical and statistical methods of statistical mathematics, it can change the many shortcomings of the traditional experimental design method such as the unreasonable distribution of test points, the number of tests, and the inability to reflect the interaction between factors, and so on, This paper addresses this issue in recent years, variety of experimental methods for comprehensive analysis, hoping to help formula designers to rationally select the formula design method, Currently the more commonly used methods are experimental methods, mathematical modelling and artificial intelligence.

2 EXPERIMENTAL METHODS

This method is a method of seeking the optimal material composition or optimal process conditions by systematically varying a variety of material and process parameters, This method is commonly used in the research and development of new materials, products and processes, and can also be applied to the improvement and optimization of existing materials and processes, Pyrotechnics can be selected as the optimal formula by experimentally testing the performance differences of different compositions or ratios of smoke generating agents, For example, the performance of a pyrotechnic agent can be evaluated by measuring parameters such as smoke density, colour and chemical composition, Among the many experimental methods, the orthogonal test method and the uniform design method are commonly used.

2.1 Orthogonal Test Method

Orthogonal experimental design is carried out through a set of carefully designed tables. Because the orthogonal table has the characteristics of orthogonality, balanced dispersion and neat comparability, so each No. l test has a strong representation, as long as the tests specified in the orthogonal table are done they can reflect the situation of the test in a more comprehensive way, and then the results of the orthogonal experimental design method of the formulation are analysed, one is an intuitive analysis, and the other is analysis of variance (ANOVA), Through the analysis of the test results (data),it is possible to determine the following: factors that have a significant impact on the indicators and factors that are not important to the indicators; the most favourable level combination for the indicators; the approximate range of changes in the indicators under the optimal level combination; the direction of further testing. The orthogonal test method has the characteristics of fewer tests and better representation of test points, and it can be used to analyse the results by both visual analysis and analysis of variance (ANOVA), and derive the significance of the factors and the optimal level combination [1]. The orthogonal experimental design has a good representativeness of the test sites.

orthogonal experimental design is more suitable for experimental arrangements with a low number of levels because the number of tests is at least the square of the number of test levels. It is widely used in the process off actor design and engineering optimisation in the fields of medicine, chemistry, manufacturing and engineering, Wang Wei [2] ,Guan hua [3], Ma Hongwei [4], Zou Jiaqi [5] et al. used orthogonal test method to carry out the formulation design of low detonation speed mixed explosives, infrared/mm wave resistant dual mode smoke generator, high precision boron deferred agent, and combustion type red phosphorus smoke generator, and the test results showed good performance, and the method has guiding significance for its formulation design.

2.2 Uniform Design Method

The uniform design method is a statistical analysis method used to determine the effect of multiple factors on an outcome. Unlike the orthogonal test method, the homogeneous design method does not require all factors to be arranged and combined, but rather the design is based on a measure of concordance, and the optimal "homogeneous design" point set is chosen to represent the range of values of the different factors, so as to obtain the optimal results with the minimum number of experiments.

The basic idea of the homogeneous design method is to divide the range of values of different factors into small intervals, each of which has representative value. When designing an experiment, a representative value is chosen from each sub-interval and these representative values are used to represent the experimental conditions. By optimising the choice of these representative values, the homogeneous design method allows the experimental results to be optimised in the minimum number of experiments.

The advantage of the homogeneous design method is that it does not require the full permutation and combination of each factor as in the orthogonal test method, thus saving experimental time and resources. It is also capable of handling non-linear multi-factor problems and is suitable for high dimensional experimental designs. Originally proposed by Japanese scholars Chou Itakura and Katsumi Tanaka in 1980, the homogeneous design method has been widely used in various fields, such as engineering, statistics, and computer science. Zhou Zunning [6], Min Jun [7], Zhou Mingshan [8], Wang Zongbei [9] et al. used the uniform design method against infrared hair and red phosphorus smoke agent and non-lethal weapon acoustic and optical bullet charge design.

3 MATHEMATICAL MODELLING

Mathematical modelling is a method of transforming practical problems into mathematical problems and solving them by building mathematical models to predict the performance of different formulations and select the optimal formulation. It is a comprehensive and widely applied technique that involves many fields such as mathematics, statistics and computer science. Usually, the problem is first clarified and the modelling objectives are determined; then data are collected processed and analysed; then an appropriate mathematical model is selected and solved; the next step is to validate the model and analyse the results; and finally, conclusions and recommendations are made on the basis of the results of the analysis. Lu Ming [10], Du Qianwei [11] by this method, several formulations of powdered ladder oil explosives, high power shock source pillars and gold containing mixed explosives were derived with reliable performance.

4 ARTIFICIAL INTELLIGENCE

Artificial Intelligence is the use of machine learning, neural networks and other artificial intelligence technologies, it can predict the best formulations for different materials and ingredients by analysing and modelling historical data, and verify them in practice. The advantages of artificial intelligence formulation design methods can quickly and efficiently generate formulas that meet the requirements, improving the efficiency of product development; and through a large amount of data analysis and learning, more accurate correlation laws and features can be found, importantly, human factors in the trial and error process are avoided, and the accuracy and stability of the formulation design is improved, At present, Al formulation design methods have been applied to many fields such as food, cosmetics, and medicine. In the formulation design of military pyrotechnic agents, Guo Haidong and Sun Yujie used support vector machine algorithms to predict the smoke density, colour and other performance indexes of different components of pyrotechnic agents. Xu Jilin [12] using CLPSO algorithm (Comprehensive Learning Particle Swarm Optimisation Algorithm), the optimal formulations were calculated and screened to prepare initial TATP and TNT explosive simulants.

5 CONCLUSION

Currently commonly used formulation design methods can be used to solve real-life problems, although they are different in nature, Their basic patterns, data requirements, speed and efficiency, and areas of application vary, In short, the various methods have their own advantages and disadvantages, the specific choice depends on the nature and needs of the research problem, according to the actual requirements of a reasonable choice, but also can be combined with each other to solve the problem, in order to reduce the consumption and greatly improve the efficiency of the work.

COMPETING INTERESTS

The authors have no relevant financial or non-financial interests to disclose.

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