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Analysis and evaluation of the leakage failure for clutch sleeve and shell

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ABSTRACT

To solve leakage failure of the product caused by uncertain factors, the clutch sleeve and shell are taken as an example for development of processing. Finite element model of clutch sleeve and shell is established, and the stress deformation is ascertained and analyzed under working load. Based on actual operating conditions of the clutch sleeve and shell, the mathematical model of leakage failure is established considering the factors of load, temperature, manufacturing error and assembling deviation. The clearance between the clutch sleeve and shell is determined and discussed using the model based on the influence of various factors. To reduce the size of the clearance, a relevant improvement that the increased step is added on outside of the sleeve is put forward. The results of discussion on the improved assembly and analysis of actual samples prove that the scheme is effective.

1. Introduction

With the progress of science and technology, industries like water conservancy, pipeline transportation and machine manufacturing require more improvements in the research on leakage. This situation urges more developments of the designing precision and processing technology [1,2]. Test and maintenance during parts' designing, processing and usage are always important means to prevent excessive leakage [3,4]. Leakage in various types of engineering facilities not only results in resources and finance losses but also causes danger to personal and property safety [5,6,8]. Aiming at studying the leakage failure, extensive research has been carried out both at home and abroad. In order to study leakage failure in engineering applications, researchers from numerous academic fields have applied different methods and lots of achievements have been obtained.

In the past, studies on the leakage failure were mainly based on computer methods or single factor [9]. These methods can be very accurate and reliable when there are only one or two impacts, and it is uncomplicated to carry out. But shortcomings emerge when impacts increase in quantity. Under this circumstance, mathematical model method shows its advantage [10,11]. However, methods considering the mathematical model from the mathematical point of view in many factors are not widely used. Multi-factor discussion is taken into account in this paper. Application of mathematical model considering certain factors is proposed to analyze the leakage failure.

The remainder contents of this paper are organized as follows. A review of related literature is provided in Section 2. Finite element analysis of the leakage is presented in Section 3. The mathematical model of the gap size is provided in Section 4, reasons leading to leakage is explored through this method. In Section 5, the improvement scheme of leakage failure is presented according to the leakage reasons. Finite element method and mathematical model method are used to get the gap size and feasibility of the

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improvement scheme is proved. Furthermore, results of the two methods are compared, the accuracy of the mathematical model proposed is verified.

2. Literature review

To solve the failure of leakage, extensive research was conducted home and abroad. Concerning the analysis of leakage failure, J. E. van Zyl et al. [12] provided a mathematical proof for an equation which was used with the concept of a dimensionless leakage number. And a more realistic description of leakage and intrusion flows was provided. In pipeline transportation, leaks plaguing the sub-optimal performance of water distribution systems can cause significant losses of treated freshwater, which exacerbated the imbalance between demand for freshwater and available water resources losses [7,13]. C. Eparu et al. [14] presented an analysis undertaken using the numerical simulation of gas leakage through defects of buried pipelines. Also in many conditions, external corrosion and other dynamic structural failure can lead to leakage, such as oil pipelines [15,16]. Another example, J. D. Butterfield et al. [17] used VAE monitoring to investigate signal processing techniques that quantified leak flow rate. A further model was developed for buried pipes. In other fields, to consider the effects of tip clearance and sandwiched interface size on the performance, numerical simulations can commendably obtain the influence degree of different factors [18,19].

For the study of academic research, the application of mathematical model method from the mathematical point have also been developed and updated for a long time to reach a mature level at home and abroad. Mathematical modeling and programming are essentially the same activities [20,21]. Although programming is more complete than the model, it is more difficult than mathematical modeling. Y.H. Huang et al. [22] applied the mathematical model method to the planetary transmission system and analyzed the vibration signal spectrum accurately. In chemical applications, Y. Tavan et al. [23] applied a mathematical model and molecular dynamics simulation to study the integrated process consisting of industrial methane steam reforming and pressure-swing adsorption (PSA) to produce pure hydrogen, and the better results were obtained. C. Busatto et al. [24] developed a model which could predict the effect of particle size and molecular weight on the degradation of PLGA-based microspheres to estimate the morphological changes of the particles due to the autocatalytic effect. In the field of material processing, A. Patel and L. Nastac [25] applied mathematical model to research solidification of A356 castings. The model matched well with experimental results. In the field of Biology, with the development method of mathematic, it is increasingly used to solve biological problems, and this approach becomes indispensable [26]. In automotive tasks and development, the experimentally validated analytical modeling of diesel engine power and dynamics in-cylinder gas speed had less relative error, and this model could better analyze and evaluate the performance of diesel engine [10]. W. Pawlus et al. [27] proposed a brief overview of different vehicle crash modeling methodologies through three different approaches. N. Bellomo et al. [28] dealt with the multi-scale modeling of vehicular traffic according to a kinetic theory approach and the modeling can be the foundation for developments of new relative models.

In the academic research, various external factors were discussed to study the failure caused by parts' function weakness [29]. In addition, certain developments were obtained. J. Diatta et al. [30] developed a multi-physical numerical model of the spark plasma sintering(SPS) process to evaluate electrical, thermal and mechanical fields undergone by the powder during sintering. The effect of temperature on the deformation of the surface during the process of laser shock processing is an important that should not be ignored [31,32]. H. Ullah et al. [33] discussed the deformation of Carbon fabric-reinforced polymer (CFRP) and concluded that the damage modes of CFRP were mainly matrix cracking, delamination and tow debonding. Random errors during the manufacturing and assembly process in active phased-array antennas could cause a certain impact in situations [34,35]. In the research of evaluating machine tool performance, M. Pezeshki et al. [36] presented a new method to identify the kinematic errors of three-axis machine tool.

3. Finite element analysis

The clutch, erected between the engine and the transmission, is the assembly directly connected to the engine, it is also the part that cuts off or transmits the power between the engine and the automobile transmission. Among the parts of the clutch assembly, the sleeve and shell are important parts. The assembly of the two parts is shown in Fig. 1.

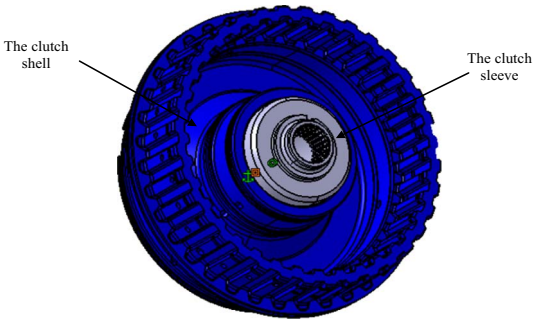

Fig. 1. Assembly of the clutch sleeve and shell.