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ENGINEERING & TECHNOLOGY MANAGEMENT

Title: A Knowledge Sharing System for Predicting Turbine Blades Flutters

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Abstract: A framework of knowledge sharing systems for predicting turbine blade flutters is proposed. Flutter is one of the serious failures in turbo machinery. Because of the complexity of flutter phenomena in turbines, most of the methods in practical use are empirical approaches, using experimental data as well as expert's experiences. So, sharing the experiences has become significant. A framework of a knowledge sharing system is proposed to help jet engine designers predict/avoid the onset of flutters in the design phase. Examples of such a system may include: 1) improving the prediction accuracy by using the available resources more effectively, 2) reducing or even eliminating the possibility of the onset of flutter to help researchers understand the mechanism of flutter phenomena, and 3) sharing knowledge more effectively among researchers in different places.

A KNOWLEDGE SHARING SYSTEM FOR PREDICTING TURBINE BLADES FLUTTERS

W. Liu

EMP - P9030

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TO: DR. KIYOSHI NIWA
FOR: EMGT 510 E

MARCH 12, 1991

To: Dr. Kiyoshi Niwa
Subject: Executive Summary for EMGT 510 E
Date: March 12, 1991

A Knowledge Sharing System for Predicting Turbine Blade Flutters

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Summary

In this paper, a framework of knowledge sharing systems for predicting turbine blade flutters is proposed.

Flutter is one of the serious failures in turbomachinery, which has a significant effect on the life span and reliability of turbomachines. Because of the complexity of flutter phenomena in turbomachines, most of the existing theoretical methods cannot give satisfactory predictions for turbine engine designs. Therefore, most of the methods in practical use are empirical approaches, using experimental data as well as experts' experiences. Several flutter prediction experimental data bases have been established in the last decade. But, because of the diversities in experimental facilities, experimental conditions, flutter types, vibrational modes, and the parameters measured in experiments, sharing the experiences (or knowledge) among researchers with specific experiences has become significant.

Consequently, a framework of a knowledge sharing system is proposed to help jet engine designers predict and avoid the onset of flutters in the design phase. Examples of production rules for predicting flutters are developed.

The expected benefits of the knowledge sharing system for predicting flutters may include:

* improving the prediction accuracy by using the available sources more effectively,
* reducing or even eliminate the possibility of the onset of flutter in the design phase,
* helping researchers to understand the mechanism of flutter phenomena,
* sharing knowledge more effectively among researchers in different places.

A Knowledge Sharing System for Predicting Turbine Blade Flutters

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Abstract

In this paper, a framework of knowledge sharing systems for predicting turbine blade flutters is proposed. Flutter is one of the serious failures in turbomachinery. Because of the complexity of flutter phenomena in turbomachines, most of the methods in practical use are empirical approaches, using experimental data as well as experts' experiences. So, sharing the experiences (or knowledge) among researchers with specific experiences has become significant. Consequently, a framework of a knowledge sharing system is proposed to help jet engine designers predict and avoid the onset of flutters in the design phase. Examples of production rules for predicting flutters are developed. The expected benefits of such a system may include: 1) improving the prediction accuracy by using the available resources more effectively, 2) reducing or even eliminate the possibility of the onset of flutter in the design phase, which would reduce the R&D cost dramatically, 3) helping researchers to understand the mechanism of flutter phenomena, and 4) sharing knowledge more effectively among researchers in different places.

I. Introduction

Flutter is one of the serious failures in turbomachinery, which has a significant effect on the life span and reliability of turbomachines. A lot of effort, both experimental and theoretical, has been made to predict and avoid the onset of flutters. Flutter in turbomachinery may include following complex phenomena:

* flow separation,
* shock motion,
* transonic flow
* secondary flow effect etc.

Because of these complex nature, most of the existing theoretical methods cannot give satisfactory predictions for turbine engine designs in most cases. Therefore, most of the methods in practical use are empirical approaches, using the experimental data as well as experts' experiences to predict the onset of flutters. Several flutter prediction experimental data bases have been established in the last decade. Those experiments can be classified according to the following aspects:

* experimental facilities
  - linear cascade,
  - annular cascade,
  - multistage rotor,
  - full scale engine.

* experimental conditions
    - subsonic,
    - transonic,
    - supersonic,
* flutter types
    - subsonic flutter
    - transonic stall flutter,
    - supersonic stall flutter,
    - A100 flutter,
    - supersonic unstall flutter,
    - choke flutter,
* vibrational modes
    - first bending,
    - first torsion,
    - second bending,
    - second torsion,
    - coupled vibration,
    - etc.
* parameters measured in experiments
    - reduced frequency
    - Much number
    - incidence angle
    - interblade phase angle
    - etc.

Different experiments have different combinations of conditions above, which will produce many kinds of experiments. The experiences (or knowledge) in different experiments will reflect different characteristics of the flutter phenomena. In this case, sharing knowledge among different researchers could help be a means to obtain overall understanding of the phenomena and to predict flutter more accurately.

A lot of research effort on knowledge sharing systems, proposed by Niwa, have been done. This concept is considered to be able to overcome some of the shortcomings of ordinary expert systems for ill-structured problem. This method can also be a useful tool for the flutter prediction problem discussed above.

In the first section of this paper, a framework of knowledge sharing systems for flutter prediction is developed. In the second section, a domain model for the flutter prediction problem is discussed with some examples of production rules. In the third section some of the issues are discussed, which include

* inference chains
* knowledge association between different kinds of flutters by human-computer cooperation.
* human-computer cooperation procedures to update the rules in the knowledge base.
* testing the performance of the system.
* maintaining and updating the system.

2. A Framework of Knowledge Sharing System for Flutter Prediction

In this section, the concept of knowledge sharing systems proposed by Niwa is used to establish the framework of flutter prediction system. As suggested by Niwa, a knowledge sharing system consists of five parts which is:

* knowledge base,
* association knowledge base,
* association guidance,
* inference engine,
* user interface

The structure of such a human-computer cooperative system for flutter prediction problems can be illustrated by Fig.1 as follows:

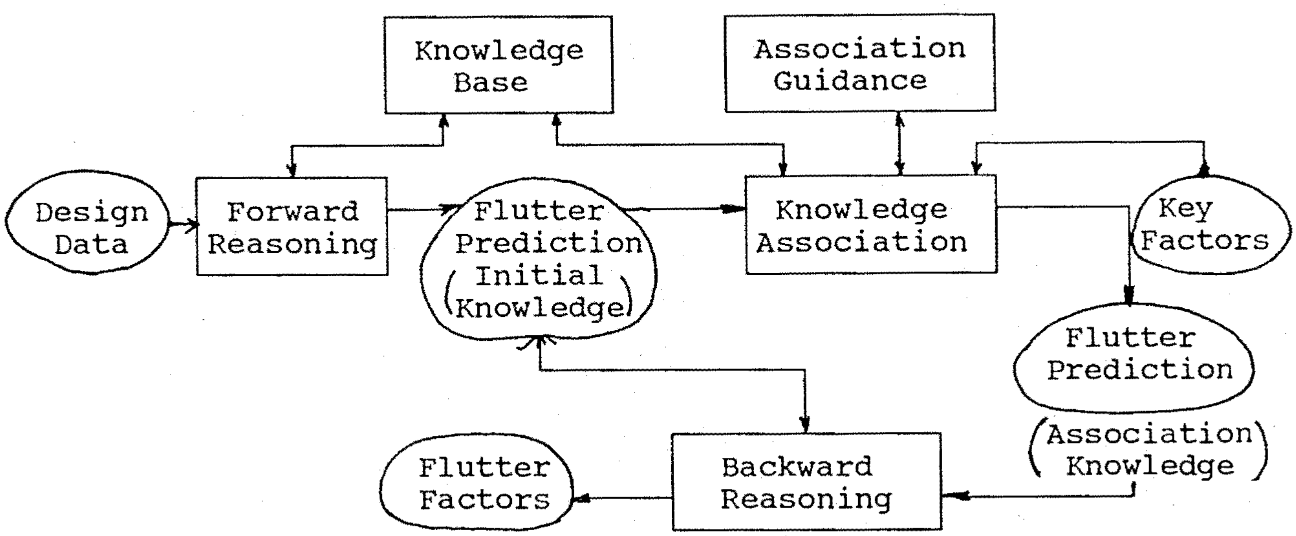

Fig.1 A Framework for Flutter Prediction Knowledge Sharing Systems

The working procedure of this system can be summarized as follows:

1) input the design data for a new engine into the system.
2) the system will use forward reasoning to predict if flutter will occur or not by using the knowledge base, which contains a number of flutter prediction rules.
3) the user (the engine designers, or flutter prediction experts) can also use their own knowledge to produce association knowledge by association guidance.
4) if the predicting result shows that flutter will occur, the user can use backward reasoning to find out which factors cause the flutter, then can modify the design data and use the system to predict again until the predicting result is no flutter.
5) In the case that the system predict no flutter but the engine

s there is a flutter, the user can use their own to analyze what causes the flutter, and input their ience (new rules) or even new factors into the ıich will be the association knowledge.

ıain Model of Flutter Prediction Problems

mechanism of flutter phenomena has not been well , the flutter influential parameters have not been .ed. In the early stage of flutter prediction ıe reduced frequency was found to be a major factor :. Under a numerous experimental studies in various veral experimental rules was obtained by analyzing al data. Since then several other parameters have have an influence on the onset of flutter. Those Lude Much number, incidence angle, interblade phase s mentioned above, because of the difference in facility, experimental conditions, etc., the experts' understanding of the phenomena, and the experimental data analyzing techniques, There are rules for different conditions. In this case the wledge sharing system will help the researchers to r more accurately by sharing the experiences (or

such rules could be as follows:

d frequency is less than 0.12)
r will occur)

d frequency is greater than 0.12), and
ed frequency is less than 0.15), and
ı number is greater than 0.8), and
ıe blades have no shroud-spans)
ıic torsional flutter will occur)

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