PREDICTION OF THE EFFECT OF THE MATERIAL AND ADHESIVE THICKNESS ON TENSILE CAPACITY OF T-JOINTS

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Abstract - Data mining techniques have been mostly used in many engineering applications In this study, the prediction of the effect of the thickness of the material and the thickness of the adhesive on the failure load in the T joints bonding was investigated. Tree model M5P and M5 rules model classifiers were used for estimation. 24 experimental instances from the literature were used as data. It was seen that the effect of materials and adhesives thickness on the failure load in T joints can be predicted by using M5P and M5 rule classifiers.

Keywords - Data mining; M5 rule; Tree model M5P; Adhesive

I. INTRODUCTION

Adhesively bonded joints are commonly used for bonding various structural components in aerospace and oil-and-gas industries due to their ease of construction and superior mechanical performance. Due to their high strength to weight ratio and their flexibility to be tailored to various complex shapes, composite materials are widely used in various industries[1]

The need to design lightweight structures and the increased use of lightweight materials in industrial fields, have led to wide use of adhesive bonding[2]. Adhesively bonded joints provide many advantages over conventional bonding. They provide a more uniform stress distribution along bonded area, high corrosion and fatigue resistance, reduce the weight and the cost[3]. They need fewer components. Different material with dissimilar thicknesses can be assembled. They have a lower aesthetic impact. They are energetically efficient and easy to automate[4].

The adhesively bonded joints are single-lap joints, double-lap joints, strap-joints, scarf joints, and step-lap joints, tapered joints and T joints. The T joint is the most commonly used joint in the civil aircraft industry.

The bonded length, adhesive thickness and adherend thickness of the joint have marked effects on the Tee joint stiffness[5]. Akpınar at all compared mechanical behaviors of T-joint types with embedded and non-embedded supports subjected to bending forces numerically and experimentally. They used T-joint samples of two types by using a two-part epoxy adhesive[6]. Zhan et all. investigated mechanical behaviors of different types of T joint subjected to tensile loading Numerical models were performed by using three-dimensional(3D) elastic–plastic finite element method to analyze the tensile process of different types of T joint[7].

In this study the rule-based M5 rule and tree model M5P are used to predict the effect of the material and adhesive thickness on tensile capacity of T-Joint adhesive bonding. Data used for prediction were obtained from Can H. master thesis[8].

II. MATERIAL AND METHOD

Data mining, is a technique to extract patterns or knowledge from huge amount of data. The data mining usually begins with raw data, goes through the procedure of data wrangling (e.g. data selection, cleaning, and preprocessing), feature engineering, machine learning, and it ends with knowledge evaluation[9].
Data mining techniques have been mostly used in many engineering applications[10]. There are a lot of learning techniques in literature such as neural network, instance based learning, regression tree, standard regression, which are used to predict numeric values. Their performances change according to application area[10].
Data obtained from literature[8] used for prediction are given in Table 1. Adherend thicknesses are given in column 2. Adhesive thicknesses are given in column 2. The failure load results are given in column 3. For prediction Tree model M5Pand M5 rules model classifiers were used.

Table 1. Input and output data

Experiment number	Adherend thicknes(mm)	Adhesivethickness (mm)	FailureLoad (kN)
1	2	0.6	0.14
2	2	0.6	0.16
3	2	0.6	0.23
4	2	1	0.22
5	2	1	0.23
6	2	1	0.24
7	2	1.5	0.16
8	2	1.5	0.165
9	2	1.5	0.17

10	3	0.6	0.32
11	3	0.6	0.32
12	3	0.6	0.41
13	3	1	0.55
14	3	1	0.53
15	3	1.5	0.96
16	3	1.5	1.1
17	5	0.6	0.82
18	5	0.6	0.95
19	5	0.6	1.04
20	5	1	0.85
21	5	1	0.89
22	5	1	0.9
23	5	1.5	0.92
24	5	1.5	1.18

III. RESULT AND DISCUSSION

3.1. Tree Model M5P results

Tree model M5P is a tree-based classification method. The method also is capable of producing a classifier rule with tree structure. For this model, 24 instances shown in Table 1were tested. For this application 8-fold cross-validation which gave the best results was used. A 0.91 correlation coefficient and a 0.11 mean absolute error was obtained.

A correlation coefficient of 0.91 means that a prediction is 91% successful. The tree structure obtained by the M5P decision tree is shown in Fig. 3. The rules for M5P model are given in table 3.

Table 2. M5P Model tree

d1 <= 2.5 : LM1	d1 >2.5
	d1 <= 4 : LM2
	d1 >4 : LM3

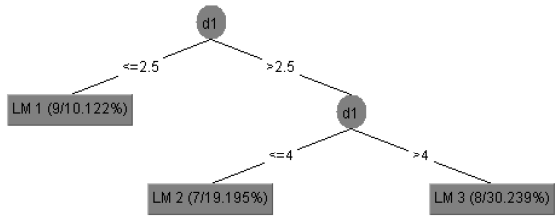


Figure 1. M5P Model Tree for Tensile Load Results

Table 3. M5P Rules

Rule	Load
LM1	Load =0.1545*d1+ 0.1555*d2- 0.2414
LM2	Load = 0.1821* d1+ 0.3912*d2-0.3859
LM3	Load =0.1796*d1+0.2656 * d2-0.1963

3.2. M5 rules model results

The M5 rules model is one of the rules-based classification methods. For this model, 24 instances shown in Table 1 were tested. For this application 8-fold cross-validation which gave the best results was used. A 0.93 correlation coefficient and a 0.10 mean absolute error was obtained.The rules for M5 rules model are given in table 4

A correlation coefficient of 0.93 means that a prediction is 93% successful. Rule-based classifier' results may be expressed with linear equations.

Table 3. M5 Rules

d1 <= 2.5 : Load =0.1545*d1+0.1555*d2-0.2414
d1 >4 : Load=0.1121*d1+0.2825*d2+0.108
Load =0.749 * d2 - 0.129

CONCLUSION

This study aimed to predict effect of material and adhesive thickness on failure load capacity of adhesively bonded T joints. 24 experimental results from literature used as data. Rule-based M5 rule and tree model M5P in the area of data mining were used for prediction. The inputs were material thickness and adhesive thickness. The output was failure load. The M5 rules model is %93 successful for prediction and Tree model M5P is %91 successful for prediction.

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