DEVELOPMENT AND DESIGN ANALYSIS OF EXPERIMENTAL RIG TO IDENTIFY PIEZOELECTRIC ACTUATOR'S TRANSFER FUNCTION

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This report submitted in accordance with the requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Manufacturing Engineering
in Robotic and Automation (Hons.)

by

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APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Manufacturing Engineering (Robotics and Automation) (Hons.). The member of the supervisory is as follow:

……

(Engr. Mohd Nazmin Bin Maslan)

ABSTRACT

This project is closely related to the widely used piezoelectric in the industry today. This project is to fabricate an experimental rig involving two types of piezoelectric bender and patch type. This experimental rig to generate the transfer functions. The project is to integrate two types of piezoelectric in the experimental rig. Once the experimental is complete, project needs to go through a vibration test. These types of test are focus on the bender holder and the patch frame. The objectives of this project are to develop and design analysis of the experimental rig. Literature review was to examine and analyze the experimental rig has been made before. This process should be carried out to know the advantages and disadvantages of the project before. The methodology is describes the procedures that must been done before completing this project and also explain how the vibration test procedures. All findings data are analyzed and. conclusion of this project is produced.

ABSTRAK

Projek ini berkait rapat dengan piezoelektrik yang digunakan secara meluas di industri masa kini. Projek ini untuk membina sebuah pelantar ujikaji yang melibatkan dua jenis piezoelektrik iaitu bender dan jenis tampalan. Pelantar ujikaji ini untuk menghasilkan rangkap pindah. Projek ini untuk menggabungkan dua jenis piezoelektrik di dalam satu pelantar ujikaji. Setelah pelantar ekperimen selesai dibangunkan, projek perlu melalui satu ujikaji tahap gegaran yg berlaku pada kedua-dua jenis piezoelektrik tersebut. Ujikaji yg dijalankan pada pelantar eksperimen adalah berbentuk ujian getaran. Ujian ini menfokuskan kepada bahagian yang memegang piezolektrik tersebut iaitu pemegang *bender* dan bingkai jenis tampalan.Permulaan untuk projek ini menyatakan objektif projek ini serta penyata masalah untuk projek ini. Kajian literatur dijalankan untuk mengkaji dan menganalisis pelantar ujian yang telah dibuat sebelum ini. Proses ini perlu dijalankan untuk mengetahui kebaikan dan kekurangan projek sebelum – sebelum ini. Dalam metodologi, menerangkan prosedur yang perlu dijalakan sebelum menyiapkan projek ini dan juga menjelaskan beberapa langkah untuk menjalankan ujian keatas pelantar eksperimen. Ia dilengkapkan dengan carta proses dan carta Gantt. Kesemua ujian yg telah dijalankan ke atas pelantar eksperimen dianalisa dan konklusi projek ini dikeluarkan.

DEDICATION

This is bestowed to my parents Johari Bin Mahadi and Embon Binti Ariffin whom without their endless support I would not be where I stand now.

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Hz	-	Hertz
mm	-	Milimetre
(N/m^2)	-	Newton per Metre
Min.		Minimum
Max.		Maximum

CHAPTER 1
INTRODUCTION

1.1 Background

Piezoelectric actuator is one of highly popular actuator that is emerging nowadays. This actuator can be any functions or applications. One of the applications can be in a form of a bender actuator and patch actuator. The difficulties that researchers faced are to determine the transfer function of a highly nonlinear and hysteresis piezoelectric actuator.

The piezoelectric actuator combines the knowledge between mechanical actuator and electrical engineering. The purpose of the piezoelectric actuator's transfer function is in control and operating the actuator. The design of the actuator can be helpful when comparing the piezoelectric based actuators. The based actuator is more conventional electromagnetic actuators such as solenoids and motor.

The change of motion and force can be caused by piezoelectric material. When the displacement is produced for the actuator it can generate devices that use electro expansive ceramic materials. The piezoelectric materials an effect whereby they expand or contract in the presence of an apply electric field.

The induce strain can change the length when the electrical dipoles in materials rotate to align with orientation when the electric field is applied. Normally the change of the length of the materials is proportional to the field strength as applied to the device actuation voltage.

It can also produce force. The forced comes when the piezoelectric materials expand proportionally to the applied electric field or actuation voltage. High motion can occur high or maximum actuation voltage. The zirconate titanate (PZT) can generate a high level of pressure aligned with an external load if the stiffness of the external load is high enough to prevent expansion.

1.2 Problem Statement

There are many types of existing experimental rig but the problem lies in achieving the best data. From the experimental rig, it also must have the accurate data and achieve to identify the piezoelectric transfer function.

The modifications of the designed experimental rig are the best way to get the accurate data. The experimental rig usually has one function whether it is for the bender or the patch. The design of rig there is compatible to hold both the patch and the bender actuator. It's easy to change the actuator in one experimental rig at the same time. At the same time, the process to get another experimental rig can be reduced.

The function of this experimental rig is just for one actuator. The problem is to change the actuator to another actuator. It takes a long time to change the actuator. If the experimental rig can be used not one actuator at the same time and didn’t have to change to another rig, the process are more easily. Simple tasks such as taking out the first actuator and replace it with another actuator.

1.3 Objective

The objective of this title is to develop and analyze the design of the experimental rig. In line with the objective, a few sub-objectives are considered:

1. To fabricate a base structure to hold the piezoelectric actuator.
2. To validate the strength of the experimental rig with vibration test analysis.

1.4 Scope of study

The scope of the study is to study the facts of this experimental rig that can be used to collect data for piezoelectric actuator. This experimental rig can be used for student that's wanted to identify the piezoelectric transfer function which is bender and patch actuator.

Study of the design of the experimental rig that's used nowadays and to improve the design to make the experimental rig is easy to use and can collect the accurate data for study and identify the transfer functions of the piezoelectric actuator.

Now the experimental rig has many existing designs. For that, this study compares the design of the experimental rig with another design. This project's to combine some types of actuator in one experimental rig. Study the design of the base of a structure to hold the piezoelectric actuator.

After design and compare the experimental rig. This project is to fabricate the experimental rig for bender and patch actuator. Before starting fabricate the experimental rig, this study to understand all functions of the experimental rig and the alignment of the laser displacement sensor.

1.5 Summary

This chapter is to give a little impression of the project to be done for final year project. This project is about the piezoelectric actuator and to generate the transfer functions from the experimental rig for bender and patch actuators.

CHAPTER 2
LITERATURE REVIEW

2.1 Introduction

In this chapter, focus on literature review about the piezoelectric actuator such as bender actuator and patch actuator at present industry. So many types of actuator, but in this study focus in bender actuator and patch actuator. In this chapter, discuss the finding of the piezoelectric and what have been done before. Study about the actuator types by previous researchers.

2.2 Piezoelectric

Pierre and Jacques Curie began his findings on this piezoelectric in 1880. Two brothers have conducted research about the existence of this piezoelectric. They carry out research about the relationship between pyroelectricity and crystal symmetry. They also study about the electrification from pressure also give the impression of being into what direction pressure should apply at crystal classes the cause expected when the pressure and electric apply. (Novotny & Ronkanen, 1997)

The term of the piezoelectricity comes from Hankel. This word comes from “piezo” translation from Greek that’s mean “press”. After years of discovery, Lippman predicted

the existence of the inverse piezoelectric effect from thermodynamic considerations and curies verified this discovery before the end of 1881. In this research, they discover the piezoelectric effect and the applications in the electric field to the piezoelectric crystal leads to a physical deformity of the materials of crystal. (Novotny & Ronkanen, 1997)

2.3 Piezoelectric Actuator

They are many types of actuator. The easy way of producing or generate displacement from a piece of ceramics and develop various actuators. The advantage of the general properties of piezoelectric actuator short response time, an ability to create high forces, high efficiency and has a high mechanical durability. The basic types of piezoelectric actuators are stacks, benders and linear motor. The piezoelectric stack actuator is the simplest way to generate a linear motion by the piezoelectric effect. There are some factor effects of the distributed piezoelectric actuator they are actuator shapes, spatial distribution and the actuator materials. The control action of the actuator laminated on zero curvature structures. In this study, focus on patch and bender actuator.

2.3.1 Patch Actuator

The patch can generate electricity to mechanical energy. The patch is particularly compressed units based on a thin piezoceramic foil between two conductive films, all fixed in a ductile composite polymer structure. From this method, the fragile piezoceramic is mechanically pre-stressed and electrically insulated it can make the transducer so tough that they can be applied to curved surfaces with low bending radius. Patch transducer characteristic a very high bandwidth, in arrangement with suiTable electronics, they can be used as high dynamics positioners with submicron precision. The patch actuator is used as high performance actuators, simultaneously detecting and damping or eliminating undesirable's vibrations. (Refer Figure 2.1)

Figure 2.2 Types of Patch Actuator (PI Industry)

Not many factories that produce these types of patch actuator. The PI Industry produced this actuator and this industry can produce the custom designs for their customers. That means customers can design any types of patch and the manufacturer can come out with the design for certain applications. (Refer Figure 2.2)

DuraAct™ Patch Transducers

Model	Dimensions (l x w x d) [mm]	Mass [g]	Active Area [cm²]	Capacitance [nF]	Supply Voltage (min/max) [V]	Lateral Contraction/ Voltage [(µm/m)/V]	Free Lateral Contraction S_0 [µm/m]	Blocking Force F_B [N]	Young's Modulus [GPa]
P-876.A11	61 x 35 x 0.4	2.1	15	150	-50 to 200	1.6	450	90	16.4
P-876.A12	61 x 35 x 0.5	3.5	15	90	-100 to 400	1.3	650	265	23.3
P-876.A15	61 x 35 x 0.8	7.2	15	45	-250 to 1000	0.64	800	775	34.7

Figure 2.2 Model and dimensions that's available at PI Industry