CHAPTER 3

EXPERIMENTAL PROCEDURE

3.1 INTRODUCTION

Manufacturing process of bimetallic piston involves casting, heat treatment and machining. This chapter explains the experimental procedures in a detailed manner.

Materials required for piston manufacturing, and cutting tool required for piston machining are explained. Experimental procedure presented in this chapter describes the various activities involved in gravity die casting, heat treatment and machining. The bonding nature of bimetal was studied through metallurgical and mechanical investigations.

Machining experiments were carried out through experimental design using Taguchi method. Influence of machining parameters on cutting force is analyzed. Surface integrity of bimetallic pistons is evaluated through ultrasonic bond checking machine. The surface roughness of machined pistons is also measured by surface roughness tester.

Machining parameters are optimized through Genetic algorithm (GA). Mathematical model was developed to predict the cutting forces during machining.
3.2 EXPERIMENTAL TECHNIQUE

3.2.1 Materials

Aluminum alloy is reinforced with the grey cast iron to manufacture the bimetallic pistons. Typical composition of aluminum and cast iron is presented in Table 3.1 and Table 3.2 respectively.

<table>
<thead>
<tr>
<th>Table 3.1 Composition of aluminum alloy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Element</td>
</tr>
<tr>
<td>Percentage (%)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 3.2 Composition of cast iron</th>
</tr>
</thead>
<tbody>
<tr>
<td>Element</td>
</tr>
<tr>
<td>Percentage (%)</td>
</tr>
</tbody>
</table>

3.2.2 Casting

The aluminum alloy reinforced with cast iron insert pistons are produced by die casting technique. First the cast iron insert of dimension of 105mm outer diameter and 83 mm inner diameter with a width of 11 mm are to be degreased, sand blasted and finally they are immersed into a liquid bath of pure aluminum maintained at 1033K for about 1½ minutes. Then the inserts are subjected to trembling in order to achieve uniform coating and to prevent the formation of oxide on the surface. Secondly, these inserts are placed in the insert carrier of the mould and then the molten aluminum alloy is poured. After cooling, the part will be ejected out. Then, the piston will be subjected to further successive operations.
3.2.3 Heat treatment

The cast pistons are subjected to heat treatment at various temperature schedules. The heat treatment processes carried out are (i) Air quenched (ii) Water quenched methods. To have comparison as cast pistons are used.

3.2.4 Various dipping conditions

The dipping time of insert plays vital role in bonding hence investigations are made on the pistons with 1½ minutes, 2 minutes, 3 minutes, 4 minutes and 5 minutes dipping conditions. After making the piston, it is cut into specimen and subjected to heat treatment at different temperature with and without tempering process. The mechanical properties are evaluated through shear strength test by using universal testing machine. Hardness testing is carried out at aluminum and cast iron portions through Brinell hardness tester.

3.2.5 Machining

To make the piston into near net shape, it is to be machined with an objective of measuring cutting force at different machining parameters (speed, feed, and depth of cut) without disturbing bonding nature. In the bimetallic region, a single tool is introduced for machining both the metals instead of using two different tools. The details of experimental set up for machining are presented below.

Work material : Aluminum alloy piston reinforced with cast iron insert
Machine tool : LEADWELL (T5) turning centre with
Maximum swing : 330 mm
Swing over cross slide : 136 mm
Maximum turning diameter : 136 mm
Maximum turning length : 150 mm
Spindle speed : 45 – 4500 rpm
Spindle motor power : 7.5 KW
Cutting tool : Cubic Boron Nitride (CBN) with
               Top rake angle 0\(^0\)
               Clearance angle 15\(^0\)
               Nose radius 0.6 mm
Cutting condition : Dry
Dynamometer : Kistler Quartz 3 component Dynamometer
               with dynaware software of type 2825A-02

Machining is carried out in a systematic way of Taguchi design
of experiment with speed, feed and depth of cut as input parameters and
cutting force as output function. The measurements of cutting forces are
taken for the piston with insert at different dipping time conditions. Tool
wear was observed through Scanning Electron Microscope (SEM).

3.2.6 Surface integrity

Machined pistons are tested at the bonding region through
ultrasonic bond tester type of ESPT II and the integration status between
the aluminum and cast iron is observed. Surface roughness of the
component is measured by using the Mitutoyo surface roughness tester type
of CV2000.
3.2.7 Mathematical model and genetic algorithm

A mathematical model was developed in order to estimate the cutting force at different input parameters by using SYSTAT software and the predicted output was compared against the experimental values. A non traditional optimization technique GA is used to optimize the machining parameters. The results obtained through GA are compared with Taguchi robust design output.

3.3 SCHEME OF RESEARCH STUDY

The scheme of research study is presented in Figure 3.1

Figure 3.1 Flow chart of Research work