CHAPTER 1

INTRODUCTION

1.1 Introduction

Major advances in solid-state laser technology have historically been preceded by advances in pumping technology. The helical flash lamps used to pump early ruby lasers were superseded by the linear flash lamp and arc lamp now used to pump neodymium-doped yttrium-aluminum-garnet lasers which had been discovered by Geusic (1994). Diode laser-pumped neodymium lasers have operated at greater than 10 percent electrical to optical efficiency in a single spatial mode and with linewidths of less than 10 kilohertz. The latest advance in pumping technology is the diode laser.

Pumping can be accomplished by means of flashlamps, continuous wave cw arc lamps, or laser diodes, and the laser can be operated cw or pulse thereby achieving pulse repetition rates from single shot to several hundred megahertz.

1.2 Research Background

There has been a considerable interest in the development of high efficiency solid state laser for potential application in material processing (Kushawaha *et. al*., 1993).

Since 1964, Nd:YAG remains the most versatile and widely used active material for solid state laser. Nd:YAG has a low threshold which permits continuous operation , and the host crystal has good thermal, mechanical, and optical properties and can be grown with relative ease (Koechner, 2006). Until now, the best material for flashlamp pumping has always been Nd:YAG, followed by more recently studied Cr^{3+} co-doped crystal (Musset *et. al*., 1997)

In the laser system, the excitation efficiency and the round trip losses determine the pump power necessary to reach the laser threshold. The higher the losses due to diffraction and output coupler and the lower the excitation efficiency, the higher the laser threshold has to be achieved by the pump (Rahman *et. al*., 2008).

The Findlay-Clay analysis (Findlay *et. al*., 1966) purposed a method to determine the resonator losses by using output mirrors with difference reflectivities and also determining threshold power for lasing for each mirror (Koechner, 2006). This analysis is a powerful and easy method to characterize the gain and losses of the active medium. It can be used in both continuous wave and pulse laser. The accuracy is much depends on the techniques use to determine the threshold.

The resonator losses and gain in the laser material are very important in the optimization process of a laser system especially in Q-switching. These two parameters also describe the laser performance (Rahman *et. al*., 2008).

1.3 Problem Statement

The resonator losses and the gain coefficient in the laser material play an important part in the optimization process in a laser system. From these two parameters, we could measure the laser performance of a laser system as well as a key parameter for optimization of Q-switching system.

1.4 Research Objectives

The objectives to be achieves in this study are:

- To determine the gain coefficient of Nd:YAG laser system in free running mode operation
- To determine the gain coefficient of Nd:YAG laser system in Q-switched mode operation
- To determine the round trip resonator losses in Nd:YAG laser system of free running mode operation
- To determine the round trip resonator losses in Nd:YAG laser system of Q-switched mode operation
- To determine the maximum output energy at different mirror reflectivity

1.5 Research Scope

In this research, gain coefficient of Nd:YAG laser rod was study. The energy loss was estimate from the Nd:YAG laser resonator. In this case only plano-concave resonator was study. The Nd:YAG laser system was operated only for single pulse in two mode, free running and Q-switch. The laser energy was verify based on capacitor voltage of flashlamp driver in the range to 900V. Determination of gain, loss and maximum output were study using Findlay and Clay method.

1.6 Thesis Outline

This thesis contains 5 chapters. The first chapter consists of the introduction and some overview of the previous researches regarding gain coefficient and resonator losses in Nd:YAG laser. Besides that, the chapter also describes the research objectives and research scope.

Chapter II review some theories that related to this study. It the four-level laser system, the theory of gain coefficient and round trip resonator losses in Nd:YAG laser as well as the background of Nd:YAG laser itself.

Chapter III explained the research methodology. This include the laser source, measurement equipment and the technique of experiment.

Chapter IV explains about the results obtained from the experiment work and calculation to estimate the gain coefficient and the resonator losses. This chapter also included the discussion about the maximum output curve.

Last but not least, the conclusion of this study was explained in Chapter V. This chapter also covered and highlighted the problems that occurred during the experiment. The solutions of the problems and some suggestion are revealed as references for further study about this project.