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THEORETICAL STUDY OF PHYSICAL PARAMETER FOR DIODE PUMPED ND: YAG LASER

Hadeel M. Rasheed*, Haider Y. Hammod, Noor L .Hussein, Marwa K. Mustafa
* Ministry of Science and Technology, Baghdad, IRAQ

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ABSTRACT

"In this research , we studying the influence of pumping power for laser diode and coupling efficiency on output power of Nd:YAG laser by using the software program to determine and plotting the relation between these important parameter and then to choice best operation condition".

KEYWORDS: high power, diode pumped laser, Nd:YAG laser, thin disk.

INTRODUCTION

Diode-pumped solid-state laser with low and medium output power has been widely used in the field of semiconductor processing, printing, instrument and scientific research. In recent years, rapid progresses in the high average power diode-pumped system have been made under the needs of industrial and military applications. Now industrial system with several kW output power is available, but the beam quality is low (in the range of M^2=20~100).Recently great efforts are concentrated on the thin disc laser design for realisation of solid state laser with high output power, high efficiency and good beam quality simultaneously [1,2,3,4,5]. The thin disk laser design overcomes the shortcoming of traditional rod and slab laser and dramatically reduces the thermal problem of laser crystal. Output powers up to 1 kW were obtained with two disc in series and M^2=10[6], which has the highest beam quality and highest efficiency in the kW-range all solid-state laser .

THEORETICAL STUDY

Laser efficiency

The relationship between the output power of the resonator and the pumping power is given by

$$P_{out} = P_p \eta_c \eta_a \eta_q \eta_s \eta_\varepsilon \eta_{out} \eta_m \quad (1)$$

Where P_p is the pump power,η_c is the coupling efficiency of the pumping system, η_a is the absorptivity of laser crystal to the pump light, $\eta_q$is the quantum efficiency of laser crystal (0.95 for Nd: AYG), $\eta_s$is stocks factor which is equal to the ratio of the pump wavelength to the laser wavelength (0.76 for Nd: YAG),η_{out}: is the couplingefficiency of the output mirror, $\eta_m$is the utilizing efficiency of the mode volume, η_ε is utilizing efficiency ofthe resonator's energy given by .

$$\eta_\varepsilon = 1 - \frac{P_{th}}{P_p} = 1 - \frac{g_{th}}{g_0} \quad (2)$$

with P_p: pump power, P_{th}: threshold pump power,: $g_0$small signal gain coefficient, : g_{th}threshold small gain coefficient.$\eta_{out}$is the coupling efficiency ofthe output mirror given by

$$\eta_{out} = -ln\left[\frac{1}{M^2}\right] \Big/ -ln\left[\frac{T^2}{M^2}\right] \quad (3)$$

with **M**: magnification ofthe unstable cavity,**T**: single transmitivity ofall optical elements in the cavity, $\eta_m = S_l/S_p$ is the utilizing efficiency of the mode volume with S_l : laser sectional area on disk, S_p: pump area on disk .

The laser should be designed to fulfill the maximum efficiency and perfect match ofthe every part .

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Pump source and output power

The pump power required for each disk is determined by the maximum thermal power that the laser medium can stand .

$$P_p = \frac{P_1}{\eta_c \eta_a \eta_q \eta_s \eta_n} \quad (4)$$

Then the total pump power is

$$P_{total} = nP_p (5)$$

Finally we calculated the total output power of laser system P_{out}10.22 kW according to the expression (1) .

RESULTS AND DISCUSSIONS

The work is concentrated on the main design parameters which have a high influence on laser system performance such as beam overlap efficiency energy transfer efficiency, output coupling reflectivity and resonator losses.
The parameter of the system are the pumping power , coupling efficiency of the pumping system absorptivity of laser crystal to the pump light, quantum efficiency of laser crystal, utilizing efficiency of the resonator's ,small signal and threshold small gain coefficient, coupling efficiency of the output mirror ,and utilizing efficiency of the mode volume .

When the program that was written for the model was developed different relationship between these parameters were obtained and they explained as follows.

On figure.1. Getting relationship between Output Power versus pumping power of Nd:YAG Laser , with value of coupling efficiencyη_c= 1 and all other parameters are constant .

We can see that the increase in the output power with increasing of pumping power. Increasing the pumping power notice that the output power is sharply increases withthe pumping power increase and reaches to the maximum (40%) with the constant of coupling efficiency .

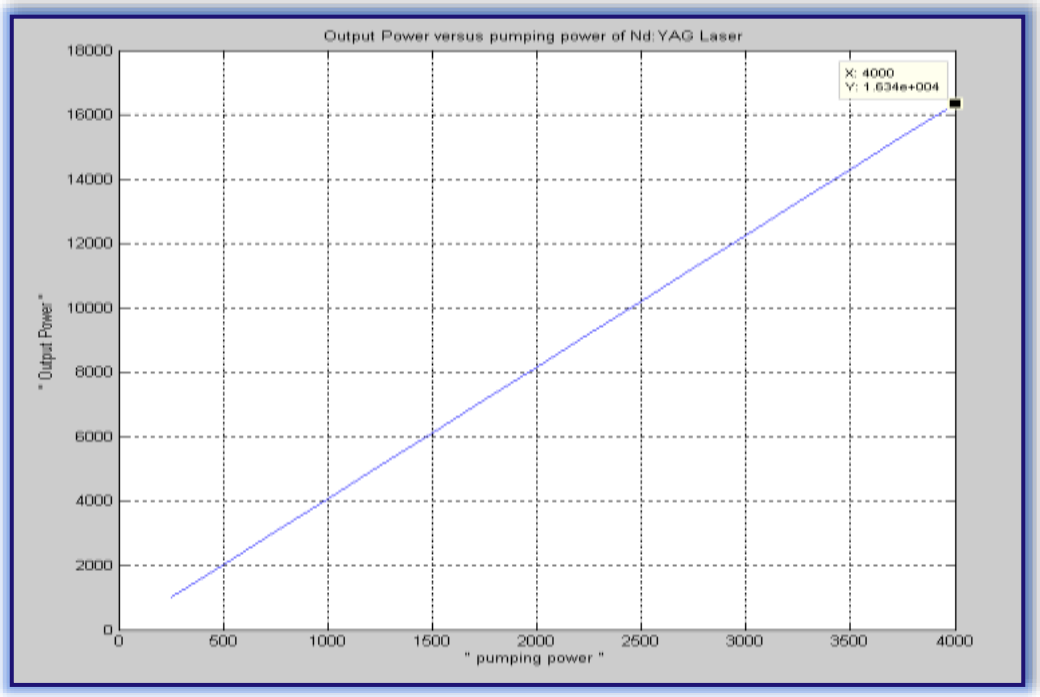

Fig.1 Output Power versus pumping power of Nd:YAG Laser

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On fig.2. getting relationship between Output Power versus coupling efficiencyof Nd:YAG Laser , with value of pumping power P_p = 2500W and all other parameters are constant .We can see that the increase in the coupling efficiency with increasing of output power.coupling efficiency is directly proportional with the output power .

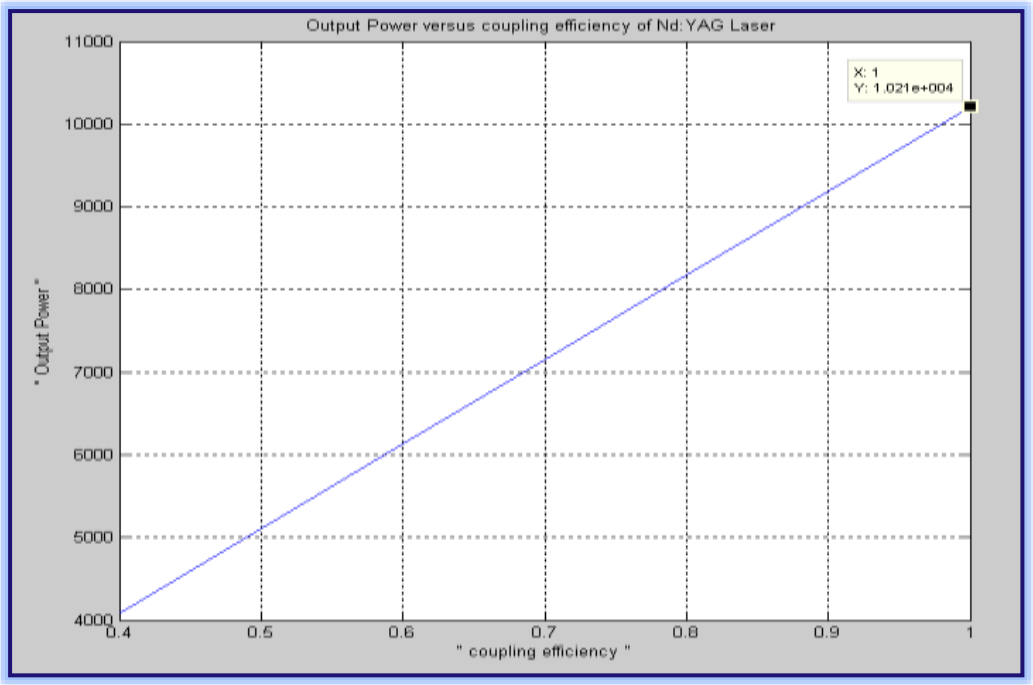

Fig.2 Output Power versus coupling efficiency of Nd:YAG Laser

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