AIR STAGING COMBUSTION AND EMISSION FROM OIL BURNER

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AIR STAGING COMBUSTION AND EMISSION FROM OIL BURNER

KAMARUL-AZHAR BIN KAMARUDIN

This project report is submitted as a part of the
fulfillment of the requirement for the award of the
Master Degree in Mechanical Engineering

Faculty of Mechanical Engineering
Universiti Teknologi Malaysia

NOVEMBER, 2004

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ABSTRACT

Emissions from combustion of liquid fuel tend to cause an effect to the environment. The formation of pollutant such as NOx, CO, CO2 and SOx were hazardous and affect the green house environment. There are many methods in reducing the composition of the pollutant. As the method of reduction becoming more effective, the cost of such technology increases. In this study, air is used as the medium in reduction of the pollutant due to the ease of handling and availability. Airflow rate at 100 l/min is supply within the range of 600 to 1200 °C. At this range, the temperature window created. Air is injected at distance of 900mm from the flame. Results taken from equivalent ratio, which calculated from fuel and airflow rate. At a fix flow rate of fuel and variation of air create a fuel rich, fuel lean and stoichiometric conditions. Combustion efficiency for the combustor is measured versus the equivalent ratio to determine the effectiveness of the air injected to reduce the pollutants. As the results, the reduction of the pollutant relates with the combustion efficiency is measured and analyzed from air staging process.

ABSTRAK

Hasil pembakaran dari bahan api cecair cenderung di dalam menjejaskan alam sekitar. Kewujudan pelbagai bahan cemar seperti NOx, CO, CO2 dan SOx adalah amat berbahaya kepada rumah hijau. Didalam untuk mengurangkan komposisi bahan cenar tersebut pelbagai cara telah dilakukan. Kaedah dan cara-cara ini juga melibatkan kos didalam menghasilan keputusan pengurangan yang lebih berkesan. Di dalam ujikaji ini, udara digunakan sebagai medium untuk mengurangkan bahan cemar tersebut memandangkan ia mudah didapati dan senang dikendalikan. Kadar alir udara sebanyak 100 l/min dialirkan pada jangkauan suhu antara 600 hingga 1200 °C. Dimana dalam jarak ini tetingkap suhu(*temperature window*) terbentuk. Udara disuntik pada jarak hampir 900 mm dari pembakar. Keputusan diambil dari nilai setara yang didapati dari kadaralir udara dan bahanapi. Pada kadaralir bahanapi yang tetap dan udara yang berubah mengikut kesesuaian membentuk keadaan lebihan udara, stoikiometrik dan lebihan minyak pada pembakaran. Kecekapan pembakaran bagi radas tersebut diukur melawan nisbah setara bagi mengenalpasti kadar keberkesanan suntikan terhadap pengurangan epada bahan cemar. Hasilnya pengurangan terhadap bahan cemar bersama kecekapan pembakaran boleh dikenalpasti dalam pembakaran udara berperingat bagi pembakar berbahanapi cecair.

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LIST OF SYMBOLS

°C	-	Degree Celsius
°F	-	Degree Fahrenheit
K	-	Kelvin
ASME	-	American Society of Mechanical Engineers
BS	-	British Standard
d	-	Diameter
gm	-	Gram
GPH	-	Gallon per Hour
H2	-	Hydrogen
HCN	-	Hydrogen cyanide
hr	-	Hour
ki	-	Kilo Joule
Kmol	-	Kilo mole
kW	-	Kilowatt
LNB	-	Low NOx Burner
m^3	-	Cubic meter
ml	-	Milliliter
mm	-	Millimeter
CO	-	Carbon monoxide
$C0_2$	-	Carbon oxide
N20	-	Nitrous oxide
NO	-	Nitric oxide
$N0_2$	-	Nitrogen dioxide
NO	-	Nitrogen oxides
0_2	-	Oxygen

0_3	-	Ozone
ppm	-	Parts Per Million
SCR	-	Selective Catalytic Reduction
SNCR	-	Selective Non-Catalytic
$S0_2$	-	Sulfuric dioxide
T	-	Temperature
Vol	-	Volume
wt	-	Weight
π	-	pie(3.14)
η	-	efficiency
ρ	-	density
ν	-	volumetric flow rate
m	-	critical flow rate
p	-	pressure

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CHAPTER 1

INTRODUCTION

1.1 Background Studies

In Malaysia, the Air Pollution Index (API) is a system to measure the air pollutants, which could cause potential harm to human health if reach the unsafe levels. The pollutants are ozone (0_3), carbon monoxide (CO), nitrogen dioxide ($N0_2$), sulphur dioxide ($S0_2$) and suspended particulate matter less than 10 microns in size. Table 1.1 shows the acceptance level of pollutant.

To reflect the status of the air quality and its effects on human health, the ranges of index values could then be categorized as in Table 1.2. The key reference point in these air pollution index systems is the index value of 100, which is the "safe" limit.

Table 1.1: Recommended Malaysia Air Quality Guidelines taken from Air Pollutant Index (API) calculation.

POLLUTANT	AVERAGING TIME	MALAYSIA GUIDELINES	
		(ppm)	(ug/m^3)
OZONE	8 HOUR	0.06	120
CARBON# MONOXIDE	8 HOUR	9	10
NITROGEN DIOXIDE	24 HOUR	0.04	320
SULFER DIOXIDE	24 HOUR	0.04	105
PM10	24 HOUR		150

#mg/m^3

Table 1.2: Categorized of Air Pollution Index(API)

API	DESCRIPTOR
0-50	good
51-100	moderate
101-200	unhealthy
201-300	very unhealthy
>300	hazardous

All these pollutant contribute to the performance of the air quality. The effects on air pollutants are:

1. Effects on Materials.
2. Effect on Vegetation
3. Effect on Health

However there are many methods to reduce the effect on pollutants. Air staging combustion is one of many methods introduce to reduce NOx, SOx and CO emission. The staged air burner is utilized for either gas or liquid fuel firing. This type of burner normally has three air registers to control the flow rate and distribution of combustion air through the burner and only one fuel injection nozzle. The three air registers are the primary, secondary and tertiary. Figure 1.1 shows the diagram of the basic staging condition. Each flow rate of air and fuel must be correctly adjusted to successfully minimize the exhaust production. NOx control is now the driving force behind the development of new burners. The formation of NOx is not only depend on the peak flame temperature but also contribute by the fuel composition. Nox formation is attributed to three type of mechamism such as:

- thermal NOx.
- fuel bound NOx and
- prompt NOx.

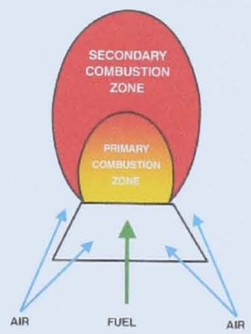

Figure 1.1: Basic Air Staging

1.2 Objectives Of Project

1. To study the emission characteristic such as CO, SOx and NOx in burning combustion system.
2. To study the effect of combustion efficiency on the process of air staging using diesel burner combustion system.

1.3 Scope of the studies

1. Combustion experiment using small-scale diesel burner.
2. Determination the effect of air staging on the diesel combustion and the emission of CO, NOx and SOx.
3. Study the combustion efficiency of the combustor.