

AIR STAGING COMBUSTION AND EMISSION FROM OIL BURNER

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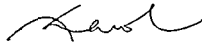
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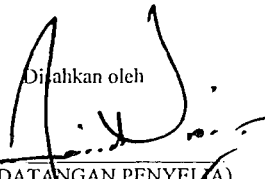
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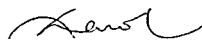
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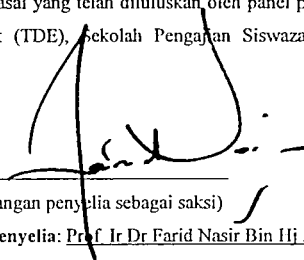
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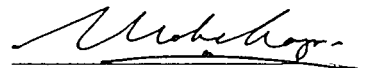
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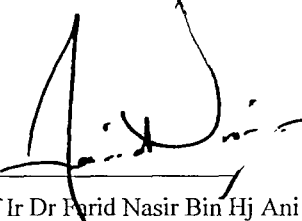
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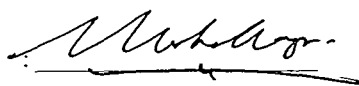
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AIR STAGING COMBUSTION AND EMISSION FROM OIL BURNER

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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
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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 NO_x, CO, CO₂ and SO_x 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 NO_x, CO, CO₂ dan SO_x adalah amat berbahaya kepada rumah hijau. Didalam untuk mengurangkan komposisi bahan cemar tersebut pelbagai cara telah dilakukan. Kaedah dan cara-cara ini juga melibatkan kos didalam menghasilkan 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 tettingkap suhu (*temperature window*) terbentuk. Udara disuntik pada jarak hampir 900 mm dari pembakar. Keputusan diambil dari nilai setara yang didapati dari kadar alir udara dan bahan api. Pada kadar alir bahan api yang tetap dan udara yang berubah mengikut kesesuaian membentuk keadaan lebih udara, stoikiometrik dan lebih 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 berbahan api cecair.

TABLE OF CONTENTS

| CHAPTER | CONTENTS | PAGE |
|-----------|---|----------|
| | TITLE | i |
| | DECLARATION | ii |
| | ACKNOWLEDGEMENT | iii |
| | ABSTRACT | iv |
| | ABSTRAK | v |
| | TABLE OF CONTENTS | vi |
| | LIST OF TABLES | x |
| | LIST OF FIGURES | xi |
| | LIST OF SYMBOLS | xiii |
| | LIST OF APPENDICES | xv |
| I | INTRODUCTION | 1 |
| | 1.1 Background Studies | 1 |
| | 1.2 Objective of Project | 4 |
| | 1.3 Scope of Study | 4 |
| II | THEORETICAL BACKGROUND AND LITERATURE REVIEW | 5 |
| | 2.1 Introduction | 5 |
| | 2.2 Literature Riview | 6 |

| | | |
|--------|--|----|
| 2.3 | Effect of Emission | 8 |
| 2.3.1 | Ozone | 8 |
| 2.3.2 | Acid Rain | 9 |
| 2.4 | Emitted Gas | |
| 2.4.1 | Oxide of Nitrogen | 10 |
| 2.4.2 | Carbon Monoxide | 10 |
| 2.4.3 | Sulfur Dioxide | 11 |
| 2.4.4 | Particulate Matter | 11 |
| 2.4.5 | Hydrocarbon | 12 |
| 2.4.6 | Nox Formation | 13 |
| 2.4.7 | Reduction of Nox | 14 |
| 2.4.8 | Reduction of CO | 14 |
| 2.4.9 | Reduction of SO _x | 15 |
| 2.4.10 | Excess Air | 15 |
| 2.5 | Type of Emission Control | 15 |
| 2.6 | Reduction Of Nox Using Pretreatment method | 16 |
| 2.6.1 | Fuel Switching | 17 |
| 2.6.2 | Additives | 17 |
| 2.6.3 | Fuel Pretreatment | 17 |
| 2.6.4 | Oxidizer Switching | 18 |
| 2.7 | Reduction of Nox using Combustion Modification | |
| 2.7.1 | Air Preheat Reduction | 19 |
| 2.7.2 | Low Excess Air | 19 |
| 2.7.3 | Staging | 20 |
| 2.7.4 | Gas Recirculation | 22 |
| 2.7.5 | Water or Steam Injection | 22 |
| 2.7.6 | Reburning | 23 |
| 2.7.7 | Low Nox Burners | 23 |
| 2.8 | Reduction of Nox usinh Process Modification | |
| 2.8.1 | Reduced Production | 24 |
| 2.8.2 | Electrical Heating | 24 |
| 2.8.3 | Improved Thermal Efficiency | 25 |
| 2.8.4 | Product Switching | 25 |

| | | |
|------------|---|-----------|
| 2.9 | Post Treatment | 26 |
| | 2.9.1 Selective Catalytic Reduction(SCR) | 26 |
| | 2.9.2 Selective Non Catalytic Reduction(SNCR) | 27 |
| 2.10 | Temperature Window | 28 |
| 2.11 | Combustion Efficiency | 28 |
| III | RESEARCH METHODOLOGY | 28 |
| 3.1 | Introduction | 29 |
| 3.2 | Burner | 30 |
| 3.3 | Combustor | 30 |
| 3.4 | Thermocouple/Temperature Recorder | 31 |
| 3.5 | Gas Analyser | 32 |
| 3.6 | Determine the value of primary air. | |
| | ◦ Method 1 – Rotameter | 33 |
| | ◦ Method 2 – Wing Propeller | 34 |
| | ◦ Method 3 – Orifice Meter | 35 |
| 3.7 | Mean Probe | 37 |
| 3.8 | Silica Gel | 38 |
| 3.9 | Condensate Trap | 38 |
| 3.10 | Flame Type | 40 |
| 3.11 | Experimental Set-up | 41 |
| 3.12 | Secondary Air | 42 |
| 3.13 | Air Injected Distance | 42 |
| 3.14 | Calculating Fuel Consumption and Fuel Density | 43 |
| IV | RESULTS AND ANALYSIS | 44 |
| 4.1 | Introduction | 44 |
| 4.2 | Injection Of Air | 45 |
| 4.3 | Nitrogen Oxide | 45 |
| 4.4 | Carbon Monoxide | 46 |
| 4.5 | Sulfur Oxide | 47 |
| 4.6 | Temperature Profile | 47 |

| | | | |
|----------|-----|----------------------------------|-----------|
| | 4.7 | Combustion Efficiency | 48 |
| V | | CONCLUSION AND SUGGESTION | 55 |
| | 5.1 | Conclusion | 55 |
| | 5.2 | Suggestion | 56 |
| | | REFERENCE | 57 |
| | | APPENDICES | 59 |

LIST OF TABLES

| TABLE | DESCRIPTION | PAGE |
|--------------|---|-------------|
| 1.1 | Recommended Malaysia Air Quality Guidelines taken from Air Pollutant Index (API) calculation. | 2 |
| 1.2 | Categorized of Air Pollution Index(API). | 2 |
| 2.1 | NOx Control Technologies in Process Heaters | 16 |
| 2.2 | NOx Reductions for Different Low-NOx Burner | 23 |

LIST OF FIGURES

| FIGURE | DESCRIPTION | PAGE |
|---------------|---|-------------|
| 1.1 | Basic Air Staging | 3 |
| 2.1 | Fire Tetrahedral | 6 |
| 2.2 | Simplified Atmospheric Nitrogen Photolytic Cycle | 9 |
| 2.3 | The Creation Of Acid Rain And Smog | 9 |
| 2.4 | Emission At Air/Fuel Ratio | 12 |
| 2.5 | Schematic Of A Typical Staged Fuel Gas Burner | 20 |
| 2.6 | Schematic Of A Typical Staged Air Combination Oil And Gas Burner | 21 |
| 3.1 | Primary Air Damper and Fuel Pump | 30 |
| 3.2 | Test Rig | 31 |
| 3.3 | Temperature Recorder | 32 |
| 3.4 | Kane May Analyser | 32 |
| 3.5 | Method To Determine Value Of Primary Air | 33 |
| 3.6 | Sketch Of Rotameter | 34 |
| 3.7 | Wind Propeller | 34 |
| 3.8 | D-1/2D Taps Type Orifice Plate In Schematic | 35 |
| 3.9 | Comparison of flow rate between Orifice Meter And Propeller | 36 |
| 3.10 | D-1/2D Taps Type In Operation | 36 |
| 3.11 | Using probe To Measure Mean Gasses From Combustion Chamber | 37 |
| 3.12 | Another Type Of Probe Use To Trap Flue Gas | 37 |
| 3.13 | Silica Gel | 38 |
| 3.14 | Types of Condensate Trap | 39 |

| | | |
|------|--|----|
| 3.15 | Drainage Bottle in Used With Silica Gel | 39 |
| 3.16 | Flame At Different Air/Fuel Ratio | 40 |
| 4.1 | Reduction of NO _x at Air Staging condition. | 49 |
| 4.2 | Excess Air in the combustion with Equivalent Ratio. | 49 |
| 4.3 | Emission of CO as a function of Equivalent Ratio. | 50 |
| 4.4 | SO _x with the effect of Air Staging | 50 |
| 4.5 | Temperature Distribution at equivalent ratio along the combustor height without Air Staging condition. | 51 |
| 4.6 | Temperature Distribution at equivalent ratio along the combustor height at with Air Staging condition. | 51 |
| 4.7 | Comparison of Temperature at Equivalent Ratio. | 52 |
| 4.8 | Graph of Efficiency (Nett) | 52 |
| 4.9 | Effect of Efficiency (Gross) | 53 |
| 4.10 | Graph of Oxygen | 53 |
| 4.11 | Graph of NO _x reduction | 54 |
| 4.12 | Graph of Temperature Reduction | 54 |

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 |
| H ₂ | - | Hydrogen |
| HCN | - | Hydrogen cyanide |
| hr | - | Hour |
| ki | - | Kilo Joule |
| Kmol | - | Kilo mole |
| kW | - | Kilowatt |
| LNB | - | Low NO _x Burner |
| m ³ | - | Cubic meter |
| ml | - | Milliliter |
| mm | - | Millimeter |
| CO | - | Carbon monoxide |
| CO ₂ | - | Carbon oxide |
| N ₂ O | - | Nitrous oxide |
| NO | - | Nitric oxide |
| NO ₂ | - | Nitrogen dioxide |
| NO _x | - | Nitrogen oxides |
| O ₂ | - | Oxygen |

| | | |
|--------|---|-------------------------------|
| O_3 | - | Ozone |
| ppm | - | Parts Per Million |
| SCR | - | Selective Catalytic Reduction |
| SNCR | - | Selective Non-Catalytic |
| SO_2 | - | Sulfuric dioxide |
| T | - | Temperature |
| Vol | - | Volume |
| wt | - | Weight |
| π | - | pie(3.14) |
| η | - | efficiency |
| ρ | - | density |
| v | - | volumetric flow rate |
| m | - | critical flow rate |
| p | - | pressure |

LIST OF APPENDICES

| APPENDIX | DESCRIPTION | PAGE |
|-----------------|--|-------------|
| A | LAW OF MALAYSIA ACT 127 ENVIRONMENTAL QUALITY ACT, 1974 | 59 |
| B | Determine value of air flow rate | 60 |
| C | Determine Equivalent Ratio of primary air using Excel | 63 |
| D | Determine Equivalent Ratio using Excel | 64 |
| E | Data Measured vs Equivalent Ratio | 65 |
| F | Reaction Calculation | 66 |
| G | Determine Value Of Combustion Efficiency | 68 |
| H | Project Schedule 1 And 2 | 69 |

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 (O_3), carbon monoxide (CO), nitrogen dioxide (NO_2), sulphur dioxide (SO_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) | ($\mu\text{g}/\text{m}^3$) |
| 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 pollutants 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 introduced to reduce NO_x, SO_x 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. NO_x control is now the driving force behind the development of new burners. The formation of NO_x is not only dependent on the peak flame temperature but also contributed by the fuel composition. NO_x formation is attributed to three types of mechanisms such as:

- thermal NO_x.
- fuel bound NO_x and
- prompt NO_x.

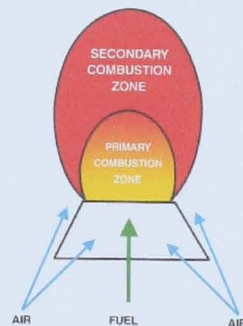


Figure 1.1: Basic Air Staging

1.2 Objectives Of Project

1. To study the emission characteristic such as CO, SO_x and NO_x 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, NO_x and SO_x.
3. Study the combustion efficiency of the combustor.