10

Department of Civil Engineering

UNIVERSITY OF MORATUWA
SRI LANKA

MEng in Environmental Engineering and Management

FEASIBILITY STUDY ON

WASTE OIL DISPOSAL IN CEMENT KILNS

FOR SRI LANKA

By

A T Thiruchelvam

Under the supervision of

Dr Ajith P de Alwis
Department of Chemical & Process Engineering
University of Moratuwa

August 2000

"This thesis was submitted to the Department of Civil Engineering of the University of Moratuwa, Sri Lanka, as a partial fulfillment of the requirements of the degree of Master of Engineering in Environmental Engineering and Management".

"This thesis has not been previously presented in whole or part to any University or Institute for a higher degree".

Signature of the candidate: ..... Date: 30/08/2000

ACKNOWLEDGEMENT

Firstly I sincerely thank my supervisor, Dr Ajith P de Alwis of the Department of Chemical & Process Engineering of the University of Moratuwa for his kind guidance, encouragement and assistance given to me for this thesis.

Puttalam Cement Company Limited extended its fullest support and cooperation to my thesis. I gratefully thank the Management, Mr Horst Hofmann, Vice President (Technical) and late Mr Priyantha de Silva, Manager operations of Puttalam Cement. Late Mr Priyantha de Silva provided the necessary information and guidance to me whenever required. I also thank Mr Raju Goyal, Operations Advisor for his valuable advice and Mr S H D Dharmasena, Sift Burner and other staff of Puttalam Cement for their assistance. I thank the Management and staff of Puttalam Cement again for their kind hospitality during my visits by providing food and lodging.

I thank Dr (Mrs) D Hewage, Head and Mr Silva, Lab Technical staff of the Department of Chemistry of the University of Colombo for providing the facilities and assistance for the determination of heavy metals in waste oil. I also thank Mr S A S Perera, Head and Energy Engineering technical staff Mr Jeyaweera and Mr Saranelis of the Department of Chemical and Process Engineering of the University of Moratuwa for providing facilities and assistance for the laboratory tests I carried out.

I also thank the following organization and people for their kind support, information and assistance given to me for this thesis:

- Mr R Manoharan, Deputy Director and Mr Sunil de Silva, System Analyst of the Central Environmental Authority.
- Mrs G Rathnayake, Statistician of the Department of Motor Traffic.
- Mr J L Fernando, Chemist of the Railway Department (Ratmalana).
- Mr Piyasena, Manager of Ceylon Petroleum Corporation.
- Owners and the staff of the services stations I visited

I extend my gratitude to the Ministry of Forestry and Environment for providing me the scholarship for this course; and my Company, Environment & Management Lanka (Pvt) Ltd and Mr Lal Rodrigo, Director-Administration for assisting and encouraging me in perusing this course.

I take this opportunity to thank Prof. (Mrs) N Ratnayake, the course co-ordinator, other course lectures and staff of the Department of Civil Engineering of the University of Moratuwa for their support and guidance given to us during the course of study.

Dedication to my wife

ABSTRACT

1. Main Objective

To study the feasibility of disposing the waste oil in the existing Puttalam Cement Kilns for Sri Lanka. To achieve this objective, the current situation in terms of technologies (manufacturing, fuel firing, process control, dust emission equipment and performance, etc.) of Puttalam Cement and the financial viability was evaluated.

2. Introduction

Disposing of waste oil in Cement Kilns will give three fold benefits: getting rid of waste oil, almost without any residue, complete energy recovery which contribute to the economy of a country and special disposal facilities are not needed as an existing facility is utilised

High flame temperatures and the nature of the product make cement kilns attractive for the destruction of a variety of hazardous organic materials. With proper management, kilns constitute a much less costly alternative to dedicated waste incinerators. Tests by USEPA and others have demonstrated that destruction of organic compounds including, PCBs and organochlorine and organophosphorus pesticides, equals or surpasses that achieved in hazardous waste incinerators that operate at lower temperatures. Many toxic metallic compounds can also be burned in cement kilns in quantities that are small enough not to adversely affect product quality or safety, since they are bonded to the clinker and become part of the product.

3. Waste Oil

It refers to lubricating oils, hydraulic, transmission & heat transfer fluids and insulants that have gone through their intended use cycle and must be either disposed of or treated and re-used. **In this thesis**, waste oil from automotive ***transport sector*** is only considered. Other transport (aviation and maritime) sector and spent industrial oils are not included here as waste oil since these oils are contaminated with unknown pollutants.

4. Waste Oil Generation and Properties in Sri Lanka

A pilot survey was carried out to estimate the waste oil generation and centrally collectable amount. According to the survey results, in 1999 around 24,000 – 27,000 ton waste oil was generated by automotive transport sector in Sri Lanka. However, the known collectable amount is 4,500 (about 18% of the generated amount) while the estimated amount is around 17,400 ton per year in 1999 as given in Table 23. With time, awareness, incentives, and enforcement of regulation, the estimated amount can be collected.

The laboratory test results show that our waste oil property is within the literature values in terms of physical property and the contaminants such as heavy metals. However, it is interesting to note that the ASTM distillation curve of the waste oil distillate resembles kerosene oil and the quantity distilled also only 63%. This shows that the best option in World of waste oil disposal by rerefining back to lube base may not be possible in Sri Lanka and therefore, the best option for our waste oil is using as alternate fuel which is well supported by the high calorific test results (> 44,000 kJ/kg). However, with the limited number of tests it is difficult to come to a firm conclusion. This is only an indication.

5. Puttalam Cement

Cement is manufactured by grinding an artificial rock called "clinker" very finely (to a few microns) mixing with a small amount of gypsum (approximately 4%). Clinker is produced by heating limestone (77%) and some other ingredients (23%) to around 1450°C in a kiln. At Puttalam Cement Factory, there are two identical rotary kilns. The length of a kiln is 54 m. The burner of the kilns were change recently by Rotaflam kiln burner which has an additional jacket tube for a waste oil gun.

A complete actual material balance could not be done with the current on line measured and recorded data at Puttalam Cement. Therefore, some assumptions were made using the equipment specifications and international norms in doing the material balance. The average amount of raw materials used for one

ton of clinker production is 1.7 tons whereas theoretical value is 1.53. With the provision of dust emission from kiln exhaust and clinker cooler at the emission standards this value can be 1.56. Current loss of materials in terms of clinker is 3,355 kg per hour that is 11% of clinker. According to the present production and the proposed Sri Lankan emission standards, the allowable dust emission from kiln exhaust and clinker cooler is only 10.3 kg/hr which is merely 0.034% and therefore the actual loss of clinker is 10.966% that is 3,344.7 kg/hr and 28,095 ton per year from one kiln.

The cyclones used for the clinker cooling air dust recovery has been replaced by bag houses which was reviewed to see whether the capacity and the review shows that the selection is good. The expected emission will be only 30 mg/Nm^3 which is very much less than emission standards.

Complete overhauling ESPs was done to recover more dust and to reduce the emission from the kiln exhausts. These overhauled ESPs will be used for only two years and after two years these ESPs will be replaced by bag houses. Therefore, the environmental issues will be under control for the disposal of waste oil.

The average thermal energy consumption for one kg of clinker production is 3.65 - 4.02 MJ. However, literature value for dry process is 2.88 to 3.40 MJ/kg. That is the actual consumption is 19 - 26% higher than the literature value.

Factors to be considered for the disposal of waste oil:

When waste oil is disposed, the values of the critical parameters should not be increased above the clinker quality standard as given in Table 25. When comparing our waste oil property and the clinker quality standard, the critical parameters for Puttalam Cement will be lead (Pb) and cadmium (Cd).

The present values of Pb and Cd in the clinker is not known and therefore it is assumed here that these values are zero. When the capture of heavy metals in the clinker can be taken (Table 9) as 99.7% and the Cd and Pb concentrations in waste oil are 4 and 3,200 mg/l, material balance show that 32% of furnace oil can be replaced by waste oil. I.e. about 16,000 tons of waste oil can be disposed at Puttalam Cement kilns (two) annually. However, Puttalam Cement has the plan to replace only 10% of furnace oil waste oil and this value will depend on the Pb and Cd content in the raw materials.

The emission level of the critical parameters should not also be increased above the emission standard. When comparing our waste oil property and the proposed Sri Lankan emission standard for cement kiln exhaust, the critical parameters for Puttalam Cement will be lead (Pb) and cadmium (Cd).

When the heavy metals capturing % and dust removal %; and the concentration of heavy metals in waste oil vary, the amount of maximum waste oil disposable varies as given in Figure 27 (graph).

6. Conclusion

Waste oil can be disposed in Puttalam Cement Kilns with some improvements to the existing situation mainly the kiln exhaust dust removal that is the efficiency of ESPs. During this study, the ESPs were repaired and therefore current performance to be determined based on material balance as given in this report or dust emission measurements. The current efficiency of the ESPs could not be calculated because the dust concentration before ESP is not available. Dust concentration after ESPs is also not measured but from the material balance it is about 48,744 mg/Nm^3. It can be assumed that the ESP was not working. Therefore, the required efficiency of the ESP to meet the standard will be 99.4%. The data used for the material balance was for one day of one kiln and therefore it may not represent the whole system. But it can be improved by using weekly, monthly and yearly data. Some trial runs should be carried out and the following records to be established for future planning:

- Characteristics of waste oil
- Heavy metal contents in raw materials and clinker
- Material balance for individual components
- Capturing ratio of heavy metal by clinker

TABLE OF CONTENTS...

List of Tables...

List of Figures...

List of Attachments...

Appendix 1	:	Pilot survey results
Appendix 2	:	Kiln process flow diagram of Puttalam Cement
Appendix 3	:	Puttalam Cement Kiln surface temperature profile
Appendix 4	:	Operation log-sheet of Kiln in Puttalam Cement
Appendix 5	:	A tender advertisement in a News Paper for getting paddy husk
Appendix 6	:	Copy of the ITI Report on Gross Calorific Value of Waste oil

Notations...

Al_2O_3 -	Aluminum oxide
As	Arsenic
$CaCO_3$ -	Calcium carbonate
CaO -	Calcium oxide
Cd -	Cadmium
CDDS -	Chlorodubezo-podioxin
CDF -	Chlorinated dibenzofurans
Cl	Chlorine
CO -	Carbon monoxide
CO_2 -	Carbon dioxide
Cu	Copper
DRE -	Destruction and removal efficiency
ESP -	Electrostatic precipitator
Fe_2O_3 -	Ferric oxide
HCl -	Hydrochloric acid
Hg -	Mercury
HF -	Hydrogen fluoride
HVI -	High viscosity index
kg -	kilo gram
LVI -	Low viscosity index
MJ -	Mega joules
NO -	Nitric oxide
NOx -	Oxides of nitrogen
O_2	Oxygen
PAC -	Polynuclear aromatic carbon
Pb	Lead
PCB -	Polychlorinated biphenyl
PM -	Particulate matters
PNA -	Polynuclear aromatic carbon
POHC -	Principal organic constituents
SiO2 -	Silicon oxide
SO_2 -	Sulfur dioxide
TNA -	Total acid number
Ti	Titanium
V	Vanadium
Zn	Zinc

Abbreviations...

CEA -	Central Environmental Authority
DIY	Do-it-yourselfers
DMT -	Department of Motor Traffic
EIA	Environmental Impact Assessment
EPL -	Environmental Protection License
ITI	Industrial Technology Institute
NEA -	National Environmental Act
NIMBY -	Not In My Back Yard
Nm^3	Cubic meter and Normal conditions of 0°C, 760 mmHg and zero moisture
Puttalam Cement – Puttalam Cement Company Limited	
UNEP -	United Nations Environmental Program
USEPA -	United States Environmental Protection Agency