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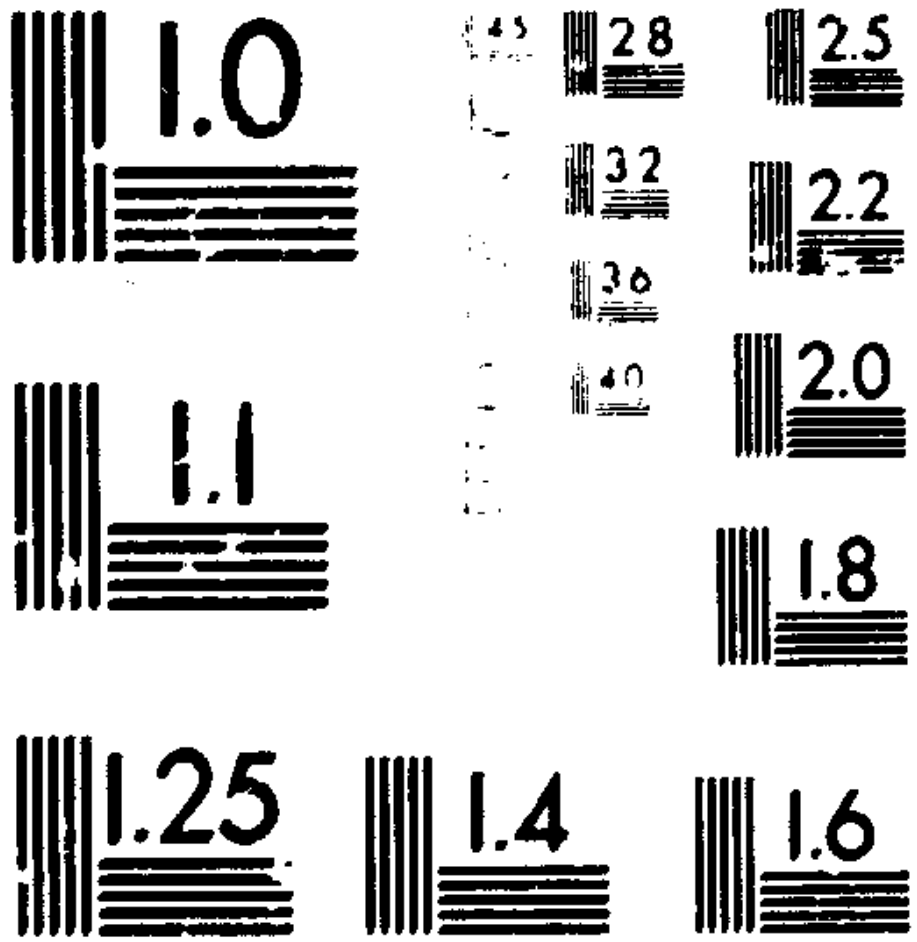

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Sri Lanka. ESTABLISHMENT OF A CERAMIC RESEARCH AND DEVELOPMENT LABORATORY

US/SRL/78/207

SRI LANKA

Technical Report *

Prepared for the Government of Sri Lanka
by the United Nations Industrial Development Organization
acting as Executing Agency for the United Nations Development Programme

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Based on the work of M. Novy,
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Vienna

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I ABSTRACT

The assignment on consultancy in Kiln Design and Fuel Engineering, post code US/SRL/78/207/11-54/32.1.B,was accomplished as a part of the project "Establishment of a Ceramic Research and Development Laboratory" US/SRL/78/207. The assignment for three months aimed in the assistance to the Ceylon Ceramics Corporation with the setting up and effective use of the laboratory within the field of energy conservation. The main activities covered the assessment of the efficiency of the Kilns and Driers of the Ceylon Ceramics Corporation,elaboration of proposals for the improvement of their operation and designs and demonstration as to how the laboratory can contribute to the programme of energy conservation. By a series of lectures and on-the-job training the local staff was prepared to continue in the work, initiated during the assignment. The additional equipment for systematic energy audits was defined and ordered. The activities performed during the period and results reached through the application of elaborated proposals proved the potentiality of the laboratory to reach significant energy savings in production plants, in close co-operation with the technical staff from these plants and with the support from the Management of the Corporation. The Central Research Laboratory represents a capable body for extensive Ceramic Research. Though the equipment installed is only at the beginning of full service, its complex forms a condition for successful work in the future. The staff of the laboratory consists of young interested people with the necessary theoretical knowledge. Under the leadership of experienced experts, this staff can grow into a strong research team. The co-operation with similiar research organisations abroad and exchange of information and experience, including training of Research Officers, will be useful. The laboratory should contribute to energy savings especially through the research of new body compositions & energy diagnostic audits in the production plants.

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INTRODUCTION

The Ceylon Ceramics Corporation has undergone a rapid development since its establishment in 1935. It comprises a wide range of manufacturing plants with various products, such as China clay refining, earthenware and porcelain tableware , wall tiles, mosaic tiles, bricks, roofing tiles and lime. The annual production reaches a value of approximately US $ 15 million. Nevertheless, the lack of specialised research facilities made the Corporation dependant on foreign laboratories for specialised development work. Therefore the management of the Corporation has decided on the establishment of a Ceramic Research Laboratory.

The project " Establishment of a Ceramic Research and Development Laboratory", US/SRL/78/207 was initiated to increase local self-sufficiency in ceramic research and development work through the assistance in the setting up of the Ceramic Research Laboratory of the Ceylon Ceramics Corporation. The mission on consultancy in kiln design and fuel engineering was materialised as a part of the project. The field activities started on September 27th and terminated on December 18th, 1984, the rest of the three months of the assignment being spent on briefing, debriefing and travel. The activities of the mission aimed in the assistance to the laboratory within the field of energy conservation. In close co-operation with the local counterpart staff from the laboratory & manufacturing plants the efficiency of different kilns was assessed by the consultant and proposals for the improvement of the operation elaborated. Valuability of these proposals was verified on the muffled tunnel kiln in Piliyandala. Realisation of proposals on this kiln resulted in increased production and reduced specific energy consumption. Moreover, conditions were created for further production intensification which will enable to close the semimuffled kiln used in firing of sanitaryware, for repair. This measure will reduce the energy consumption sharply. Additional equipment for performance of systematic energy audits by the laboratory is needed. The list of this equipment was

discussed with the management of the Corporation and the order was placed.By extensive on-the-job training and by a series of lectures, the local staff from the laboratory and production plants was prepared to continue in the activities, initiated during the assignment and thus contribute to the programme of energy conservation.

The objectives of the mission were successfully attained thanks to the well conducted preparatory work of UNIDO Vienna, wide support of UNDP and UNIDO office in Colombo, broad understanding and help handed over by the management of the Ceylon Ceramics Corporation, fruitful co-operation within the international team of experts and active work of laboratory and plants counterpart staff.

Personal thanks are due mainly to :-

Mr. N. Biering, UNIDO Headquarters Vienna

Mr. T. Schroll, SIDFA,UNDP Colombo

Mr. I. Mattsson, JPO,UNDP Colombo

Mr. M.D.J.A. Sebastian, Chairman, Ceylon Ceramics Corporation

Mr. C.T.S.B. Perera, General Manager, Ceylon Ceramics Corporation

Mr. Y. Kato, Chief Technical Adviser

RECOMMENDATIONS

1. The instrumentation installed in the laboratory and young staff of qualified and interested people represent a good condition for successful research activities in the years to come. With regard to the limited experience of the laboratory staff in research work, the assistance of experienced experts in the next 12-24 months is necessary.

2. The co-operation with similar research institutions abroad in the field of technical information exchange and research officers training will be very useful.

3. In the field of energy conservation and management the main activities of the laboratory should be focussed on the research of new body compositions with lowered energy demands from local raw materials and on diagnostic audits of the energy consuming equipment in production plants.

4. As far as the research of new body compositions with low energy demands is concerned, this is an activity for which large experience in the matter is indispensable. Therefore, the assistance of an expert - ceramic technologist with experience in energy conservation - is recommended for the near future.

5. The diagnostic audits should comprise of the following basic steps:-

   a) calibration of measuring instruments which are installed on the equipment to be tested.

   b) collection of projected data and factual operational data about the equipment through the diagnostic measurements.

   c) analysis of the current situation on the basis of the data obtained as far as thermal treatment of products and heat balance of the equipment are concerned; eventual laboratory firings.

d) working out proposals and recommendations for the improvement of energy conservation and for thermal treatment in a technical report, which should also comprehend projected, measured and calculated values and description of measurements and calculations.

e) realisation of the proposals and recommendations on the respective equipment step by step to be able to recognise and record the reaction of the equipment on a new adjustment.

6. The proposals and recommendations should be concentrated expecially on:-

a) energy conservation achieved through better adjustment of the equipment.

b) improvement of thermal treatment of products and hence the final product quality.

c) waste heat utilisation.

d) possible improvement of the equipment design and modernisation.

7. The diagnostic audits and especially realisation of proposals and recommendations must be done in close co-operation with the management and technical staff in the production plants.

8. The laboratory should prepare an operational manual for the particular equipment on which the diagnostic measurements were completed.Such a manual will assist the managers and operators in factories to run the equipment in optimal production mode, thus achieving energy savings and appropriate product quality.

9. The execution of a complete diagnostic measurement necessitate a special instrumentation. The list of instruments required was discussed by the consultant with the management of the Ceylon Ceramics Corporation and the order has already been placed. Construction of a mobile diagnostic unit(such as that developed by the Research

Institute for Ceramics, Refractories and Raw Materials in Pilsen, Czechoslovakia) equipped with these instruments is recommended as a follow-up of the first series of diagnostic audits. This mobile diagnostic unit will increase the capability of the laboratory in equipment testing significantly.

10. Considerable improvement was achieved in Sri Lanka during the last period in utilisation of local raw materials. Nevertheless, still about 10% by volume but almost 40% by value of raw materials are being imported. Research programme of the laboratory was already established, comprising the research of new body compositions and energy conservation studies. Attention should be paid within research both to increase self-sufficiency aw materials and to lower energy demands of new body mixtures.

11. The kilns and driers operated in the visited plants of the Ceylon Ceramics Corporation are with few exceptions in good condition enabling proper adjustment after the diagnostic measurements.. Specific heat consumptions of these kilns vary from 8375kJ.Kg^{-1} in the semimuffled tunnel kiln for bisquit firing of crockery to 97000kJ.Kg^{-1} at the semimuffled tunnel kiln firing sanitaryware. While the first figure is acceptable, the second value is about eight times higher than what the average consumption should be. Energy conservation studies must be therefore focussed on the review of the existing situation first,, then the analysis should follow, establishing the priorities for actions to be taken.

12. The muffled and semimuffled kilns in Piliyandala for firing crockery and sanitaryware are heated by furnace oil. All these kilns use the same burner units with electrical preheating of oil and manual adjustment of the output. Their replacement by automated units regulating the burner's output in

dependance on the firing temperature is feasible for the future. This system will minimize variations in firing conditions thus having a positive influence upon energy consumption and quality of products.

13. For the present the regular exchange and maintenance of burners with an interval of 4 - 6 days is highly recommended to improve the efficiency of oil firing. This system was already introduced in the sanitaryware kiln in Piliyandala with positive results, especially as far as the stability of firing temperature is concerned.

14. Waste from cooling zones of tunnel kilns in visited plants for drying is utilised on a large scale. Further improvement can be reached by an introduction of heat exchangers on exhausts of combustion products in kilns with exhaust temperature above 250°C. Simple heat exchanger was suggested by the consultant for sanitaryware kiln in Piliyandala and its installation already started. Heat from this heat exchanger will be used for drying.

15. Loading density increase and better filling of the cross-sections of kilns will reduce specific energy consumption, while temperature equalisation the cross-section will be better. It was verified on tunnel kiln for glost firing of crockery in Piliyandala, where higher setting on kiln cars lowered the temperature difference between top and bottom deck by about 30% in firing zone.

16. Substitution for currently used classical car linings with high temperature insulating materials in combination with refractory shaped stones as supporting and covering elements will reduce heat losses by conduction to inspection tunnels as well as losses by accumulated heat in kiln car linings. Moreover, the lifetime of kiln cars and maintenance interval will be prolonged.

17. Possible utilisation of alternative energy sources comes into account in small and medium size brick & tile producing plants using at present firewood as a fuel. While direct use of solar energy for drying of tiles brings about problems with output variation in deperdance on the itensity of insolation it can be recommended for the smallest productions only.

18. Medium level plants such as Brick & tile Factory,Weuda can favourably utilise combination of alternative energy sources. During sunny days the solar energy can be used for drying of agricultural wastes, such as coconut fibre dust or rice husks, which currently enter the factory with high relative moisture content (about70%). Being dried to sufficient extent (about 10% of water content) by solar energy, these materials can be briquetted and then fired together with firewood, reducing its consumption by 15 to 30%.

19. Gasification of agricultural wastes in combination with other materials such as wood and rubber wastes (e.g.,worn tyres) for increase of gas calorific value can be used under the condition that relevant gasifiers are available. Similarly direct firing of dried agricultural wastes requires the use of special boilers.

20. Simple solar collectors using air as a drying medium can be introduced using black painted corrugated steel insulated from bottom side and covered with glass with 3 to 5cm airspace inbetween. Heated air from that space is sucked by a fan and blown to the drier of tiles or agricultural wastes. In temperature range 40-60^{o}C, relatively high efficiency od collectors can be reached with an output 0.5-0.7kW per square meter of collectors during sunny hours. For example the roof of the Brick&Tile Factory Weuda being of corrugated steel can be successfully used as a solar collector if insulated from the bottom side,painted black and covered by sheet glass.

III. CONSULTANCY IN KILN DESIGN AND FUEL ENGINEERING

A. Activities and Output

The consultant was attached to the Ceylon Ceramics Corporation to assist in the setting up of its Ceramic Research Laboratory and to advise on the effective use of the laboratory within the field of energy conservation. He acted in close co-operation with the local counterpart staff from the laboratory and from production plants.(list of the counterpart staff is presented in Annex A) The main duties were as follows:-

- to assess the present level of efficiency of the different kilns and driers of the Corporation and identify scope for possible improvement.
- to elaborate proposals for the improvement of the operation and designs of kilns & driers with the aim to increase fuel efficiency without impairing product quality.
- to identify potential alternative sources of energy e.g.agricultural wastes and solar radiation for possible firing and drying, respectively, of structural clay products.
- to demonstrate how the laboratory can contribute to the energy conservation programme and initiate appropriate activities.
- to define the need for additional equipment required by the laboratory to allow for systematic energy audits in manufacturing plants.
- to prepare the local staff to continue the work initicted through on-the-job training.

The counterpart staff from the laboratory and manufacturing plants were instructed by the series of lectures dealing mainly with energy management in the ceramic industry. List of delivered lectures is presented in Annex B. During the lectures special attention was paid as to the possible contribution that the laboratory could make to the energy conservation programme, especiallly in the field of new body compositions and energy audits within the ceramic industry. The research programme of the laboratory was discussed with the management of the Corporation and international team of experts. This programme comprehends

both the research of new body compositions and energy conservation studies. The energy audits were initiated during the assignment though with regard to the incomplete necessary instrumentation, the measurements were not complex. The necessary additional instrumentation for complex diagnostic measurements was ordered by the management of the Corporation after negotiations with the consultant. Nevertheless, the laboratory contributed to the improvement of kiln operations significantly, especially by -

- calibration of installed instruments (recorders) in manufacturing plants. These instruments were then used for measurements
- combustion gas analyses verifying the proper adjustment of burning conditions in kilns.
- Laboratory firings, which enabled adjustments of firing condition in production kiln in dependance on the results of these firings.

The counterpart staff was trained through on-the-job training in diagnostic measurements and working out proposals for improved operation. These proposals were prepared in collaboration between the consultant, laboratory staff and kiln managers in manufacturing plants.Advantages and disadvantages of different suggestions were analysed and optimal strategy of relevant action was chosen. Stress was laid on application of recommendations on the equipment step by step to determine its reactions on individual measures taken. Attention was paid to gradual increase of activity and self-sufficiency of local staff in the analyses of data obtained and in preparation of proposals and recommendations.

Six production plants of the Ceylon Ceramics Corporation were visited by the consultant with the aim to assess the efficiency of kilns and driers operated in these plants and identify the scope of possible improvements.Details of these activities and proposals for the improvement elaborcted are presented in Annex C.

Possible utilisation of alternative energy sources was taken into consideration during factory visits too. These are applicable in smaller brick and tile production plants which currently use firewood for drying and firing of products.

8. Utilisation of Results of Activities

The recommendations elaborated in close collaboration between the staff from laboratory (kiln room) and kiln mangers from production plants with the assistance of the consultant on the basis of diagnostic measurements and data collected were verified on the tunnel kiln of the Ceylon Ceramics Corporation in Piliyandala.This kiln was recommended by the management of the Corporation. The diagnostic audits on this muffled tunnel kiln in the sanitaryware plant started on October 3rd,1984. The adjustment of burning conditions and pressure curves in burning chambers enabled to reduce the oil consumption by 30% in the first phase, while production was increased by 14%. Specific energy consumption was reduced by 39%. The conditions were created for further production increase by 20% in the second phase. It will enable to incorporate the production of bisquit semimuffled tunnel kiln in crockery producing plant in Piliyandala, firing sanitaryware. A total energy conservation of about 40,000 l of furnace oil representing Rs. 240,000/- (US $ 9170), per month can be expected after this measure is realised. Also reduced damages due to handling and transport of green ware from sanitaryware plant to crockery plant can be expected. Moreover, the simple heat exchanger was suggested to be installed on the exhaust of combustion products from sanitaryware kiln, utilising partly their heat. Installation of the heat exchanger has already started.

The follow-up of the work initiated during the assignment is to be ensured by the Ceramic Research Laboratory in co-operation with kiln managers of the production plants. This activity will be even more effective after the delivery of the instrumnetation ordered. In the meantime some improvements can be done following the proposals presented in Annex C.

C. Conclusions

The activities performed during the assignment proved the capability of the local staff from the laboratory as well as from production plants to solve the energy conservation problems from the technical point of view in mutual co-operation. With the support from the management of the Corporation in organisational matters they will be able to contribute considerably to the energy conservation programme both within the Corporation and in other ceramic enterprises especially after they have got more practical experience with the adjustment of different types of kilns and with the research of new body and glaze compositions. Pilot firings done in the laboratory kilns are very beneficial not only for experiments with new body and glaze mixtures, but for research of limiting firing conditions leading to the adjustment of optimal firing curves in production kilns as well. To improve the practical experience and knowledge of the technical staff the management of the Ceylon Ceramics Corporation decided andnegotiated with UNDP Colombo to send a technician fro individual training on energy conservation and management to Czechoslo akia.

Good conditions of most kilns in visited plants guarantee the possibility of proper adjustment after the completion of diagnostic measurements. The scope of possible improvements on these kilns ranges from an adjustment of burning conditions and firing curves to waste heat utilisation in a technological process. At present the heat from the cooling zones of the kilns is used to sufficient extent, especially for drying, while the utilisation of waste heat from combustion products is rare. Increasing of the loading density on kiln cars and better filling of the kiln cross section are another fields of possible reduction of specific heat consumption and production increase.

Verification of elaborated proposals on sanitaryware kiln and contributions reached showed the significance of energy management in ceramic industry and large savings, which can be achieved by activities of the Ceramic Research Laboratory in this field.

ANNEX A

Members of the Management of Ceylon Ceramics Corporation met during the assignment.

Mr. M.D.J.A.Sebastian, Chairman

Mr. C.T.S.B. Perera, General Manager

Mr. A.S. De Silva, General Manager

Mr. D.N. Wijesiriwardene, Energy Manager.

Mr. B.G.R.Premawansa, Clay Technologist

Counterpart Staff

-Laboratory

Mr. P. Mithrarathna, Instrumentation Officer

Mr. N. Dharmasiri, Technical Officer

-Production Plants

Mr. U.J. Udawatta, Kiln Manager, Piliyandala

Mr. C.P. Kumarasiri, Glost Kiln Manager

Mr. D.B.W. Samarakoon, Sanitaryware Kiln Manager, Piliyandala

Mr. M. Jayaratna, Assistant Factory Manager, Negombo

ANNEX B

List of Delivered Lectures

1. System of Energy Management in Ceramic Industry
2. Reduced Energy Demands of Ceramic Production through the Application of New Body Mixtures
3. Modernisation of Heat Consuming Equipment in Ceramic Production Plants
4. Waste Heat Utilisation
5. Information about the UNIDO -Czechoslovakia Joint Programme Activities
6. Diagnostic Mobile Unit and Diagnostic Measurements in Ceramic Production Plant

ANNEX C

Plant Visits and Proposals for the Improvement on Kilns and Driers

1. Piliyandala

a. Sanitaryware Kiln

This kiln was adjusted after the diagnostic measurements according to the worked out proposals. Basic technical data are presented before and after the first stage of adjustment:

	Before Adjustment	After Adjustment
Type:	Muffled tunnel kiln, firing furnace oil	
Product:	Vitreous China Sanitaryware	
Daily Output/Kg/:	1800	2050
Firing temperature/^{o}C/:	1200	1200
Firing cycle /h/:	36	31.5
Oil consumption/l/day/:	1852.3	1275.0
Specific energy comsumption /kJ.kg^{-1}/:	39113	23738

The proposals, leading to the adjustment, comprehended:

- adjustment of firing conditions by the amount of secondary air for burners.
- adjustment of pressure curves in burning chambers by relevant dampers.

After the application of these proposals one pair of burners was closed and production was increased. It was decided to start with the operation of this pair of burners again in the second phase of the adjustment. It will enable further increase of kiln car speed and thus production increase.

Proposals for further improvements:

- installation of a heat exchanger on the exhaust of combustion products (already started) and the heat obtained used for drying.
- increase of the loading density by a new pattern of loading (two protype kiln cars with increased capacity by about 50%are already in use)
- higher setting on kiln cars will minimize the free space between

the setting and kiln arch, which will lead to better temperature equalisation in the cross-section.

- modernisation of kiln car linings by application of high temperature insulating materials will reduce heat losses by accumulated heat and losses to inspection tunnel.

b. Bisquit Kiln in Crockery Plant Firing Sanitaryware

Type: Semimuffled tunnel kiln, firing furnace oil

Product: vitreous China sanitaryware and once fired crockery items

Daily Output/kg/:	600
Firing temperature/°C/:	1200
Firing cycle/h/:	36
Oil consumption[l/day]	1525
Specific energy consumption /kJ.kg^{-1}/:	97035

Present situation:

The kiln is operated far below its optimal output. Density of loading is very low and proportion between the mass of products and that of kiln furniture is unfavourable as the kiln cars must be partly covered by refractories to avoid glaze contamination by combustion products. Specific energy consumption is therefore too high, four times higher than that of sanitaryware kiln firing the same products.

Recommendation:

To increase production of sanitaryware kiln and incorporate the production of bisquit kiln which can be thereafter closed for repair and used for firing crockery bisquit for which it was originally designed.

c. Bisquit kiln firing crockery

Type: Semimuffled kiln, firing furnace oil

Product: Bisquit of earthenware tableware

Daily Output/kg/:	7200
Firing temperature/^{o}C/:	1150
Firing cycle/h/:	28
Oil consumption[l/day]:	1580
Specific energy consumption /kJ.kg^{-1}/:	8375

Present situation:

The specific energy consumption of the kiln is the lowest of all tunnel kilns inspected during factory visits, but kiln itself is in a bad condition (cracked brickwork in preheating and firing zones, fused dampers in preheating zone). High temperature in the inspection tunnel (about 350^{o}C) is partly caused by higher overpressure in the kiln, partly by leakage between kiln cars.

Recommendations:

- to measure pressure curve of the kiln atmosphere and improve it by a new adjustment i.e., with lower overpressure in the main zone.

Nevertheless, it can be difficult with regard to the insufficient draught in the exhaust of combustion products.

- to improve kiln car linings with the aim to lower its heat conductivity and especially leakage between kiln cars.
- for the long run it will be necessary to close the kiln for repair, including improvement of draught in the exhaust of combustion products. It will be possible after the bisquit kiln currently firing sanitaryware will have been repaired while sanitaryware will be fired in the sanitaryware kiln only.

d. Glost kiln firing crockery

Type: semimuffled tunnel kiln, firing furnace oil

Product: earthenware tableware

Daily Output/kg/: 6900

Firing temperature/°C/: 1080

Firing cycle/h/: 12

Oil consumption[l/day]: 2179.2

Specific energy consumption /kJ.kg^{-1}/: 12054

Present situation:

Output of the kiln is higher by 60% and speed of kiln cars is double than originally designed. It brings about high temperature difference between the top and bottom of the setting in preheating zone(about 400°C) and increased specific energy consumption as the kiln is operated above its optimum output, especially as far as kiln car speed is concerned. Moreover, the lowest part (about 20cm) of the cross-section can not be used for loading as products would be underfired in this part.

Recommendations:

- to change the loading pattern so as the space between the top of the setting and kiln arch is minimized. It will increase the temperature in the lower part of the kiln cross-section, which can then be also used for loading. Kiln car capacity will be increased by 25-50%, enabling proportional reduction of the speed. This measure will bring about reduced energy consumption and better temperature equalisation in the kiln cross-section.
- to install a heat exchanger on the exhaust of combustion products from the kiln (similar as that on sanitaryware kiln) and use the heat obtained for drying. Current temperature of combustion products about 380°C can be reduced to 150°C.

2. Negombo

a. Bisquit kiln firing crockery

Type: tunnel kiln with open flame firing furnace oil

Product: bisquit of earthenware tableware

Daily Output/kg/:	6400
Firing temperature/°C/:	1145
Firing cycle/h/:	36
Oil comsumption[l/day]	1500
Specific energy consumption / $kJ.kg^{-1}$/:	8900

Present situation:

Specific energy consumption of tne kiln reaches relatively favourable value, especially thanks to proper filling of the kiln cross-section by fired products. Furnace oil is preheated in a tank which is installed on the kiln, utilising thus the heat transfered through the kiln arch (beginning of cooling zone). However, final temperature of oil 50°C is not sufficient for proper oil atomizing by burners. Closing door system on the kiln entrance is missing, causing the flow of cold air into the kiln and increasing losses. Hot air from cooling zone of the kiln is used in crockery driers with electricity as auxiliary heating system.

Recommendations:

- oil preheating to higher temperature (80-100°C) will improve its atomizing and hence economy of burning and lower contamination of products by insufficiently burnt oil particles. This preheating can be realised in additional preheater similar to that currently used or another source of waste heat (e.g. from exhaust of combustion products) can be used.
- closing door ct the kiln entrance will prevent flow of cold air into the kiln, improving thus operation economy and pressure

conditions in prehecting zone too.

a. Glost kiln firing crockery and sanitaryware

Type: muffled tunnel kiln, firing furnace oil

Product: earthenware tableware and sanitaryware (squatting pans)

Daily output/kg/:	6400
Firing temperature/°C/:	1150
Firing cycle/h/:	16
Oil consumption [l/day]	1892
Specific energy consumption /kJ.kg^{-1}/:	11300

Present situation:

The value of specific energy consumption ranges among the lower ones of the kilns inspected and is acceptable for this type of kiln. Filling of the cross-section by products is satisfactory and kiln output is close to optimal one. Some muffle plates in firing zone are broken causing penetration of combustion products into the kiln and affecting from time to time (depending on pressure conditions and oil atomization) the glaze of products in front of the cracks. Lining of some kiln cars has been reconstructed, using for the inner part shaped insulating refractories.

Recommendations:

An improvement in the sphere of energy conservation can be achieved through the installation of a heat exchanger on the exhaust of combustion products (current temperature about 260°C). The heat obtained can be used for further preheating of the furnace oil to improve its atomization both at glost and bisquit kilns. Better atomization will reduce contamination of products by smoke gases in both kilns. Improved insulation of kiln cars will reduce losses to imspection tunnel and losses by accumulated heat.

3. Meepe-Lanka Refractories

Kiln firing refractories

Type: tunnel kiln with opened flame firing furnace oil

Product: medium alumina (45%Al_2O_3) refractories

Daily output/kg/: 6850

Firing temperature/°C/: 1420

Firing cycle/h/: 210

Specific energy consumption /kJ.kg^{-1}/: 9240

Present situation:

The kiln is operating at 25% of projected capacity (9600t/year) with regard to the limited salability of products. It influences negatively the specific energy consumption and lifetime of the kiln too. The measures has been taken by the manufacturers to adjust the kiln for lower output. Only 10 pairs of burners out of total number 25 pairs are in operation at present. Improvements of the brickwork in the firing zone and installation of an exhaust fan with increased output are planned to be done in the future to reach higher firing temperature (currently up to about 1550°C) and increase thus products variety.

Recommendations:

Before the planned improvements will take place the knowledge of existing firing curve (obtained by pilot car) and pressure curve will be very useful for proper adjustment of the kiln for existing conditions to reduce oil consumption. Nevertheless, the output increase in the future is the necessary condition for effective operation not only of the kiln, but production plant as such too. Current specific energy consumption will be reduced by about 30-50% (depending on type of products and firing temperature) if the kiln is operating at full capacity. It will reduce expenditures for oil and price of final products improving thus their salability.

4. Brick and Tile Factory Weuda

Drier of tiles

Type: chamber driers heated by radiators by steam

Product: roofing tiles

Daily output: 9600 pieces

Evaporated water /kg per day/: 4300

Specific energy consumption /kJ.kg^{-1} of evap. water/; 6730

Present situction:

Specific energy consumption of the drier was calculated without the efficiency of the boiler. If this is comprehended, the value increases 3-4 times. The drier as such is in a good operating condition except some radiators blocked by condensate. The boiler firing firewood is old and inefficient.

Recommendations:

- cleaning of malfunctioning radiators and putting them into operation will improve drying efficiency.
- - replacement of the boiler by modernised one, favourably constructed for firing firewood and agricultural wastes (coconut fibre dust, rice husks) will reduce the consumption of firewood.
- drying of agricultural wastes can be done by solar energy, if the steel roof of the factory is used as a solar collector. It should be covered by glass with airspace about 5 cm. The heated air from that space will be sucked and blown by fans to the drier of agricultural wastes. Dried wastes can be then stored under the roof for briquetting or direct firing.

5. Brick and Tile Factory Mahiyangana

The plant was visited with the aim to consider the possible re-opening of originally installed tunnel kiln for firing roofing tiles and bricks. This kiln had fired heavy furnace oil originally and was closed with regard to the high price of energy used for firing. Expenditure for oil formed one third of the final price of tiles. Currently two chamber kilns (each of two chambers) are used for firing of tiles, using firewood as a fuel. Kilns consuming 2.5 m^3 of firewood for firing 1000 pieces of tiles, the expenditures for firewood form 7.5% of final tile price at present. Reopening of the tunnel kiln was taken into consideration due to the high demand for roofing tiles in the region. This reopening is feasible under the condition that specific energy consumption of tunnel kiln is reduced by more than 50% from its value before kiln was closed or an alternative fuel is used. Design of firing zone enables its reconstruction and installation of burning chambers for firewood instead or together with the four oil burners which were originally used. The beginning of preheating zone must be repaired and exhaust of combustion products reconstructed in case the kiln is put into operation again. The situation requires elaboration of a feasibility study before any measures are taken. Specific energy consumption under 4000kJ.kg^{-1} can be expected after reopening of the kiln is adjusted and operated properly.