**DFID Project R7413:**
**Mechanisms to Improve Energy Efficiency in Small Industries**

# Part Three: Some Problems and Solutions in Khurja

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## PART 3: SOME PROBLEMS AND SOLUTIONS IN KHURJA

**PREFACE**

The main objectives of the DFID Project R7413 are to promote mechanisms to increase the adoption of energy efficient technologies and practices in the case of one small scale industry sector in India and Ghana. The sector chosen in India is the ceramic sector. The focus of the work has been in one large cluster of ceramic firms in Khurja, India. The process followed in the project has been to:

- map the operational practices in a sample of units and develop working relationships with relevant stakeholders;
- examine existing practices to determine possible improved practices that could be adopted including new technologies in the main energy using parts of the operations, and,
- analyse the extent to which energy efficiency gains can be achieved in a manner that is also financially attractive to the firms.

Finally, the intention of the project is to examine the barriers to the adoption of improved technologies and to suggest specific interventions to reduce the barriers. This is provided that the suggested improvements are found to have a sufficiently high rate of financial return, making them potentially sustainable without subsidies.

This section reviews previous studies conducted on the Khurja pottery cluster and the various recommendations made; some seven studies have been conducted in the past ten years. Then each type of kiln – coal-fired downdraft, shuttle, tunnel and gas fired kilns are examined, including their energy consumption. Lastly the dynamics of change in the pottery sector in terms of the movement away from downdraft kilns to tunnel and shuttle kilns are explored.

The work done in India is detailed in the following sections:

The people and institutions who participated in this project and their contact details are listed below:

Stephen Ward
Intermediate Technology Consultants Ltd
Schumacher Centre for Technology and Development
Bourton Hall, Bourton-on-Dunsmore
Rugby CV23 9QZ, UK
Tel: +44 1788 661198
Fax: +44 1788 661105
E-mail: stephenw@itdg.org.uk
Website: www.itcltd.com

Dr Amitav Rath
Policy Research International (PRI)
6 Beechwood Avenue, Suite 14
Ottawa ON K1L 8B4, Canada
Tel: +613 746 2554
Fax: +613 744 4899
E-mail: arath@pri.on.ca
Website: www.pri.on.ca

Mr B L Dhar
Industrial Development Services (IDS)
M-1 Kanchenjunga
18, Barakhamba Road
New Delhi - 110 001, India
Tel: +331 3469/ 2287/ 4714
Fax: +1 331 6470
E-mail: idsindia@satyam.net.in
Website: www.industrialdevservices.com

Dr Abeeku Brew-Hammond
P.O Box 6534
Kumasi Institute of Technology and the Environment (KITE)
Kumasi, Ghana
Tel: +233 51 33824
Fax: +233 51 33824/26026/60232
E-mail: kite@ghana.com
Website: http://linklive.net/KITE

Mr Vhingra
Petroleum Conservation Research Association (PRCRA)
Northern Region
609, New Delhi House, 27, Barakhamba Road
New Delhi – 110001, India
Tel: 3357457, 3315879
Fax: 3320629
E-mail: pcrad@del2.vsnl.net.in
Website: www.pcra.org

Dr H S Maiti, Director
Central Glass & Ceramic Research Institute (CG&CRI)
196, Raja S.C. Mullick Road
Calcutta 700032 India
Tel: 473 5829
Fax: 033 473 0957
Email: director@cscgcri.ren.nic.in, hsm@cscgcri.ren.nic.in

Shri A K Gupta, Deputy Secretary in Charge
Central Glass & Ceramic Research Institute (CG&CRI), Khurja Centre
G.T. Road, Khurja, 203 131, India
Fax: 05738 42501

Carl Shenton
CERAM Research Ltd
Queens Road, Penkhull
Stoke-on-Trent
Staffordshire, UK
Tel: +44 1782 76 4444
Fax: +44 1782 412334
Email: carl.shenton@ceram.co.uk
Website: www.ceram.co.uk

## SOME PROBLEMS AND SOLUTIONS

### *Earlier Studies*

A significant number of studies have been carried out to examine the problems of the ceramic industry in Khurja and to find and recommend solutions for the problems identified. This section briefly reviews the main problems identified in other studies, as important to the pottery industry and their principal recommendations. Some of the earliest studies of the industry, which led to the various interventions until the seventies, described in the section on the development of the industry, were not available. But, we can imagine the earlier findings from the solutions that were followed to provide support to the industry. The interventions have included the provision of experts to provide advice, training and demonstrations; a major effort at providing common services, which had some successes and later was a failure; and provisions for subsidised fuel supply and some inputs into design and market development. These early interventions have been categorised in the section on the historical evolution of the industry.

A complete list of the studies and documents that have examined problems and solutions for the ceramic cluster in Khurja, that we could find are listed below.

| | ***Author*** | ***Title*** | ***Date*** |
|---|---|---|---|
| 1. | Dr T N Sharma | "Khurja Pottery Industry – Its Growth and Development" | 1976 |
| 2. | Dr T N Sharma | "Let Us Also Turn Our Common Clay Into Gold" | Undated ~ 1970s |
| 3. | C G Agrawal | "Status Report on Glass and Ceramic Industries in Uttar Pradesh" | Undated ~ 1970s |
| 4. | Department of Scientific and Industrial research (India) | *Technology Evaluation in Ceramics Industry* | 1991 |
| 5. | RITES India | *Infrastructure Survey of Khurja* | Undated ~ 1992 |
| 6. | CG&CRI | *Thermal Energy Conservation in Conventional Downdraft Kilns* | 1992 |
| 7. | CG&CRI | *Basic Considerations Guiding Improvement in Productivity and Quality of Ceramic Wares Produced in the Small Scale Sector* | 1993 |
| 8. | Dalal Consultants and Engineers Limited | *Study of Energy Efficiency Gaps and Potential For Energy Conservation In Small Scale Ceramic Tableware Units* | 1997 |
| 9. | U P Industrial Consultants Ltd | *Brief Survey Report of Potteries, Glass, Leather and Brassware* (under Technology Mission Program) | 1998 |

| | | | |
|---|---|---|---|
| 10. | Pottery Developent Office, Khurja | *Demand Study and Industrial Profile – Development and Possibilities for Pottery Industry (Khurja)* | 1999 |
| 11. | CG&CRI (Sponsored by TERI) | *Diagnostic Study for Problem Areas And Remedial Measures In Respect of Raw Material Preparation, Moulding Practices, Drying And Glazing Processes of Ceramic Units At Khurja** | 2000 |
| 12. | TERI (Project Report No.2000CR61), | *Diagnostic study for the development of pottery industry cluster at Khurja in Uttar Pradesh* | 2001 |

* This study was done by CG&CRI with support from TERI and in parallel with TERI's *Diagnostic study for the development of pottery industry cluster at Khurja in Uttar Pradesh*. Much of the material from *Diagnostic Study for Problem Areas And Remedial Measures…* was incorporated into the later report.

The earliest documentation found, of problems facing the Khurja pottery cluster, was in an article by G.C.Agrawal, then Deputy Director of the Small Industry Service Institute, Kanpur, published in the 1970s[1], entitled "Status Report on Glass & Ceramic Industries in Uttar Pradesh". He identified the following as the "main industrial problems" facing the industry and that required the attention of the experts at that time:

- extending the life of saggars;
- improving the fuel efficiency of the downdraft coal fired kilns;
- improved glazes and colours;
- better design and more attractive prints, and
- diversification into new lines of products.

An infrastructure survey of Khurja was conducted in the early 1990s by RITES India (1992). It again identified the inefficiency of the still predominant coal fired down draft kilns as a major problem. It strongly recommended 'technological upgradation' of the kilns and other manufacturing processes in the cluster. It advocated the replacement coal-based down draft kilns with gas, electrical and diesel-fired tunnel kilns. It also suggested the use of newer machines like isostatic presses, pressure casting machines and roller heads. Further problems suggested by this infrastructure study was the lack of access to capital for the firms to allow them to modernise their production. It noted the irregular power supply, the absence of gas supplies and the poor condition of roads in Khurja as additional problems

[1] Sharma, Dr T. N., "Let Us Also Turn Our Common Clay Into Gold", undated. Estimated 1970s.

Table 3.1 All Recommendations

Y = Recommended NE = Not Explored * = the three priority recommendations

| | ***Recommendation*** | **This Study** | **TERI 2001*** | **PDO 1999** | **UP 1998** | **Dalal 1997** | **CG&CRI 1993** | **CG&CRI 1992** |
|---|---|---|---|---|---|---|---|---|
| | *Infrastructure* | | | | | | | |
| 1 | Improvement in the condition of roads and telecommunication infrastructure | | | Y | Y | Y | Y | Y |
| | *Process/Technology Related* | | | | | | | |
| 2 | Use of modern manufacturing techniques | | | Y | Y | Y | Y | Y |
| 3 | Encourage potters to diversify into new value added products | NE | | Y | Y | Y | Y | Y |
| 4 | Encourage addition of new units with improved technology in high value added category | | | Y | Y | Y | Y | Y |
| 5 | Improved instrumentation in the kilns | Y | | | Y | | | |
| 6 | Improve saggars through superior production methods | Y | | | Y | | | |
| | *Raw Materials* | | | | | | | |
| 7 | Provision of raw materials testing facilities (raw materials testing laboratories) | Y | | Y | Y | Y | Y | Y |
| 8 | Extended role for CG&CRI in the testing of raw materials and training and development | Y | | Y | | | | |
| 9 | Specialised firms for procurement/purchase | | | | | | Y | |
| | *Process optimization and quality control* | | | | | | | |
| 10 | Use UPSIC facilities for training and demonstration | Y (not likely) | | | | | | |
| 11 | Specialised firms for crushing non-plastic materials | Y | | | | | Y | |
| 12 | Separate grinding of non-plastic raw materials to get the required fineness | NE | | | | | Y | |
| 13 | Use filter and de-airing pug mill in the raw material preparation processes | NE | | | | | Y | |
| 14 | Use of high quality dies in insulator making process | NE | | | | | Y | |
| | *Energy Supply* | | | | | | | |
| 15 | Availability of uninterrupted power supply to the units and upgradation of the power distribution system in Khurja | Not possible | | Y | Y | Y | Y | Y |
| 16 | Ensure regular supply of coal to the units | Not so | | Y | Y | Y | Y | Y |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | important | | | | | | |
| 17 | Supply of natural gas to the cluster | Y | | Y | Y | Y | Y | Y |
| | *Energy Efficiency in Existing Kilns* | | | | | | | |
| 18 | Optimum loading of kilns | Y | | | | Y | | |
| 19 | Optimization of firing and regulate the firing schedule | Y | | | | | Y | |
| 20 | Waste heat minimization in the kilns by improving insulation | Y | | | | Y | Y | |
| 21 | Regular repair and maintenance of the kilns | Y | | | | | Y | |
| | *Waste heat and waste material utilization* | | | | | | | |
| 22 | Utilize the waste heat for drying of greens | Y | | | | | Y | |
| 23 | Recycle waste fired material in the process or for manufacture of porcelain balls for captive consumption | | | | | | Y | |
| | *Energy Efficiency – Downdraft Kilns* | Not important | | | | | | |
| 24 | Providing layer of insulation bricks on the floor of the downdraft kiln | NE | | | | Y | | |
| 25 | Reducing radiation loss through the crown by a layer of insulation bricks | NE | | | | Y | | |
| 26 | Reduction of heat loss in down draft kilns through better insulation | NE | | | | | | Y |
| 27 | Use of proper instrumentation to control the firing in the kilns and use of simple mechanization in the kilns | NE | | | | | | Y |
| 28 | Improvement in the operating practices and the firing method in the kilns | NE | | | | | | Y |
| 29 | Regular maintenance and cleaning of the kilns | NE | | | | | | Y |
| 30 | Improvements in the design and construction of the kilns | NE | | | | | | Y |
| | *Energy Efficiency – Tunnel & Shuttle Kilns* | | | | | | | |
| 31 | Ceramic fibre veneering of intermittent kilns | | | | | | | |
| 32 | Use of deckers plates (instead of saggars – tunnel) | Y | Y | | | | | |
| 33 | Kiln weight car reduction | Y | Y | | | Y | | |
| 34 | Improved burner system | Maybe | Y | | | | | |
| | *Machinery Modernisation / Upgradation* | | | | | | | |
| 35 | Replacement of downdraft kilns by shuttle/tunnel kilns | Y | | | | Y | | |
| 36 | Common facilities for testing | Y | | | | | | |
| 37 | Common facilities for firing | Y | | | | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 38 | Provide concessional finance/subsidy to the entrepreneurs for technology upgradation/modernization | | | Y | Y | Y | Y | Y |
| 39 | Incentives for adoption of new machines in place of traditional machines | | | Y | | | | |
| | *Government Interventions* | | | | | | | |
| 40 | Provision of subsidy/incentive scheme and suitable financial support for the upgradation of the cluster | | | | | | Y | |
| 41 | Constitution of “Implementation Cell” at PDO, Khurja | | | | | | Y | |
| | *Exports* | NE | | | | | | |
| 42 | Establish an export promotion council (under the department of foreign trade) at Khurja | | | Y | | | | |
| 43 | Provide export related infrastructure (such as inland container depot, foreign exchange counters at banks etc) | | | Y | Y | Y | Y | Y |
| | *Human Development Resource* | | | | | | | |
| 44 | Provision of technical assistance to the entrepreneurs | Y | | Y | Y | Y | Y | Y |
| 45 | Extended role for CG&CRI in training and development | Y | | Y | | | | |

Y = Recommended NE = Not Explored * = the three priority recommendations

A major study of the ceramics industry in India was carried out by the Department of Scientific and Industrial Research, Ministry of Science and Technology (India) (this work was done also by Dalal Consultants); it was completed in 1991. The tables below summarise a few findings relevant to energy use and efficiency in Khurja.

Table 3.2: Findings by type

| **Parameters** | **Type of Kiln** | |
|---|---|---|
| | **DD Kiln Coal Fired** | **Shuttle Kiln** |
| Quantity per charge (MT) | 13 | 4 |
| Cycle time (hrs) | | |
| Loading and unloading | 18 | Negligible |
| Preheating | 48 | 18 |
| Soaking | 2 | 2 |
| Cooling | 40 | 18 |
| Total | 90 | 38 |
| Furnace Efficiency | 3-5% | 25%-35% |
| Specific Fuel Consumption (kcal/kg) | 6000 | 3150-3200 |

Source: *Technology Evaluation in Ceramics Industry*, p.419

Table 3.3: Summary of Energy Conservation Opportunities In Khurja Pottery Cluster

| **Measures** | **Energy savings (in that area)** |
|---|---|
| **SHORT AND MEDIUM TERM MEASURES** | |
| Ceramic fibre veneering of intermittent kilns | 4% |
| Kiln car weight reduction | 1% |
| Optimum loading of kilns | 15% |
| Excess air control | Varies with plant |
| Waste heat recovery | |
| i) for preheating combustion air | 5% |
| ii) reutilisation (in dryer) | Varies with plant |
| Load factor and power factor improvement | Varies with plant |
| Replacement of V-belt with flat belt | 5% |
| Replacement of oversized motors | Varies with plant |
| Reduction in compressed air working pressure & losses | 9% |
| **LONG TERM MEASURES** | |
| Redesign or replacement of kiln | 20-30% |
| Modernisation of kiln technology | 20-40% |
| Reduction in rejection level | Varies with plant |

Source: Technology Evaluation in Ceramics Industry p.178, 1991.

***TERI & CG&CRI Study***

The Tata Energy Research Institute has completed the most recent and most comprehensive study entitled *(A) Diagnostic study for the development of pottery industry cluster at Khurja in Uttar Pradesh* in February 2001. The study was chiefly concerned with how to modernise the cluster. It assessed problem areas in production, identified measures to overcome the problems and formulated strategies for implementing the measures. Their examination looked at two main areas of the production process: firstly raw material selection, procurement and processing, and secondly firing and the performance of the three different types of kilns. A large number of problems were identified and recommendations made. However three were singled out as being the most promising recommendations, all of which pertain to improving the efficiency of firing in tunnel kilns.

The three major recommendations were:

- reduce the dead-weight of the trolley,
- use of decker plates instead of saggars, and
- improved burner systems.

The report also states that the currently discernible shift from coal-based downdraft kilns to shuttle and tunnel kilns is likely to continue such that within three to four years no downdraft kilns will remain.

| ***Table 3.4*** <br> ***TERI Recommendations*** | **Recommended in this report** |
|---|---|
| Information database related issues | |
| - training program at CGCRI and periodic visiting of different International Trade fairs for ceramic machinery to address lack of knowledge regarding raw materials and their functions; | Y |
| - gain information about cost effective products through different workshops/ seminars and national and international market surveys; | Y |
| - special training and development programs and short term marketing management courses should be provided to reduce the communication gap for technological upgradation and market demand; | |
| - collection of information on alternate non-conventional raw materials from different local mining offices; | |
| - deputation of qualified technical/supervisory staff to training programs about technological upgradation. | Y |
| Raw materials related issues | |
| - Substandard quality of raw materials | |
| o Upgradation of mining industries; | |
| o Test each lot/batch of raw materials; | Y |
| o Use of same type of blended raw material in production; | |
| o Blending of clay materials in large quantities should be carried out at the mine to improve the green strength before incorporating into the body mix; | |
| o Test moisture content of china clay and ball clay; | Y |

| | |
|---|---|
| o Testing of particle size and particle size distribution of ground non-plastic materials and clays for each batch at the plant | Y |
| Compounding of body mixes and related issues | |
| - with respect to compounding body mixes, there should be a regular supply of raw-materials of similar composition; | |
| - use best quality plastic ball clays to reduce green rejection; | |
| - use plastic mass of moderate plasticity and uniform pressure during fabrication of articles by jiggering to reduce warpage in green stage; | |
| - widening the firing range to accommodate the temperature differences at the top and bottom of the kiln at the same profile. | |
| Process technology and its control related issues | |
| - ensure correct proportion of materials, water and pebbles in the ballmill to improve grinding efficiency | |
| Pug Milling | |
| - use of appropriate pug mill to mix body uniformly | |
| - pug mill auger should be rectified to remove stress and strain in the side of the plastic mass; | |
| - use de-airing system in the pug mill; | |
| - control moisture content during filtration by using pressure gauge fitted with filter press | |
| Shaping of article by casting | |
| - control density of slip; | Y |
| - use electrolyte in slip; | |
| - use sodium carbonate solution as required for slip; | |
| - use clays containing minimum free calcium carbonates; | |
| - make slip with required amount of water and electrolyte; | |
| - remove moulds of high porosity; | Y |
| *Glaze preparation:* | |
| Problems encountered during glaze preparation can be removed by controlling the following: | |
| - alumina silica ratio; | |
| - ensuring glaze material is ground properly; | |
| - using materials and chemicals after proper testing of their chemical constituents has taken place; | |
| - fritted glaze has a lower energy consumption than raw glaze and thus can be used in the place of raw glaze, fritted glaze also minimizes defects like pinholes and improves surface finish; | |
| - adjust density of glaze slip by controlling the amount of water as well as the amount of electrolytes; | |
| - remove air bubbles from glaze slip by adjusting fluidity, amount of water and electrolytes. | |
| Tunnel Kilns | |
| - use decker plates instead of saggars; | Y |
| - use of auto on-off burners; | |
| - reduce dead-weight of trolley; | Y |
| - provision of alarm for limiting temperature conditions; | Y |
| - improvement of kiln insulation | |
| o high alumna coating in the firing zone | |
| o provide aluminium cladding at the back of the ceramic fibre module | |
| o improve the quality of insulation lining in the firing zone | |
| - sealing of firing zone from cooling and preheating zones; | |
| - provision of inlet filter for the blower; | Y |
| - use of baffle wall inside the firing zone; | |

| | |
|---|---|
| - maintain air flow through the kiln;<br>- optimize blower power;<br>- use LPG instead of diesel for fuel;<br>- address heat loss in flue gas. | Y<br>Y<br>Y<br>Y |
| Shuttle Kiln<br>- use recuperator or recuperative burner;<br>- regular maintenance of the insulation of the kiln. | <br><br>Y |

***Some Summary Remarks***

There are several noteworthy features of all the earlier studies, their comments on the nature of knowledge available to the firms, the problems identified, the main solutions and recommendations, and the nature of the changes that have occurred in the industry. All of which are relevant to any program of intervention and support that was to be developed in our project and they frame many of the recommendations that are made at the conclusion.

1. The most relevant from a larger policy perspective, is the common finding over 50 years, that the existing knowledge base of the firms was weak.

2. A large part of the reason for the existence and the growth of the entire cluster can be traced to the technical support of various kinds that was supplied to the firms and entrepreneurs. This also included subsidised energy supplies, financial support, infrastructure support and for marketing and common facilities.

3. The ground reality of the Khurja industry pottery cluster is a dynamic one. The gaps and problems that exist at one point in time will not be the same as those which exist at another point in time.

4. Knowledge in the cluster is also dynamic and improving. However, because few people in the sector have received formal training, it has not been possible for the cluster to integrate and adopt a scientific approach.

5. There are different types of studies and they are conducted for different purposes:
   (a) Broad sectoral studies which give an overview of the sector;
   (b) More focussed studies which include the firm level and provide a basis for action-oriented intervention;
   (c) Studies which document the impacts of interventions.

   Often studies of type (a) and mixed up with studies of type (b), whilst there are no studies of type (c).

6. Interventions have been discontinuous. Each project is commenced, conducted and then completed – including this one.

## KILNS

### *Coal-fired Downdraft Kilns*

The downdraft kilns used in Khurja are a typical example of coal-fired kilns of European design. The kiln makes use of natural draft and as such does not require any blowers or fans for its operation. The hot gasses from the fireboxes circulate to the top of the kiln chamber, and are then pulled down through the setting and leave through flue gas holes in the floor. These flue gas channels combine to one main gas flue path under the floor which is then connected to the chimney of the kiln.

Downdraft kilns are batch kilns with greenwares placed in saggars and then in the kiln for firing. A typical operation cycle from cool to cool takes approximately 5-7 days. The required temperature gradient over time and its uniformity cannot be maintained in the downdraft kiln which contributes to a high rejection rate of between 15-30%. There is little monitoring and control capability and the ware is tested by removing a sample from the kiln through a hole.

Downdraft kilns using coal have been used in the Khurja pottery cluster for over fifty years. During this time the technology has undergone no modification or improvement. And until early 1990s all production was carried out using these kilns and there are around 200 coal fired down draft kilns in Khurja. The advantages of this kiln are that its construction is well known to the local people and the cost of a unit is in the order of Rupees 500,000. While the newer oil fired kilns cost at least two times more and up to four times as much, depending on the size and quality of construction.

Their energy efficiency is extremely low at only between 3-6%. Pottery units using coal-based downdraft kilns can expect 33-35% and sometimes 40% of their production costs to be spent on energy. No new coal-based downdraft kilns are known to have been installed in Khurja in the past decade.

### *Shuttle Kilns*

Shuttle kilns are also batch kilns and are particularly suited to the firing of specialized items like bonechina and stoneware decorative items and crockery. This is because these products are light weight and require high biscuiting and low gloss. Combined with loading and unloading shuttle kilns have a total cycle time of 2-3 days, compared to 5-7 days for coal fired downdraft kilns. Firing and cooling cycles take approximately 12 hours each. Shuttle kilns have an energy efficiency of 25%; they are more energy efficient than coal-based downdraft kilns but not as efficient as tunnel kilns. Compared to tunnel kilns however, shuttle kilns require less space and a smaller capital investment.

The sample of shuttle kilns examined in Khurja, ranged in size from 4 to 20 cubic metres, and a firing of between 0.7 to 5 tons per day. This translates to an annual capacity, with around 120-150 firings per year, of 100 to 600 tonnes of product. The cost of the shuttle kilns naturally will depend on the size and the quality of materials and insulation, but in general in Khurja ranges from Rupees 700,000 to 1,200,000. So one obvious reason for choosing shuttle kilns over tunnel kilns is the lower capital cost. Another is that because its throughput is smaller than the tunnel kiln, those units who have a smaller out put can put this intermittent kiln to better use. Finally, the intermittent nature of the tunnel kiln allows it to be controlled more easily than the continuous tunnel kilns and so those who are making higher quality products and are not confident of the tunnel kiln find this a more convenient alternative.

Shuttle and tunnel kilns were first introduced into the Khurja pottery cluster in 1993 - 1994.

***Tunnel Kilns***

Tunnel kilns are steady state continuous kilns; on average about 22 to 23 trolleys travel through the kiln in 24 hours. Tunnel kilns have an energy efficiency of 30% and a the rejection rate of finished products is 2-3%. This translates into significant savings as compared to coal-based downdraft kilns. Although tunnel kilns do however do require a significant capital outlay and also more land space than either shuttle or downdraft kilns. In the late 1990s as employment of tunnel kilns became more widespread, TERI has found that production costs of Khurja units which have installed tunnel kilns have fallen by about 10-15% as compared to units using coal-based down draft kilns (TERI 2001). This in turn has resulted in a lowering in prices of finished products in the cluster (TERI 2001). The cost of tunnel kilns in Khurja range from Rupees 1,200,000 to 2,000,000.

***Gas Fired Kilns***

At this time there is only one gas fired tunnel kiln in Khurja and it is not working well.

The Khurja pottery cluster has been demanding access to natural gas from the nearby pipeline, which passes at a distance of 14km from Khurja near Shikarpur, for over a decade. They have been repeatedly denied access on the basis of the short supply with the Gas Authority of India (GAIL) and because Khurja does not lie within the prioritized "Taj-Trapezium" zone. The priority provided to the "Taj trapezium" is because the monument is deteriorating due to pollution caused by coal burning and other industrial gases which corrode the marble. Hence the area around it has been declared a special zone with stricter environmental emissions and pollution standards than are applicable in Khurja (see the section on environmental pollution in Khurja). In order to allow the manufacturing firms to shift to cleaner burning gas, these supplies have been made available to the Taj area.

The manufacturers in Khurja believe that they are being neglected as there is a gas pipeline passing close to Khurja but Khurja it self is not connected to the pipeline. There has been talk for many years that the pipeline may be extended to Khurja but the likelihood of that is unknown.

Recently however a private gas supplying company has approached the pottery manufacturers with the proposal of supplying piped gas to the units at a rate at which normal cooking gas cylinders are available. The supplier has however desired that they be provided with a small plot of land (80 meter by 80 meter) to enable installation of their gas capsules. The gas can be transported up to about 2 kms from these capsules.

About 85 units have expressed their desire to use the gas. The matter is being very actively pursued and the local district authorities are favourably considering this request for a piece of land. Gas can be a very efficient, cheaper and less polluting alternative to coal and diesel. The proposed rate of gas quoted is Rs 14/kg while the current price of diesel is Rs 15/liter. The pottery manufacturers believe that the gas will be about 25 to 30 percent cheaper than diesel . They estimate that 1 litre of diesel is equal to 1.4 Cum of gas.

The manufacturers believe that gas firing will not only reduce their cost and make their product more competitive. Many firms believe that gas firing will also enable them to manufacture porcelain tableware, for which they believe there is a greater market and is still not manufactured on any large scale in India, as the gas enables more control over the temperature.

In fact, the greater control of temperatures can be achieved in the oil fired kilns being used in Khurja with the instruments and the temperature control equipment discussed and recommended in section four. But our view is that to fire porcelain correctly greater control of the atmosphere is also required and this should be a slightly reducing atmosphere. If the reducing atmosphere is attained using oil, it will create a “dirty” atmosphere in the kiln resulting in poor quality of products. So it is true that to move to porcelain tableware Khurja will need to be supplied with gas.

A switch to gas does not require major modifications to the current kilns. It will require a change in burners. Given the higher calorific value of gas per unit cost it should result in lowering the energy cost of the units that make the switch. It will also further reduce the emissions from the kilns. These benefits combined with the possibility of making a higher value product, should make this a priority for the industry, and policy makers.

**ENERGY CONSUMPTION MEASUREMENTS (OF KILNS)**

Table 3.5: Coal Down Draft Kilns

| Firm No. | Size (dia) ft | Consump / Cycle (Ton) | Output / Firing (Ton) | Average coal (ton)/ton output | Kcal / kg |
|---|---|---|---|---|---|
| 14b) | 17 | 10 | 8 | 1.25 | 7,500 |
| 6 | 9 | 10 | 7 | 1.43 | 8,580 |
| 14a) | 24 | 18 | 12 | 1.50 | 9,000 |
| 3 | 22 | 14 | 9 | 1.56 | 9,360 |
| 9b) | 24 | 18 | 10 | 1.80 | 10,800 |
| 10 | 20 | 16 | 8 | 2.00 | 12,000 |
| 9a) | 24 | 18 | 8 | 2.25 | 13,500 |
| 11 | - | 7 | 3 | 2.33 | 13,980 |
| 18 | 14 | 17 | 5 | 3.40 | 20,400 |
| ***Average*** | ***17*** | ***14*** | ***8*** | ***1.83*** | ***10,980*** |
| ***Other Studies*** | | | | | |
| TERI Study | 17 | - | - | - | 6,262 |
| Mr Gupta IDS | | 24 | 28 | 0.86 | 4,800 |
| TEICI | 18 | 16 | 8 | 2.00 | 9,000 |
| TEICI | 21 | 18 | 12 | 1.50 | 6,750 |
| TEICI | 18 | 12 | 4.5 | 2.67 | 11,700 |

TERI = TERI Diagnostic study for the development of pottery industry cluster at Khurja in Uttar Pradesh. p.97.
TEICI = *Technology Evaluation in Ceramics Industry*, A Report Prepared Under Technology Absorption and Adaptation Scheme, Government of India, Department of Scientific and Industrial Research, Ministry of Science and Technology, 1991, pp.140-1.
Assumption: 1kg coal = 5,500 kcal

Table 3.6: Shuttle Kilns

| Firm Reference | Size $m^3$ | Consump/ Cycle (Litres) | Output/Cycle (Tonnes) | Litres/tonne output | Kcal/kg |
|---|---|---|---|---|---|
| 1 a) | 18.4 | 750 | 5.0 | 150 | 1,500 |
| 1 b) | 18.4 | 750 | 5.0 | 150 | 1,500 |
| 16 | 12.2 | 700 | 4.0 | 175 | 1,750 |
| 24 | - | 1,120 | 5.0 | 224 | 2,240 |
| 25 | - | 1,280 | 4.5 | 284 | 2,840 |
| 2 | 6.1 | 225 | 1.5 | 333 | 3,330 |
| 7 | 5.5 | 700 | 2.0 | 350 | 3,500 |
| 12 a) | 8.0 | 1,000 | 2.5 | 400 | 4,000 |
| 18 | 9.0 | 900 | 2.0 | 450 | 4,500 |
| 23 | - | 750 | 1.6 | 469 | 4,690 |
| 12 b) | 3.5 | 400 | 1.5 | 500 | 5,000 |
| 5 | 4.5 | 700 | 0.7 | 1000 | 10,000 |
| ***Average*** | ***8.9*** | ***773*** | ***2.9*** | ***374*** | ***3,738*** |
| **Other Studies** | | | | | |
| TERI Study | - | - | - | - | 4,822 |
| TEICI | 15.44 | 700-1000 | 1.5 | 467-667 | 4,900-7,000 |

TERI p.97; TEICI pp.136-7.    Assumption: 1litre fuel = 10,000kcal

Table 3.7: Tunnel Kilns

| Firm Reference | Fuel Consum. Litres per Day | Output/Day (Tonnes) | Fuel/ton output litres | kcal/kg |
|---|---|---|---|---|
| 5 | 460 | 4.0 | 115 | 1,150 |
| 5a) | 460 | 3.3 | 139 | 1,390 |
| 22 | 600 | 3.4 | 176 | 1,760 |
| 21 | 660 | 3.5 | 189 | 1,890 |
| 19 | 600 | 3.0 | 200 | 2,000 |
| 1 | 720 | 3.5 | 206 | 2,060 |
| 20 | 560 | 2.4 | 230 | 2,300 |
| 13 | 600 | 2.5 | 240 | 2,400 |
| 10 | 500 | 2.0 | 250 | 2,500 |
| 1 | 720 | 2.5 | 288 | 2,880 |
| 1a) | 600 | 2.0 | 300 | 3,000 |
| ***Average*** | ***589*** | ***2.9*** | ***212*** | ***2,121*** |
| ***Other Studies*** | | | | |
| TERI | - | - | - | 1620 |
| TEICI | 600 | 1.5 | 400 | 4200 |
| Mr Gupta IDS | 600 | 5.0 | 120 | 1200 |

TERI p.97; TEICI pp.140-1.    Assumption: 1litre fuel = 10,000kcal

### *A Summary of Kilns' Energy and Cost Features*

To summarise the above information we find that the different kilns have the following energy and cost features:

Table 3.8

| Kiln | Cost (INR) | Cost ($) | Output per year tonnes | Energy Use Kcal/kg |
|---|---|---|---|---|
| Coal DD | 500,000<br>750,000 | 12,500<br>19,000 | 200<br>500 | 7,000-12,000 |
| Shuttle Oil Local | 700,000<br>1,200,000 | 18,000<br>30,000 | 100<br>600 | 3,000-5,000 |
| Tunnel Oil Local | 1,200,000<br>2,000,000 | 30,000<br>50,000 | 500<br>1200 | 1,400-2,500 |
| Shuttle (Imported[1]) | 4,200,000 | 105,000 | 300 | Low 660<br>Average 2040<br>High 3300 |
| Tunnel (Imported[1]) | 19,200,000 | 480,000 | 900 | |

1 The numbers provided above for UK are for one specific kiln of that size, while the SEC numbers provided for UK are for the sanitary ware sector as a whole. It should be noted that these ranges do not *only* represent the kiln efficiency. Larger kilns, heavier pieces, inherently provide higher output to energy use than smaller kilns loaded with small and lighter pieces. Second, more complex pieces and higher quality products need more heat work to be performed and so will show a lower output to energy than simpler pieces and those of lower quality.

We may also add that in comparison to the kilns in Khurja, the measurements taken of two large scale units in India, with daily production of 20 to 35 tonnes shows that the kcal/kg is around 1,000. This compares more favourably with the SEC figures of UK and is not totally surprising as these kilns are imported from abroad.

In terms of orders of magnitude we see from the above table that if we compare the most efficient figures for the different kilns, and rate the SEC of the best kiln from UK at 100, the best tunnel kiln at Khurja has a SEC of around 200, the best shuttle kiln has a figure of 400, and the best DD coal kiln is at 1000! It is also obvious that the imported kiln from UK is too expensive to justify the capital expenditure on energy savings alone. Thus while the move to the local shuttle and tunnel kilns are cost effective, the next step lies in improving their performance, and not importing the latest kiln from abroad.

## DYNAMICS OF INNOVATION AND CHANGE

It is difficult to be precise on some of the economic situation faced by the units currently without a more detailed market study and also a more detailed micro, firm level study of the costs incurred by the firms. It is even more difficult to be numerically precise about the historical evolution of the units and how and why they changed.

In interviews with the firms, there was general concurrence that the cluster faced many difficulties in the late 1980s and the early 1990s. The interviewees suggested that many firms either stopped production or had to reduce their production because of insufficient supply of coal and its poor quality; the lack of government support and the decline in the common facilities provided earlier; and, increased competition from manufacturers from other regions.

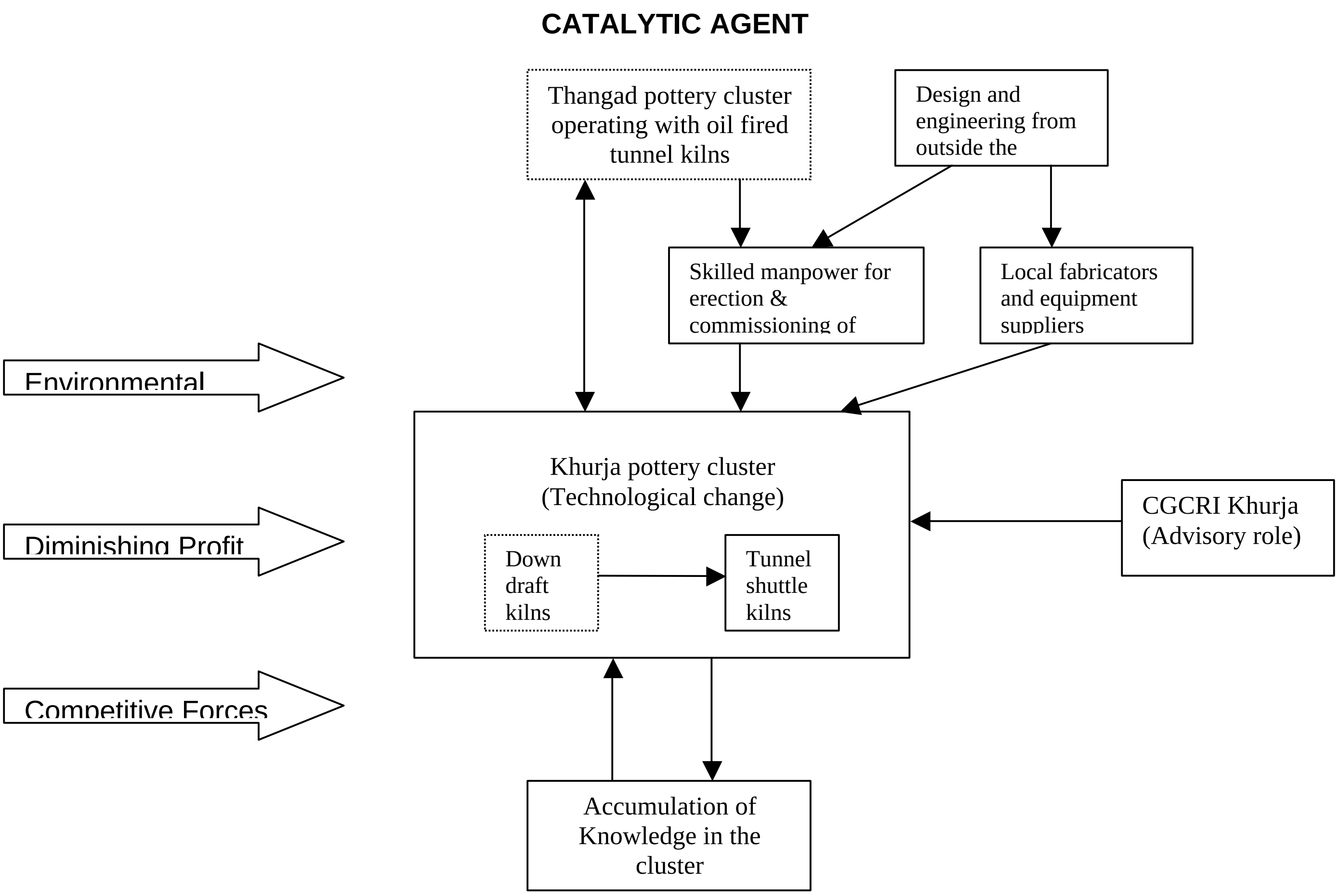
In one version, one group of entrepreneurs from Khurja took the initiative to visit the Thangad pottery cluster (near Ahmedabad, Gujarat), which had been operating tunnel kilns for about ten years earlier and which has a reputation for greater efficiency and productivity. In the other version, this visit did take place but was organised by one of the support agencies of the government to allow the owners from Khurja to learn from Thangad.

In fact, immediately after this visit, several owners, who we found tend to be the more productive and successful firms in the cluster, decided to invest in shuttle and tunnel kilns.

The adoption of shuttle and tunnel kilns was motivated by competitive pressure from other pottery clusters in India and also fears of globalization. In the 1990s the Khurja pottery cluster was finding it increasingly difficult to match its (domestic) competitors in price and quality.

The original design for the tunnel kilns in Thangad had came from the UK. After the first UK-designed tunnel kiln had been commissioned, technicians in Thangad began constructing the kilns locally. The first tunnel kiln was subsequently built in Khurja in

1992. However, few pottery units followed this example until the late 1990s. In 1997 two pottery units were issued with notifications to close their operations by the UP SPCB. This motivated Khurja entrepreneurs to hire technicians from Thangad to construct tunnel kilns in Khurja. Adoption of tunnel kilns has been rapid since this time.




Dynamics of technological change in Khurja cluster, adapted from TERI 2001

***One Case of a Unit Converting from a Coal-fired Kiln to a Tunnel Kiln***

Case of Unit AA:

During the course of the research one member firm of the KPMA changed over from a coal fired down draft kiln to diesel fired tunnel kiln. During the course of our first field survey conducted during the first quarter of 2000, this unit was still running on downdraft coal fired kiln. By the end of the project, in March 2001, the firm had successfully installed and was operating the new diesel fired kiln. As a KPMA member firm, and one building a new tunnel kiln, the firm that was keen to utilize any technological improvements that could be suggested by the research team. The team was able to view the progress of this construction and had detailed discussions with the Kiln “mistry” or builder and also the manager and owner of the firm.

As a result of the change, the company’s capacity and actual production has increased from an average of 2 tonnes per day for around 200 firings earlier to almost 5 tonnes per day for over 300 working days now (or from 400t/year to 1000t/year). The products manufactured by the company are LT & HT insulators. The company has been able to increase their production capacity by almost 2.5 times with little additional capital investment beyond that required for the kiln. The cost of the kiln is around Rupees 1,600,000 (or $40,000). The company did not need any additional investments in other equipment or in other sections, such as ball mills, body preparation, glazing and the like. The increased turn over of the firm is now around Rupees 1,300,000 from the earlier estimated value of around Rupees 500,000.

Discussions with the owners suggest that the labour inputs have increased by over 40 per cent for the increase in production of 250%. Originally there were approximately 14,000 person days of labour used and now it is approximately 20,500 workdays. This suggests an increase in outputs to labour by almost 100% and the incremental labour to capital ratio of 1 person year per investment of 80,000 rupees.

It should be noted that beyond the increased investment for the kiln there is also a need for higher working capital with the higher production. If we assume that working capital requirements are approximately two months of the value of sales, then before the change the firm would need a working capital investment of around Rupees 85,000 and after the change it will need to invest Rupees 215,000, an increase of Rupees 130,000.

In terms of energy and pollution, the following gains are observed:

Before the change two DD Coal fired kilns, consumption of coal 28 tonnes for an output of 20 tonnes. 400 tonnes of output required 560 tonnes of coal. At 5,500 kcal/kg, the earlier production required 3,080,000,000 kcal.

After the changeover, the same output of 400t required only (400/5)X620X10,000 = 496,000,000 kcal. The energy use after the change is 16% of the original amount for the same production.

Even if we take into account the larger production of 2.5 times the earlier amount, the energy use is still 40% of the earlier amount.

We have already remarked that the major difference in pollution between the coal fired and the diesel units is in the amount of particulates emitted to the air. In the coal fired kilns the range of flue gas flow rate is 9,000 to 15,000 M3/hour (or 4,000 to 11,000 Nm3/hour) . The particulates in the flue gas range from 1,200 to 9,500 mg/N m3 . (Ceramic Industry, Central Pollution Control Board, 1995, page 69). Or the 22 t output per batch in the DD kilns generated (taking a middle number of 5,000 Nm3/hourX5,000 mg/N m3 = 25,000,000 mg per hour. This for a cycle of say 30 hours amounts to 750,000,000 mg or 750 kg. In 20 firings per year this would amount to 15,000 kg.

In contrast the dust load generated in a tunnel kiln was found (Ibid, page 72) to be in the range of 0.036 kg per hour to 0.8 kg/hour. For the same out put the tunnel kiln needs 80 days of 24 hours, or 1920 hours. Therefore the particulate emissions will range from a low of 69.12kg to a maximum of 1536kg. Thus even if this tunnel is in the worst emissions range it will produce 10.24% of the particulates as DD kiln.

Technical knowledge of the Kiln was found to be poor with the kiln builder and with the owner. As the kiln was being built, two small changes were immediately possible. This was to reshape the combustion chamber and also to add an exhaust fan to improve the pull of the hot gases over the incoming material.

Without additional time required to undertake further work on air flows, pressure balance and temperature profile, not much more could be done. But the enthusiasm of the owner and the kiln builder to learn from the outside experts suggests that there is considerable scope for obtaining the ongoing co-operation of the firms and the association for further work.

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