OCCASION

This publication has been made available to the public on the occasion of the 50th anniversary of the United Nations Industrial Development Organisation.

DISCLAIMER

FAIR USE POLICY

CONTACT

Please contact publications@unido.org for further information concerning UNIDO publications.

For more information about UNIDO, please visit us at www.unido.org

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

Distr.
LIMITED
ID/WG. 282/105
18 October 1978
ENGLISH

08932

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

INTERNATIONAL FORUM ON APPROPRIATE INDUSTRIAL TECHNOLOGY

New Delhi/Anand, India 20–30 November 1978

WORKING GROUP No. 5

APPROPRIATE TECHNOLOGY FOR THE PRODUCTION OF CEMENT AND BUILDING MATERIALS

APPROPRIATE TECHNOLOGY FOR BRICKS AND CERAMICS: AIMS AND APPROACHES ,

Background Paper

id. 78-7293

APPROPRIATE TECHNOLOGY FOR BRICKS AND CERAMICS: AIMS AND APPROACHES

by

I. Knizek
UNIDO consultant

The description and classification of countries and territories in this document and the arrangement of the material do not imply the expression of any opinion whatsoever on the part of the secretariat of UNIDO concerning the legal status of any country, territory, city or area, or of its authorities, or concerning the delimitation of its frontiers or boundaries, or regarding its economic system or degree of development.

The views and opinions expressed in this document are those of the author(s) and do not necessarily reflect the views of the secretariat of UNIDO.

Mention of firm names and commercial products does not imply the endorsement of the secretariat of UNIDO.

The document is reproduced in the form in which it was received and it has not been formally edited.

Appropriate Technology for Bricks and Ceramics: Aims and Approaches

Abstract

The author endeavours to illustrate some of the approaches to choosing appropriate technology by two examples taken from the manufacture of ceramics and fired clay bricks respectively. He points out that the gradual process of mechanization of the dinnerware making process that has taken place in developed countries is characterized by diminution of the need for the so-called direct skills, that is such as are directly necessary to make the product. He also demonstrates that while direct skills are being eliminated the need for certain "higher" skills increases considerably. Another characteristic of the process is that with increasing sophistication of the making equipment the productivity increases approximately in a linear fashion whereas investment costs increase exponentially. He concludes that technology at least in the industry under discussion should be chosen utilizing criteria based on availability of skills or on the need for their development or promotion. In the second part of his presentation dealing with brickmaking the author discusses some of the criteria to be used in the choice of appropriate technology in this field. They are respectively : the characteristics of the market and the availability of certain type of labour. He advises caution as regards adoption of full mechanization and advocates selective and frequently piecemeal mechanization of such operations which while being excessively labour-intensive do not contribute to the quality of the finished products. He discusses specific needs of developing countries as regards brick-making equipment and singles out three area for special attention, suggesting that developing countries should pool available resources and develop and manufacture their own equipment, because their needs differ fundamentally from those of the developed countries.

We all know - or should know what appropriate technology is and I shall therefore abstain from commenting on it. Undoubtedly better prepared speakers will discuss it. Instead I propose to illustrate the approach to it by means of two examples taken from ceramic technology. I shall first present the case taken from the manufacture of dinnerware.

Ceramic Dinnerware Technology

You may want to interrupt me at this point and protest that in selecting an example from this industry I am straying too far from the agreed theme of the conference. That may be so. Allow me to point out, however, that the ultimate beneficiary of the Construction and Building Material Industry is man. The most important task of this industry must then be the satisfaction of one of the basic needs of man, the shelter. But shelter can not remain to be something to protect man from the inclemencies of weather. It must become housing, that is something that keeps the family together. However even this must be transcended - housing must become a household. To be thus affected all kinds of things are necessary. Sanitary fixtures, sheet glass for the windows, tiles for the floor, and dishes and cups to eat and to drink from. Dinnerware, therefore, becomes an integral part of a household. And therefore indirectly one of the goals of our endeavour. Furthermore, the functioning of a household depends on income and the Industry of Ceramic Utensils for domestic use with its procrustean flexibility as regards labour contributes toward improving living condition by providing income for many. We realize perhaps now that the inclusion of one aspect of ceramic dinnerware technology is legitimate.

Flatware Making

To convey my point I have concentrated on a single process; the actual forming operation. However, I beg you to keep in mind that there are other aspects of the manufacture of dinnerware which all together deserve then to be called Technology. For the sake of brevity and simplicity I shall omit body preparation and the firing process because I feel that the "making" process lends itself better for our purpose due to its labour intensive character. Body preparation never had that character and as regards firing only two of its ancillary operations those of setting and drawing are labour intensive. But due to their particular nature these two ancillary operation have been so far little affected by the perenial trend to labour-saving and therefore do not lend themselves for the kind of analysis I have in mind.

Now since I will deal only with the making process it does not matter whether the final product will be white or coloured, whether it will be earthenware, vitreous china, bone china or hard porcelain. I shall also confine myself to the manufacture of flatware, that is dishes, which normally account for at least 60 per cent of a manufacturer's output. I could easily have chosen cups. Perhaps even to some advantage because cups normally represent the second largest item and as compared with flatware its labour component is larger.

Tools and Equipments

The simplest device for manufacturing dishes is of course the potter's wheel. Historically-minded people may argue that dishes can also be manufactured without the wheel. True. I have seen teenagers turn out quite handsome dishes by just turning around a clod of clay on the ground. But allow me to be a bit casuistic on this point. In this case the wheel has not been eliminated. The clod itself became the wheel. However, the truly pre-industrial dishmaking tool is the wheel.

An incipient division of labour is frequently introduced already at this stage as there could be a helper to preform blanks and to finish the plates. Furthermore there will almost always be someone else to prepare the clay.

Degrees of Skill

Please observe in this context that the degree of skill here required is very high and that outputs may be considerable. I have observed a roadside potter near Varanasi turning out handsome and quite thin saucers at speed that should be the envy of many industrial operator equipped with a hand jigger. As far as skill is concerned, we have, in fact to do with three degrees of skill. The least skill is required by the one who kneads the clay. Considerable more skill is needed for pre-forming of blanks whereas the actual throwing will demand skill of the highest order. Anyone who has ever tried to become a thrower will know how much time it takes to master the wheel at all and how much more training is needed to attain commercial speeds.

You will have observed that I have dwelled on our first example rather long. This was because I wanted to drive home the concept of degrees of skill. It will stay with us in good stead later on.

With the introduction of lever-operated jigger equipped with a template we enter the industrial stage proper. Here the division of labour will be carried one step further. To begin with this will now be almost invariably a two-man operation; while one pre-forms the bat the second jiggers out the finished dish. The degree of skill required by a good jigger, while still considerable, will be a great deal lower than that which a hand thrower needed, but it still takes many months of training.

Machines as Skill Eliminating Devices

Following common usage we would be inclined to call this double spindle jigger a labour saving device. In one sense it is because through the use of it the labour component of the operation is reduced. Much more, however it is a skill reducing device. Observe, however that the reduction of skill was in this case not so dramatic as it may appear. Some skill requirements have been simply shifted. And it is so because the jiggerer forms the dish over a plaster mold and normally uses each day a number of molds equal to the number of dishes turned out. And it takes a high degree of skill to produce first the model of the dish, then the case mold, that is the mold to make further molds and finally the working mold. And the skill of the model maker will be of a higher order than that of the hand thrower because of the high degree of precision required here. And of course you also need skill to sharpen and profile the template.

The following stage is reached with the introduction of semi-automatic machines operating with a steel roller. These machines are generally combined with a dryer and an edge finishing machine. Here the degree of required skills has been further reduced. There will be one person to feed the plaster mold into the machine, to remove it again and to place it into the dryer. Since the dryer is continuous there is another person at its other end who removes the partially dry dishes from the dryer and feeds them into the edge-finishing machine. These people require no special skill. Again, however, higher skills will be required elsewhere - behind the stage. You need a very good machanic to service and maintain the roller machine and the dryer. And whereas any handy blacksmith is usually able to sharpen a jiggering template a good operator is required to turn the roller on a lath.

In the operation of an entirely automatic flatware machine manual handling is dispensed with entirely and from the beginning to the end the dishes are not touched by human hands. There is now only a highly qualified mechanic watching the machine's operation who is perfectly able to oversee two such machines at the same time. In the background, however, you will have an engineer trained in electronics. And after each shift a maintenance crew will spring into action and service the equipment with all the care a 747 receives before a transatlantic flight.

Investments against Productivity

To get the whole panorama into proper perspective let's consider now investment costs. You could probably get a kick wheel type of potter's wheel for less than 200 dollars. A heavy duty power driven wheel may cost you over 1000 dollars and a double spindle jigger 4000. But a free standing roller machine with its margle dryer and edge-finishing machine will cost you 70.000 dollars and a fully automatic flatware plant 400.000 dollars.

Observe now that the gradual elimination of what I shall now call direct skills is accompanied by a tremendous increase in investment. At the same time, however, the rise in productivity is much less spectacular. Two people operating a hand jigger will turn out about 1400 dishes in eight hours. The free standing roller machine about 4800 and the fully automatic machine close to 10.000. It seems that with an increase in sophistication of the equipment the output increases linearly the investment does so exponentially. The ultimate will probably be reached as soon as the first generation of dust-pressing equipments become operational. Their operation requires no more skill than a pill press.

How to Choose Appropriate Technology

How then do we choose our appropriate technology? The question must be answered on the basis of three factors: the availability of labour over the whole qualification range, capital resources and finally and more importantly what skill we wish to develop or to promote. I wish to stress at this time that I don't intend to give advices nor am I offering solutions. I am only suggesting that considerations based on skills either to be developed, promoted or made use of be given preference over such based on cost-wise feasibility considered in isolation. I would also like to suggest that countries with a large pool of unskilled labour may well want to consider the convenience of developing those direct skills I was talking about rather than converting people into robots feeding molds into a machine or off-bearing the finished dishes at the other end of the line.

Development of Higher Skills

Hand jiggering, even within its mass production function still gives the worker a sense of association with the work being performed and the material handled.

And I would also like to suggest that these skills, this sense of association with the work performed and the feeling for its materials are valuable and may well be worth developing and cultivating. They are among the essential prerequisite for a healthy industrial development.

On another stage of development it might become more important to develop and promote what I have called for lack of a better word "higher skills", such as required for supervisory job, for servicing and maintaining the ever more complex equipment. In fact we have already reached the point where engineers are needed in the day by day operation of our modern equipment.

Appropriate Technology in Brickmaking

When it comes to the manufacture of bricks we find ourselves in an altogether different situation. It has been frequently maintained that hand moulding is only appropriate for small scale operations involving no more than say 5.000 bricks per day. This is not the case and experience in many developing countries shows that the output of brickyards based on manual work can be extended almost indefinitely. My own experience with the Capital City Project of the State of Gujerat indicates that given sufficient labour resources, good bricks can be produced in very large quantities by means of proper organization and supervision and that it is even possible to avoid one of the pitfalls of hand-moulding, that is, gradual deterioration of quality caused above all by sloppy moulding.

Manual vs. Mechanized Brickmaking

It seems, therefore that the choice between manual and mechanized brickmaking does not depend so much on the scale of the operation, that is the size of the available market, but rather on the ready availability of a sufficiently large labour force. In Mexico City, for instance, which is a metropolis of close to 10,000.000 people no mechanized brickwork has been ever able to hold its own against the competition of hand-made bricks manufactured in extremely large quantitites at competitive prices. In fact a survey completed a few years ago, revealed at the basis of prevailing market prices (roughly US$ 20 per thousand) even the distributors realized profits of close to 20 per cent.

The feasibility of manual brickmaking is also dependent on the characteristic of the market, that is the use to which bricks are put. In most cases handmade bricks are not particularly suitable for load-bearing walls. Since the average crushing strength exceeds 50 kg per sq. cm only exceptionally, such bricks are well enough suited for curtain walls that is such in which bricks serve only for filling up the spaces between the elements of structural steel or concrete framework. Most high rise buildings are of this type. Furthermore in seismic regions even one- or two-storied structures will be built with some kind of a concrete skeleton thus making the use of high-strength bricks unnecessary. Generally speaking hollow or perforated bricks can not be made by hand-moulding, even though isolated efforts have been made and simple equipments developed. The operating speed was always too low to make them a feasible operation.

Cost of Mechanized Brickworks

The establishment of new mechanized brickworks must always be approached with a great deal of caution. More so in our days. World-wide inflation has brought with it such an increase in the cost of brickmaking equipment to the extent of making it prohibitive in many cases, not only because of the capital investment involved but also due to the resulting high amortization charges which in many cases makes the products too expensive.

(Costs of mechanized brickworks of varying capacities will be given during the presentation).

Selective and Piecemeal Mechanization

Nevertheless we should strive for some mechanization, but it should be selective and probably partial. When I said selective mechanization what I actually meant was that mechanization should be confined to those operation which while being labour-intensive do not add to the quality of the products. The areas to which this might apply may vary. Where hard obdurated clays are worked preparing the clay for moulding might be quite a job. In such cases a set of rolls and/or a kneading tub may be just what is needed to improve the quality and output. Most frequently, however, it's the moulding operation itself that needs mechanization. Experience shows that when this operation is not closely supervised and minimum workmanship standards strictly enforced quality of the product sadly deteriorates.

Once more I want to draw on my experience with the Capital City Project in the State of Gujerat. I have been able to observe there that the Project's own brickmaking operation, which was always closely watched, invariably produced better bricks than the various private brickyards in the neighbourhood.

The third area where a degree of incipient mechanization may be required is that of loading and unloading kilns. When the brickmaking activity as a whole is analysed, one usually discovers that the above operations not only consume a disproportionate amount of labour but that they frequently undo the work of the preceding operations by damaging the moulded bricks.

One of the main faults here is that hand-made bricks are somewhat difficult to stack. Unless moulded from a rather stiff clay by the "throw-in-and-cut-off" method they usually slump after discharge from the mould which makes them resemble a low, flat truncated pyramid. This of course makes the stack potentially unstable.

By far the largest damage to handmade bricks is caused by too much handling to which they are subjected. After having partially dried they are usually stacked to some height for further drying. Then they are loaded on one or other kind of pushcarts and carried to the kiln. All this is usually done quite unceremoniously and with the least of care because most of the time the least skilled and therefore least paid labour is employed for this task. More or less the same happens at the time of unloading and during transport to the yard or on trucks.

What Do We Need ?

Unfortunately brickmaking equipment manufacturing industries in developed countries have been in the past rather unresponsive to the needs of developing countries for gradual and/or selective mechanization. The advances of the above industry has always been directed towards increased sophistication and size of the equipment and towards ever more complete automation. Nevertheless, developing countries offer a potential market of great size to the equipment manufacturer. Up to now and with very few exceptions the need for piecemeal and selective mechanization has been satisfied by making use of individual pieces of vintage equipment that has been discarded by brickmakers in developed countries a generation or two ago.

Development of Appropriate Equipment - How Do We Go About It ?

This does not need to be so any longer. And the point I am trying to make is that developing countries know better what their needs are and should design and manufacture their own brickmaking equipment. But no country can do it alone. There are, however, among developing countries many that possess engineering facilities sufficiently advanced to tackle such a job. I would like to single out for special attention the three areas in which progress in the above sense is required.

In the area of clay preparation we need simple rolls. They should not be of great size, perhaps not exceeding 40 cm in diameter. They should have cast and not cut gears and should be so designed as to permit easy installation and/or superposing over simple substructures or pugs.

We need a simple, so to say stripped down version of an extrusion machine. This should be a sturdily built affair of simple design, without de-airing. The pugging chamber should be longer than in most commercial extruders. All parts should be simple so as to be easily manufactured by casting or forging. The auger diameter need not exceed 25 cm. In fact even 15 and 20 cm augers might be needed. Such small-size extruders are particularly suitable for end-cut bricks (which

are better for unrendered constructions) and for split-tiles. They also consume less energy.

The design of such extrusion machines should not be a too difficult task. After all auger extrusion has been with us for a long time and principles of good extruder design are well known. I have made a similar proposal during and after my 1967 mission in India. Unfortunately, it did not progress then and was finally dropped. Since that time the need for such and similar equipment in developing countries did not diminish but has increased and I want to take advantage of this opportunity to renew it in a more ample form and appeal to all concerned and interested to give it the attention it deserves.

Furthermore we need - and need badly - a manual loading and unloading equipment for bricks. Ideally it will consist of compressing fingers at the bottom and a lifting device. It would be sized for handling packs of small size suitable for instance for setting Bull's Ring kilns. If employed in connexion with a field extruder it will take the stack of freshly extruded bricks from the extruder and transport it to the drying areas. It will then take the dried packs and set them in the kiln. Similarly it will unload the fired bricks and deposit them in the yard. It will certainly not be labour or time-saving equipment but its use will increase output of saleable bricks.

And Now Some Futurism

Before closing I would like to indulge in a bit of futurism. I have always felt that extrusion is not the most ideal nor logical brickmaking process and I have discussed this matter in a number of publications. By what I said I did not want to imply that I am advocating dry-pressing as appropriate technology for developing countries. What I do propose, however, is that we in developing countries do a bit of our own R+D in the direction away from extruding because developed countries are just not interested in it and the reason is that any other shaping method but extruding will have a comparatively lower rate of output.

I want to call your attention to the great potential of compacting by vibration. This principle has been made use of in the concrete and sand-cement blocks industry and I don't see any basic reason why it should not be applied to the manufacture of clay bricks. At the time being I am visualizing a simple one- or multiple-mould machine sometimes known as "egg-laying" machine that would form and deposit on the ground bricks or blocks in a row as it moves along. Such machines will use defficiently plastic clay or even non-clay materials with a clay bond and will require much less water

than the extrusion process. Drying would therefore become less of a problem. It will also use less power. The principle of compaction by vibration could be combined with some tamping as employed in the soft-mud process.

Such an equipment, if it could be developed, will not be a panacea. It will certainly not work with all clays but properly used it might solve many of our problems. Nor surprisingly the idea in itself is not even new. In fact it has been developed years ago for Saudi Arabia and field-tested there.

To be more generally applicable this principle considerable research might be required. But I believe we have the means and the capacity to do it and we should be interested enought to give it a try. Many developing countries have good Building Institutes or Building Materials Development and Testing Stations or Institutions where such work could be done. But we would have to pool our resources.

SOPHISTICATION - INVESTMENT - OUTPUT

Dinnerware Flatware Making

	Throwing wheel	Two-spindle jigger	Semi-automatic roller	Fully automatic production line
Investment/US$	1.000	4.000	70.000	600,000
Output/hour	10	175	600	1200
Output/manhour	10	88	300	Infinite
Skill Requirements				
Direct Skills	high	medium	none	none
Higher Skills	none	low	medium	high

B-89

80.02.07