

Current Situation of Brick Work and Future Tasks

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Abstract

Although it becomes to increase constructing and repairing operations of refractories equipments on the momentum of a prosperity in steel industry, brick layers are so tight in these market. About 35% of high skilled worker are older than 50 years old as the investigation. It is necessary to break the situation that must stimulate alternation of generations rapidly. Refractories Div. in NSC and associated companies have established the social meeting for friendly discussion to work positively toward the resolution of alternation of generations for brick worker. The contents of the argument are the treatment improvement, work environment improvement, the promotion of education, the upbringing system, the technology development and so on. It will be examined the concrete measure with an integrated, systematic manner in the future.

1. Introduction

Reflecting the high levels of steel output in recent years, there is growing demand to expand the existing iron-making processes. In the relining of blast furnaces and the construction of coke ovens, the bricklayers—workers specializing in furnace construction—are the leading players. However, due to the extended economic recession that persisted until recently, various strains have arisen in coping with the accelerating generational shift. The general public is apprehensively talking about the mass retirement of baby-boomers (expected to be most conspicuous in 2007) that might aggravate the handing down of their accumulated know-how and techniques to the younger generation. In this connection, the shortage of bricklayers is not merely a matter of transferring know-how and techniques. Actually, the number of bricklayers has seriously declined, and skilled hands with rich experience in the construction of furnaces can even be labeled an “endangered species.”

The gravity of this shortage of bricklayers had been pointed out by people in the industry since around 1990.¹⁻⁴⁾ Nevertheless, due mainly to the recession that followed the collapse of the bubble

economy and to the prolonged periods spent relining blast furnaces and coke ovens, demand for construction of new blast furnaces and coke ovens shrank significantly. As a result, the above shortage apparently caused no short-term problems. Such being the case, the issue has since been neglected. Namely, no improvements have been made and no effective measures have been taken to cope with the underlying problem. Today, with the bricklayer-shortage problem still unsolved, iron-making processes are being expanded and more and more new furnaces are being built. Under these conditions, it has become increasingly difficult to secure an adequate number of bricklayers who are required for the construction and maintenance of these furnaces.

Unfortunately, however, the actual labor situation is hard to fully recognize, due in part to the fact that the furnace-building industry has no national organizations. The furnace refractory department of Nippon Steel has recently established a cooperative organization which consists of the persons concerned at Nippon Steel and its affiliated furnace maintenance companies. This new organization is studying various problems relating to bricklayers and discussing how to identify and solve them.

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2. Present Conditions of Bricklayers and Furnace Construction Industry

2.1 What is a bricklayer?

Bricklayers are skilled workers who build various types of furnace equipment by laying bricks, mainly refractory bricks, in rows and columns. The furnace equipment includes cement kilns, lime kilns, furnaces for manufacturing chemicals/glasses, incineration furnaces, etc. in the non-ferrous materials industries, and blast furnaces, coke ovens, hot stoves, converters, secondary refining furnaces, various types of reheating furnaces, heat-treatment furnaces, pickling tanks, etc. in the iron and steel industry. Bricklayers are engaged in the construction, maintenance and repair of such furnaces. Those who are responsible for construction and maintenance of furnaces are basically divided into brickwork designers (who draft brickwork plans), brickwork supervisors, mold makers (who fabricate wooden forms or molds), labor assistants (who help with brickwork) and bricklayers. Although the problem of the shortage of bricklayers embraces the ever-dwindling number of people who fall within any of the above categories, I shall focus on bricklayers in this paper.

A bricklayer is a sort of qualification based on the national skill certification system. Those who have passed a test conducted by an organization specified by law are called certified bricklayers. The above tests are divided into first-class and second-class certificate according to the level of knowledge and skill tested. It should be noted, however, that holding a qualification does not always mean having the corresponding skill. In fact, the bricklayer certification test consists of written and practical tests. In the skills test, the applicant is required to build a furnace wall (the difficulty involved in building the wall varies according to the level of skill required) within about three hours (this time also varies according to the level of skill required).

In actual brickwork, the skill required of a fully-fledged bricklayer embraces not only the ability to translate the brickwork drawing into the actual brickwork, but also the ability to grasp a solid layout of the bricks from the actual brick dimensions and shape, decide the bricklaying sequence and the method of machining the bricks, and even imagine the mortared surfaces of each brick before starting the bricklaying work. The working efficiency (speed) of an experienced bricklayer is reputed to be as much as ten times greater than that of a qualified but inexperienced bricklayer. **Table 1** shows the classification of skill levels for bricklayers as used at a certain company. It can be seen that the work efficiency and accuracy vary widely according to the skill levels of the individual bricklayers.

2.2 Structure of furnace construction industry

As mentioned earlier, since the furnace construction industry has no unified trade organizations, it is difficult to grasp the overall picture (number, age configuration, etc.) of bricklayers. Besides, there is a marked difference in job structure between bricklayers who engage in furnace maintenance/repair for a certain steelworks, etc. on a permanent basis, and bricklayers who engage in furnace construction work at various construction sites throughout the country on a part-time basis.

When it comes to constructing furnaces, the contractor (engineering company/construction company) often finds that the number of bricklayers working under its direct control is insufficient for the purpose. In many cases, therefore, in order to cover the shortage, the contractor mobilizes bricklayers from its affiliated company, that is, a subcontractor that has bricklayers of its own.

It is not unusual for bricklayers to travel around the country to engage in furnace construction work at various sites. Formerly, there

were quite a few bricklayers who were literally “self-employed workers”. Today, it seems that even those bricklayers are being gradually organized or employed as full-time workers as more and more intermediate firms are engaged in hiring them in or out, or helping them to find a job.

In terms of furnace maintenance work, bricklayers are engaged in both on-line and off-line maintenance of furnaces at their steelworks. The mode of furnace maintenance work is almost stereotypical, and the workload is nearly proportional to the volume of steel production. Since furnaces are repaired routinely, experts in furnace repair are employed on a full-time basis. At steelworks, the torpedo cars, converters, secondary refining furnaces, ladles, etc. are subject to ordinary maintenance, which is mostly performed periodically. The other maintenance work includes the operation of maintenance equipment (e.g. gunning, casting, injection, brick replacement). In many cases, this is done by multi-faceted bricklayers included in the maintenance staff (**Photo 1**).

At present, there are estimated to be 600 to 800 qualified brick-



Photo 1 Situation of brick work

Table 1 Diagnostic criteria of skilled level for brick worker

Skill level	Qualification	Skill contents	Work contents	Correspondence facilities	Construction speed (piece/day)	Knowledge	Operation
1	2 grade	<ul style="list-style-type: none"> Ability of mortar coating without accuracy Reading of fundamental brick shape and name 	<ul style="list-style-type: none"> Ability of brick work for easy part Ability of brick forming with inking-in 	<ul style="list-style-type: none"> Safety lining for BOF bottom and wear lining for BOF wall Castable tube of CAS 		<ul style="list-style-type: none"> Understanding of usage for tools and tooling Understanding of usage for equipment Mention of brick shape Understanding of classification for refractory Understanding of usage for dismantling 	<ul style="list-style-type: none"> Mixing of mortar Mortar coating on standard size brick Easy inking-in on brick Brick cutting for half bat and soap shaped brick etc. Usage of braker and pick
	2 grade	<ul style="list-style-type: none"> Ability of mortar coating on standard brick Understanding of brick shape and name 	<ul style="list-style-type: none"> Ability of easy brick working Ability of easy brick forming 	<ul style="list-style-type: none"> Safety lining for BOF & ladle wall Safety lining for TPC wall 	About 100 pieces	<ul style="list-style-type: none"> Understanding of meaning for joint center and brick center Understanding of name for arch structure Ability of discrimination for refractory material Ability of selection for refractory material Ability of confirmation for dismantling position 	<ul style="list-style-type: none"> Brick work for standard brick Brick laying in a horizontal on brick Usage of brick cutter Cutting for easy key brick Preparation of equipment and materials for dismantling
3	1, 2 grade	<ul style="list-style-type: none"> Ability of classification as to brick shape Understanding of drawing for simple furnace 	<ul style="list-style-type: none"> Ability of brick working for easy moulded brick and arch forms Ability of brick forming for complicated brick shape 	<ul style="list-style-type: none"> Roof brick for PIM Upper part of CAS Wear lining for ladle Repair for heating furnace 	About 300 pieces	<ul style="list-style-type: none"> Understanding of refractory material by drawing Understanding of dimension by simple drawing Understanding of brick shape on required position Understanding of name for scaffolding and framing Understanding of dismantling method 	<ul style="list-style-type: none"> Brick work along the leveling string Mortar coating on the brick adequately Cutting for key brick and skewback brick Making a frame for key brick Dismantling with accuracy
		<ul style="list-style-type: none"> Ability of brickwork procedure on the drawing Judgement of brickwork method and order 	<ul style="list-style-type: none"> Ability of brick working by self judgement Ability of brick forming for complicated brick shape 	<ul style="list-style-type: none"> Wear lining for TPC and REDA Brick work for heating furnace 	About 800 pieces	<ul style="list-style-type: none"> Centering of furnace and inking-in Making the division rule for brick and joint Ability of inking-in with hand screw clamp Understanding of forming for arch-form Understanding of installation for scaffolding and framing 	<ul style="list-style-type: none"> Spining standard brick on the palm of one's hand Cutting a brick to any shape by hammer Having full command of bolster, chisel, double edge Setting a easy scaffolding and framing Finishing by machine file for brick processing
5	1 grade	<ul style="list-style-type: none"> Understanding of drawing for complicated furnace Ability of marking and fabrication of frame suit up for furnace 	<ul style="list-style-type: none"> Ability of brick working for complicated design with accuracy Ability of suitable scaffolding and framing 	<ul style="list-style-type: none"> Brick work for REDA roof and duct 	Over 800 pieces	<ul style="list-style-type: none"> Ability of inking-in with drawing dimension Ability of accounting for brick pieces at required position Ability of installation for brick and joint at required position Understanding of installation procedure Understanding of positioning for scaffolding and framing 	<ul style="list-style-type: none"> Brick processing for complicated brick shape Brick work for specially shaped brick and set up brick Brick work to smooth surface Making a foam-made frame Red brick work
		<ul style="list-style-type: none"> Understanding of drawing for almost all furnace Ability of education and guidance for brick work 	<ul style="list-style-type: none"> Teaching of brick work for the key points Management and supervise for a big project construction 	<ul style="list-style-type: none"> Brick work for big construction in steel making Brick work for big construction in heating furnace 	Over 800 pieces	<ul style="list-style-type: none"> Accounting for scaffolding and framing Checking-up complicated drawing Ability of installing procedure from drawing Making-up of installing schedule and operating procedure Reporting ability on various types 	<ul style="list-style-type: none"> Preparation of equipment and materials for construction A reliable construction supervision
6	Instructor						

layers in the country. However, the actual number of bricklayers dedicated to the construction of furnaces, excluding those who are engaged in furnace maintenance, is small. Relining a blast furnace (furnace bottom, furnace walls, cast house, etc.) requires 70 to 80 bricklayers, and constructing a coke oven needs 50 to 60. It is said that with the current number of bricklayers that can be mobilized, only one coke oven and two blast furnaces can be constructed a year.

Besides, with the aging of these highly experienced bricklayers, the number of bricklayers available to construct furnaces is decreasing rapidly. Already, the number is insufficient to meet the demand to expand the iron-making process. As mentioned earlier, bricklayers are required to skillfully handle bricks by hand. Therefore, fostering bricklayers takes much time. Some say that raising an inexperienced bricklayer into a fully-fledged one takes 10 years. Although furnace construction companies are pressing ahead with the training of bricklayers, the present condition—the shortage of bricklayers—has not improved much. Saddled with a heavy workload already, they do not seem to have sufficient time to effectively train apprentice bricklayers.

2.3 Present condition of furnace equipment at companies affiliated with Nippon Steel

At Nippon Steel, monolithic refractories now account for 75% of the furnace materials consumed. Thus, the company has been reducing its dependence on the skills of bricklayers. It seems, however, that the company's efforts have reached saturation point. Although the quality of furnace materials is guaranteed by their manufacturers, the total quality of the furnace equipment made from those materials must be guaranteed by the combined capacity of the furnace maintenance department under the direct control of Nippon Steel and the affiliated companies that construct the furnace equipment.

From the standpoint of securing the total quality of furnace equipment as mentioned above, the furnace material engineering & maintenance department of Nippon Steel and the affiliated furnace construction companies have been working in close cooperation since 2006 to detect and resolve quality-related problems.

2.4 Manpower configuration of furnace construction companies

With the aim of analyzing the personnel currently available for furnace maintenance, we conducted a survey of the age contribution of bricklayers at furnace maintenance companies. Fig. 1 shows the age profile of bricklayers at the seven major companies that contract for maintenance/construction of furnaces at the steelworks of Nippon Steel.

The above questionnaire survey showed that: (1) More than 30%

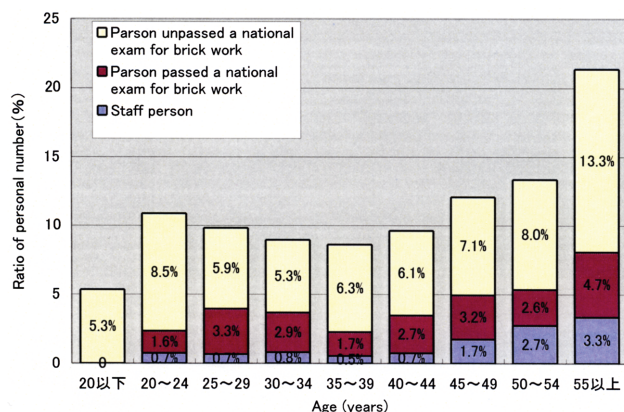


Fig. 1 Age distribution of brick worker in 7 associated companies for NSC

of those engaged in furnace construction work are 50 or older, and (2) about 35% of the highly experienced bricklayers (first-class certificate or higher level) are 50 or older. Thus, it was confirmed that the aging of bricklayers has become a serious problem. In particular, the high proportion of those who are 55 and over highlights the urgency of this problem. Another big problem is the paucity of young and middle-aged bricklayers who are supposed to shoulder the next generation of work. As a result of this survey, it was also found that nearly 50% of bricklayers working for the furnace construction companies surveyed were dispatched from subcontractors. Under that condition, it might be difficult to hand down their accumulated know-how and techniques from generation to generation. The above situation has probably been brought about by an increase in outsourcing and a drain of skilled workers into other industries, such as civil engineering and construction, as a result of the relative shrinkage of furnace construction work amid the persistent economic recession.

2.5 Problems in present furnace construction work

- (1) The present age profile of bricklayers is problematic.
- (2) It has become increasingly difficult for a single company or steelworks to secure personnel required to complete routine maintenance work or specific works for itself.
- (3) Maintenance equipment, etc. is becoming aging. The renewal of aging maintenance equipment is slow compared to that of production equipment. Besides, the functions of maintenance equipment are becoming outmoded. The existence of special machinery makes it difficult to renew and to enhance the functions of maintenance equipment.
- (4) An environment conducive to skills training and fostering of bricklayers has not been established.
- (5) The following three recent advances in furnace construction technology are worthy of special mention:
 - i) The development of monolithic refractories has made it possible even for inexperienced bricklayers to build furnaces. However, concerning those furnace parts which are still made of shaped bricks, it is extremely difficult to substitute them with monolithic refractories. It seems that these parts will continue to be built mainly by skilled bricklayers for some time to come. (The use of monolithic refractories has reached a plateau.)
 - ii) In the downstream processes (reheating furnaces, atmosphere furnaces), the application of fiber blocks has facilitated the building of furnaces. As a result, it has become possible to construct furnaces even without the skilled bricklayers.
 - iii) It is now possible to construct the furnace bottoms of some converters in segments. This has contributed to a reduction in the peak load of the construction work.

With respect to the automation and mechanization, etc. of furnace construction work, however, no significant developments have been made.

2.6 Background to the shortage of bricklayers

(1) Remuneration

Formerly, in Japan in the mid-Sixties when the construction of blast furnaces and coke ovens was brisk, bricklayers were well paid. Recently, however, their wages are not commensurate with their skills.

(2) Work environment

Bricklaying is, frankly speaking, a hard, dirty, and dangerous job. It also involves heavy muscular labor, often requiring the worker to ascend to and descend from an elevated place. Generally speaking, bricklaying is carried out night and day in an extremely hot and dusty

environment. Apparently, newcomers these days are shocked to see the condition of their workplace for the first time. Since childhood, they have lived in an environment which is comfortably air-conditioned throughout the year. I once heard that a new graduate who joined a steelmaker said that he experienced the heat of summer for the first time during his first year of service at the company. It is said that quite a few freshmen in this particular industry become disillusioned about their future in view of the lack of cleanliness at their workplace and the poor working environment of their workplace and company offices. Even though their feelings may be difficult to understand to those accustomed to the conventional environment of steelworks, it is hoped that the present working conditions at steelworks will be improved in the future.

(3) Training method and training system

Each individual furnace construction company provides its employees with some form of training. In many cases, however, the training of employees is nothing more than a traditional apprenticeship. Only a few companies have adopted a systematic training system. On the other hand, the cost of training and the shortage of instructors make it difficult for many companies to provide their employees with adequate training.

(4) Other

The iron and steel industry does not always appeal to bricklayers with experience in other industries. Apparently, some of those people feel disgusted not by the remuneration they receive, but by the unique climate of the industry, which seems incompatible with artisan spirit—the complicated procedures, rigid rules, numerous control items, red tape, obligation to participate in voluntary improvement activities and other events.

2.7 Improvement measures

At present, the furnace construction companies under the direct control of Nippon Steel and their affiliated companies are discussing what they should do in cooperation to improve the present situation.

(1) Remuneration

If nothing is done to improve the present situation, the supply of bricklayers will become overstretched whenever a concentration of furnace construction projects occurs. This will inevitably cause much delay in construction work, a hard scramble for bricklayers throughout the country, and hikes in unit prices. Besides, since relatively inexperienced bricklayers will also enter the market, it might be difficult to secure the necessary quality of finished product. Such a chaotic situation is undesirable for sound development of the industry even if it does not last long. In order to secure an adequate number of bricklayers in the future, it is indispensable to accord appropriate remuneration to experienced bricklayers.

(2) Work environment

As mentioned already, there seem to be cases in which newcomers being trained to become fully-fledged bricklayers feel desperate when they ask themselves: “Are we going to have to spend all our life in this awful workplace?” After all, pay is not everything that encourages people to work hard. It is hoped that the management and contractors will be reminded of the importance of creating a work environment in which their workforce can take pride in working. In addition, I think that there should be a climate in which highly skilled persons and skilled labor are respected. Needless to say, it is the high level of Japanese artisans’ skills that have supported the international competitiveness of Japan’s industries, including the iron and steel industry, and have made Japan world-famous for its superb products. As exemplified by the World Skills Competition held by other industries, I hope that our industry, too, will plan projects to

establish a skills evaluation system and create a climate and atmosphere in which highly skilled persons are duly evaluated and respected.

(3) Training and support

Training is a management investment in human resources. Under this prolonged recession and the accelerating economic globalization, the flow of labor from company to company or from industry to industry has been conspicuous and the concept that any labor procurable from outside should be treated as a variable cost was prevalent. Today, however, it has become increasingly difficult to procure skilled labor from the market with the loss of many highly skilled workers from their workplaces. This phenomenon is observed in our industry too.

In view of the present condition under which an environment that utilized the skills market is changing to one that is controlled by the skills market, fostering skilled persons as management resources is significant for the user too. Against the traditional market that has been determined largely by man-hours and unit prices, it is necessary for management to consider training as a reasonable and indispensable cost. For example, the owner of a construction project should allow the contractor to allocate surplus workers, including those with limited experience, and contrive to secure funds (or reserves) for their training. On the other side, the contractor should positively allocate management resources to training.

(4) Training system

As mentioned in 2.6, the training of unskilled bricklayers has been carried out by comparatively small companies. Only a few of those companies have systematic training manuals and offer sufficient opportunities and training sites.⁵⁻⁹⁾ They recognize the need for systematizing skills, preparing appropriate training manuals, establishing technical standards, and developing a new skill-assessment system for bricklayers.

Those responsible for maintenance of furnaces of the owner, too, must have management capacity. The furnace manager must not necessarily have the ability to build a furnace, but without a thorough understanding of furnace construction work, he will not be able to manage the furnaces properly. The manager needs to systematically grasp the points for work quality management. From the standpoint of cultivating management capacity too, it is necessary for the project owner and the contractor to work in cooperation to systematize, formulate and “make visible” the body of tacit knowledge of skills in furnace construction. In order to foster a manager of furnace maintenance, I also consider it effective to transfer the trainee to the furnace maintenance company on a temporary basis (**Photo 2**).

(5) Technological developments

Technological developments are significant for two important reasons. One is that it lightens the physical burden on bricklayers and formulates the tacit knowledge of furnace construction techniques. The other is that it reduces technical barriers to the flow of labor and thereby enhances the labor fluidity. In particular, technological developments should be pursued in the following two fields.

i) Automation and mechanization

In order to save labor, reduce the over-dependence on personal skills, and liberate bricklayers from heavy muscular labor, it is effective to mechanize and automate bricklaying work. Thanks to the progress of robotics in recent years, the prospects for mechanization and automation of furnace construction work are much brighter. For example, by introducing a remote-controlled robot and applying a muscle suit/robot suit, it will be possible to significantly reduce the physical burden of furnace construc-



Photo 2 Skill competition

tion work. In addition, various devices which help lighten the burden of handling heavy objects are being developed. For example, if the balancer (lifting machine), etc. can be adapted to furnace building work, it should be possible to reduce the technical barriers to furnace building work. Furthermore, if a portable type of personal computer which is capable of recognizing patterns of bricklaying can be developed, it should become possible to eliminate the need for high levels of skills in terms of knowledge.

ii) Replacement of all shaped bricks with monolithic refractories or pre-cast blocks

If this is made possible, highly skilled bricklayers can be substituted with bricklayers having skills of the level required by the general construction industry. In Japan, with the shrinkage of public investment, the employment rate of construction industry workers has decreased. If the level of skills required for furnace construction can be lowered markedly thanks to the development of new technology, that would open up the potential for labor fluidity between the furnace construction industry and the general construction industry. Even partial replacement of shaped bricks with monolithic refractories or pre-cast blocks would help resolve the problem under consideration.

(6) Employment of foreign labor

In view of the law in Japan and the receptive capacity of Japanese society, etc., promoting the employment of foreign labor in this particular industry is problematic. It calls for careful judgment on the total cost, including the cost of complicated personnel management.¹⁰⁾

(7) Coordination of project schedule

It is desirable that any adjustment between the project owner and the contractor and the organization and cooperation or adjustment of companies in the same trade should be implemented legally and reasonably.

I have so far described the contents of matters that are recognized as tasks to be tackled in the future by the Refractory Division of Nippon Steel and its affiliated companies. Their activities were only recently started. At present, with the same degree of problem consciousness, they are identifying specific tasks to tackle, working out specific themes, forming work groups, and seeking effective approaches by task forces. They intend to discuss some of the tasks as R&D themes and others as management policies.

In either case, the above tasks are recognized as ones that should be tackled with the understanding of the top management of both the project owner and the contractor. As mentioned earlier, the mass retirement of skilled workers is expected to occur in five years or so. Under that condition, effective measures to resolve pending problems will have to be taken as soon as possible. I have only described the present conditions of bricklayers from the standpoint of someone responsible for furnace maintenance. Concerning the present conditions of furnace builders, no quantitative analysis has been undertaken. Although this might be difficult in view of the absence of a national organization, it is hoped that the actual state of the furnace construction industry will be analyzed in the future.

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