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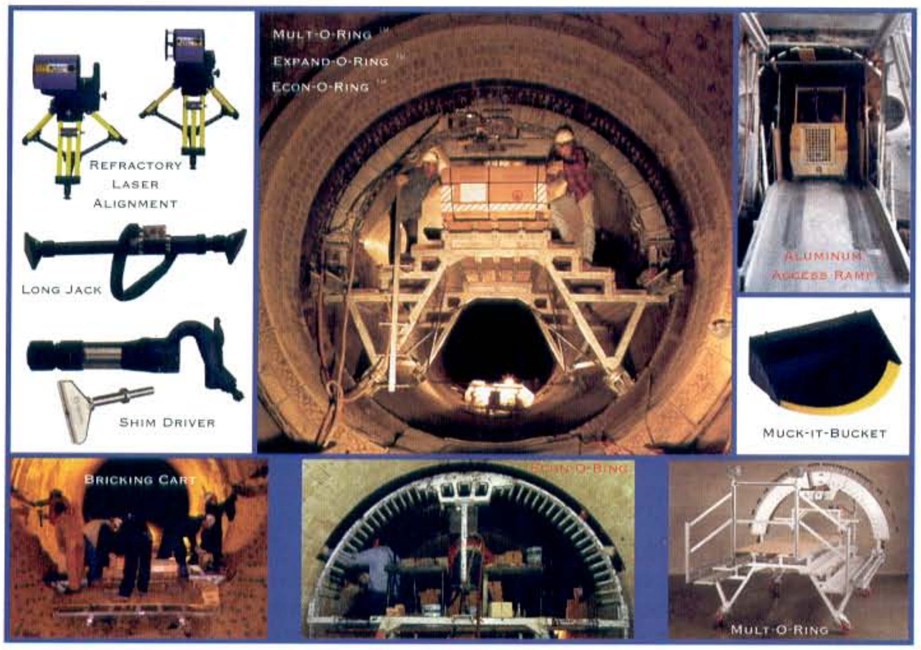

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Modern techniques for bricking cement kilns

William Barraugh, Pneumat-O-Ring, USA, discusses the techniques currently in use for the relining phase of the kiln maintenance system.

Figure 1. Access to the kiln.

Introduction

One of the major causes of premature brick failure which results in unplanned kiln downtime, lost production revenues, and higher maintenance cost is incorrectly installed brick. Once the kiln is down (planned or unplanned), further revenues are lost and higher maintenance cost incurred from poorly planned and inefficient kiln bricking systems. The proper maintenance equipment and planning programme will save hundreds of thousands of dollars in revenues and cost. The use of a modern bricking machine, radial alignment device, adequate kiln access, remote controlled debricking machines and other modern planning and measurement devices are essential to the modern bricking techniques needed for today's cement kilns.

This article discusses the total kiln bricking system with focus on the bricking machine, considered to be the heart of the system. The goal of any bricking system is to reduce cost. The bricking system can reduce cost by reducing kiln downtime through the speed of removing and installing brick and by increasing the longevity of the brick through proper installation. Another cost saving benefit of a good bricking system is safety. This, in turn, reduces cost by minimising lost time due to accidents or lower efficiency due to an unsafe or risky situation.

Planning and organisation

Management, production, engineering, purchasing, maintenance, and operations departments should be brought together to devise a maintenance programme. If the plant is using an outside contractor, they should also be advised of the schedule and plans for the outage. Management of the refractory needs, equipment requirements and organising of manpower are critical considerations for the success of any plant maintenance programme. Due to the capital intensity of hundreds of thousands of dollars involved in refractory and kiln downtime in the relining of the kiln, it is important to understand what is the best equipment and material available.

Organisation of the burn floor is an important part of the plan. The first step is to take a full inventory of all refractories. Use of historical bricking data, along with the kiln monitoring equipment, will determine the amount of refractory needed for an outage along with the areas believed to be in need of repair. Once the shutdown begins, the kiln needs a cooling down period of 18 to 30 hours. Cool down time varies with kiln diameters, amount of coating, draft control, and kiln length. During this period, it is important to begin staging the materials and double checking supplies. This process may start with the location and organisation of the refractories in order of need. The burn floor needs to be used carefully since storage space is critical, and it should, therefore, be clean and organised. Accordingly, only necessary materials and supplies are to be stored on the burn floor, and further only those supplies required for each shift should be kept in this area.

Gaining access to the kiln (Figure 1) is another important consideration. Many plants have limited access into the kiln which makes the use of equipment difficult and material access a challenge. Also, the burn floor design may be too small for storing material and equipment necessary for the repair of the kiln during outages. These small doors and burn floors create many disadvantages and slow down the job of bringing the kiln back on line quickly. The hoods of most kilns can be modified to allow for greater access into the kiln. A large access into the kiln will allow for the use of a forklift for transporting pallets of brick, a loader for removal of rubble, and easier access for the bricking machine. The cost of reworking the hood could easily be regained within two or three maintenance outages of the kiln. The same argument can be used for making the burn floor larger. A kiln with adequate access allows for a kiln ramp to span the cooler to allow equipment and personnel to enter the kiln easily and safely. A ramp made of aluminum is recommended for reduced weight and ease of handling.

Removal of coating, inspection of and removal of brick

Removal of coating (Figure 2) is a dangerous task because coating build up can be very unstable and unpredictable. Coating thickness will vary from kiln to kiln, and the coating material needs to be handled with great care. With the cooling of the kiln, the coating will shrink, causing fractures and large chunks which can drop without warning. All plants should remove the coating completely as soon as the temperature allows for entry. A remote controlled Brokk™ demolition machine is suitable for removing coating.

Although entering a kiln with the coating up should always be avoided, there are times when only a small repair or inspection of a hot spot is necessary; a safety cage (Figure 3) offers workers a protective haven. The safety cage is constructed of radiused aluminum pipe and covered with a specially designed expanded aluminum mesh. The cage is only to be used as the last resort; good judgment must be made whenever entering the kiln with the coating still overhead.

Once the coating is removed, it is time to inspect the condition of the refractory. There is much to be learned by taking the time to inspect the brick work. The discovery of spalling, capping, squirreling, crushed or twisted brick, gaps, cupping and sagging indicates the types of problems and conditions within the kiln. Previous methods of installation and concepts should always be examined closely for any clues or damage that will better prepare the work force for the next maintenance period.

There are as many variables in removing brick as there are in removing coating. Again, a remote controlled Brokk™ demolition machine is an appropriate tool for removing the brick. To remove all of the rubble, some plants may use a skid steer loader equipped with a Pneumat O Ring "Muck it Bucket" (Figure 4) to take the debris from the kiln and dump it over the railing of the burn floor. Some plants may roll out the material and let it drop into the cooler, while others remove it through a manhole in the kiln. If mucking out through a manhole, it is important to place the manhole at the top of the kiln before tear out. When the kiln is rotated, the manhole will be on the bottom of the kiln and in the proper position for mucking. This method avoids rotating the kiln twice. It is important to examine the remaining brick to assess its stability and ensure it does not pose a threat to the personnel. The masons will determine the need to install a retaining ring to the existing brick rings on the discharge side of the exposed brick rings, which will help to prevent creeping of the existing brick rings.

Figure 2. Removal of coating and brick.

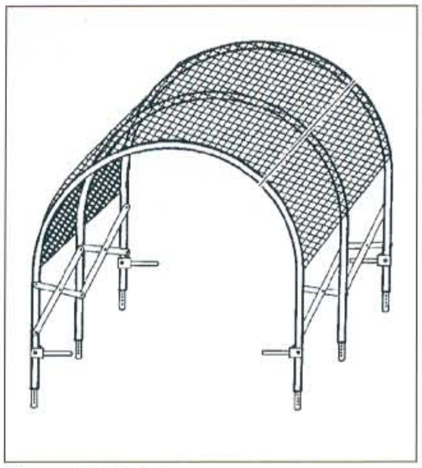

Figure 3. Safety cage.

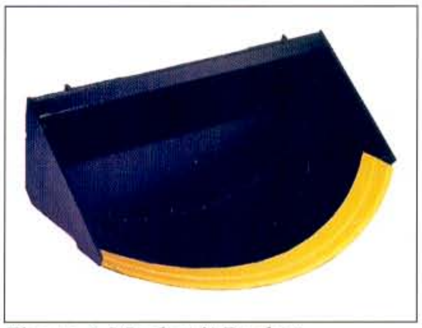

Figure 4. Mucket it Bucket.

Radial alignment of the brick

It is critical to install the brick perpendicular to the axis of the kiln. If the bricks are not placed in the proper alignment, the chance for premature brick failure will increase greatly. Operators in the cement industry have become increasingly uncomfortable with the old methods for determining radial alignment and with the amount of downtime of their kilns due to improperly installed brick. This was a driving force behind efforts to design a simple method that would give an accurate means to ensure their brick was installed radially aligned. The Radialign™ (a laser type device) was designed and manufactured because of the demand for a easy to use device that could ensure radial alignment (Figure 5).

The purchase of such an alignment device can be justified simply by the cost of lost brick due to improper radial alignment. This lost brick also adds up to premature shutdown of the kiln and thousands of dollars in lost production. There is a documented case of the laser alignment device being used for the first time inside a kiln, and the laser's accuracy discovered an improperly installed retaining ring. The radial welds that were being used for reference were found to be out of alignment. It was also discovered that many of the adjacent radial welds had varied from weld to weld. In many kilns, the radial welds have either been ground down with a grinder or have worn. With the use of

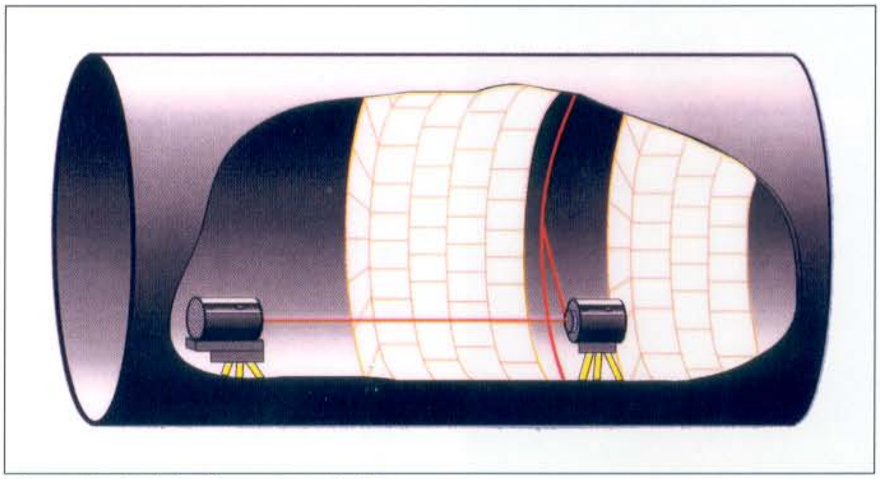

Figure 5. Radial alignment of brick.

Figure 6. The Bedding Process.

these rings have been bedded out, the rings will now be aligned radially and the use of full length brick can now proceed.

a tape measure and out of tolerance radial welds, it is very difficult to expect accuracy and it is typical to have a tolerance buildup which can result in brick being installed out of radial alignment. The laser alignment device gave the kiln maintenance supervisor instant feedback and quality control.

Transportation of brick and bedding out

While the kiln is being radially aligned, the staging of material and equipment is in process. The refractory pallets and refractory supplies (shim stock, mortar, etc.) can be organised according to what will be needed first. Depending on the diameter of the kiln, some plants will begin to stage the bedding material into the different areas of the kiln according to the need per row and the number of rows per pallet. In larger kilns, a fork truck can be driven under the bricking machine scaffold, eliminating the need for staging since the brick can be driven into the kiln.

Since there may be a need to roll the kiln for other repair reasons, the intentions of the plant's maintenance crew should be determined and the brick staged accordingly. Typically, the crew will bring in enough brick to lay 25'/ 8 m to 30' /10 m. This will give the bedding crew an appropriate head startr. Other materials for the job can be used on the intake end of the kiln, near the end of the bare kiln shell. For instance, the refractory saws may be placed at the intake end of the kiln since the discharge end will be busy with the continuous shuttling of material and men. It is best if the electrical service can be supplied from the intake end of the kiln. Proper lighting is important for the workers to inspect their work, and lights shining toward the discharge end are obviously very helpful. Once the refractory material, supplies and equipment are in place, it is time to lay the first row.

Cutting the first row of brick

Once the kiln has been radially marked, it must be determined how far the old brick is out of radial alignment (variance). This variance will dictate whether it will be necessary to cut the first row. A rule of thumb is never to install a brick which has been cut less than half of its original length. Some masons recommend always starting with a ring of full length brick and then installing the cut ring. It is important to stagger the cuts from ring to ring, as this will stagger the joints and strengthen each cut row ring. It is also wise to butter in each brick to strengthen the installation of the cut rows. After

Bedding of the kiln

The bedding process (Figure 6) is critical since it is the foundation for the upper rows of brick. It is important to watch the rows for radial alignment and make sure the bricks are staying true to the kiln shell. The refractory supplier will provide a published brick ratio sheet to assist the masons in staying true to the shell. The masons must determine how the brick ratio relates to the actual installation of the brick to the kiln shell. It is important to cross check the supplier's ratio sheet to make sure enough brick is available to finish the required run. The brick may run in or out of the radius (Figure 7); this needs to be corrected because it is important that all of the brick angles match. All heads, toes, and heels need to match to ensure proper refractory lifespan. To correct this problem, steel shims can be used to get the brick back into the proper angle and to match the radius of the kiln wall.The masons will need to be aware of kiln distortion, radial welds, and lineal welds. Rotation of any bad distortion in the kiln shell down to the bottom should be considered which will make it easier to work on these problem areas. The first row must start on the centre of the kiln floor; the brick joints are staggered from row to row, each stagger measuring half the width of the row before. The floor mason will install the lower portion of the floor and will work toward the intake end of the kiln. There will be two other masons on either side of the floor mason who will work the brick up the kiln wall and lay brick as high above the spring line as possible. The use of a bedding cart (Figure 8) that

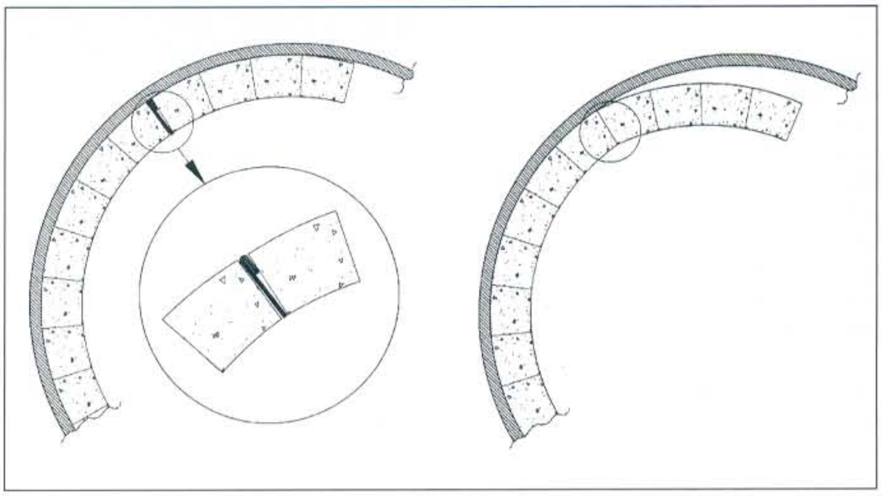

Figure 7. Run Out of a Course of Brick.

Figure 8. Bedding Cart.

stair steps up the kiln shell wall is helpful especially in large kilns. It is important to have a safe working platform especially in large kilns. The bedding cart can hold the necessary refractory and can move laterally on casters. Depending on the diameter of the kiln, 2 - 3 hod carriers will be needed to supply the brick to the masons. The hod carriers need to stack the brick properly so the mason can insert the brick without having to flip the bricks towards the proper installation side. Stacking the brick consistently will save considerable time. The most important thing is to keep the masons supplied with brick. Once the floor is bedded out to about 25'/8 m, the bricking machine can be assembled on the freshly laid floor.

Determining how to transport brick

The challenge of transporting brick will depend mostly on the size of the kiln. The smaller the kiln, the smaller the access under the bricking machine scaffolding system. The more limited the access, the more difficult it is to get brick past the machine to the bedding crew. This problem can be addressed by specialised transporting equipment; either motorised conveyor systems, manual systems, or customised lifts. Another way is prestocking the kiln, but this can create problems if the kiln has to be rotated. Another solution is bedding out the entire section needing repair; this can be done, but is not recommended if close attention is paid to the installation and to radial alignment. Also, the kiln cannot be rotated until the job is completed. In large kilns, forklifts can move easily under the scaffold frames and brick can be transported to the bedding crew as well as lifting the brick onto the intake side of the scaffold work platform.

The bricking machine

The principal

The Pneumat-O-Ring bricking machine (Figure 9) was designed to reduce downtime cost through ease and speed of operation, safety, and quality of work. The machine is constructed of strong yet light weight, aluminum modular components with each component of reasonable size and weight so that in the event of restricted access, one or two men can transport it into the kiln for assembly. The machine can typically be assembled in less than one hour.

Figure 9. Pneumat - O - Ring Dual Arch bricking machine.

Construction of the machine

The machine consists of a mobile working platform capable of supporting a pallet of bricks, the men working on it and a half circle aluminum centre. The platform has ergonomically designed steps so the men can work comfortably around the top half circumference of the kiln. The platform wheels can be turned through 90° allowing the machine to stay inside the kiln should it be found necessary to turn the kiln for mechanical reasons. The half circle aluminum centre is equipped with pneumatic cylinder lifters, which are used to raise the bricks into place against the kiln shell, and is supported by carts and a rail system to allow the aluminum centre to move along the length of the platform scaffold. Three types of centres are available, one which enables a single brick ring to be installed at any one time, while the other two double arch machines permit a second ring of brick to be started while the first one is being completed. The difference in the two double arch machines is that one is custom built for each kiln size while the other is adjustable over a 2 m variance in kiln diameter. The double arch machines are recommended for kiln diameters over 3.5 m due to considerations for congestion in smaller kilns.

Additional features

The machine is equipped with a finger tip control hydraulic jack assembly used to tighten each ring of bricks radially, allowing a key to be installed; a main control valve (or valves on double arch machines) releases all the cylinders simultaneously allowing the centre to be advanced to the next course; pneumatic shim driver; cutaway front ring design on the double arch machines for ease of access to the rear bricking ring; adjustable spacer assembly allowing the machine to adjust to various brick lengths; and a light ring.

Advantages of the machine

The advantages of using this machine include reduced worker fatigue, faster installation, a better, more consistent and tighter installation, no unkeyed brick overhead. In addition, the machines are custom designed for the specific needs of each user.

Preassembly of the bricking machine

The bricking machine should be inspected prior to each use in the kiln. This should be accomplished by the people responsible for the bricking machine and the installation of the brick.

The machine is prepared for assembly inside the kiln by staging the bricking machine on the burn floor. It is important to stage the machine in the proper order to ensure the components enter the kiln in sequence and facing the correct direction.

Once the top machine has been assembled on to the freshly bedded floor and adjusted to the kiln dimensions and brick being installed, it is rolled into position (Figure 10) to brick the first row of brick.

Now that the method for transporting the brick to the machine crew and to the bedding floor crew has been determined and the machine has been set into position, the brick can be installed onto the intake arch. It is important to have enough brick on the platform at all times and to make sure the proper types of brick are supplied on the platform. The space on the platform is at a premium.

The first few rings may need to be cut in accordance with how far out of radial alignment the rings are. Before starting, the bedded out rings are examined closely and the findings discussed with the bedding crew; these rings will take some extra time if they need to be cut in. The bricking machine can be adjusted to accommodate the process. Eventually, the rings will be brought back into radial alignment and the machine will be used with standard adjustments and in its most efficient form.

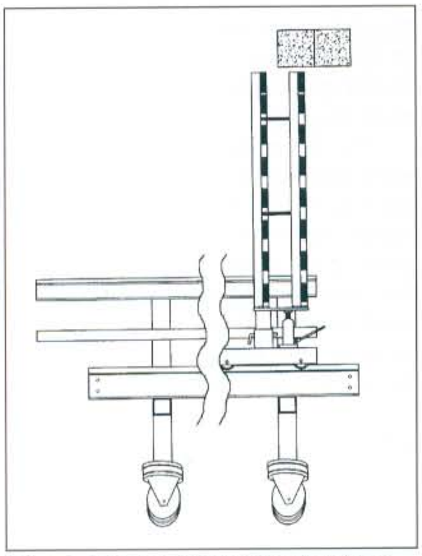

Figure 10. Positioning the bricking machine.

Figure 11. Keying out.

Standard operation

For optimum performance, a double arch machine is employed (approximately 40% faster than a single arch machine). Both sides of the arch are worked at the same time installing bricks from the centre line towards the top keying void. Both 'wing' masons should reach the keying void at approximately the same time. The key mason should also be finished keying the previous row of bricks (Figure 11) by this time. The key mason then installs the hydraulic jack and uses the master valve to release all of the up kiln arch's cylinders, freeing the arches to move forward one row. The down kiln master cylinder is then activated to support the previous ring so the jack can be released and the keying process can began while the wing masons begin installing the next row of bricks. Once the travel distance on the scaffold is used up, the whole scaffold is moved up kiln until the arches are positioned at the front of the scaffold and under the last row of brick, and the process starts all over again.

The closing out process is as important as beginning the first row, as this ensures a quality lineal installation. As with the first row, it is a good idea for the masons on the bricking machine to confer with the bedding crew since they have already bedded out the last row. Again, the machine can be adjusted and used with special close out straps to facilitate the closing out process.

Use of the machine in problem areas (conical sections and kiln distortions)

Special attachments to the custom single arch and double arch machines, such as lifter kits and caster extensions, are available to help the machine brick through conical or taper sections, oval shells, outward blisters and inward blisters. The adjustable machine has these variations built in and is the most versatile of all the machines to handle these abnormalities.

Documented performances

Performances vary according to the type of lining being installed, the state of the kiln shell, the size of the kiln shell, installation type (dry or jointed) and the number of men employed to carry out the work. It has been found that the maximum requirements to work the machine efficiently in larger kilns (above 4 m) are one foreman, six brick setters, six helpers, and one fork-truck driver. This represents 14 men per shift. (Documentation on installations using this machine in kiln sized from 3.9 m to 5.5 m is available on request. Productivity in these kilns ranged from an average of 20.00 rings per shift to 28.56 rings per shift [4.98 M2 to 7.98 M2 per hour] with varying conditions and situations.)

Conclusion

Down production costs for today's kilns are increasing rapidly. Kiln maintenance, including refractory relining, can no longer be approached in a fragmented manner. Kiln maintenance must be approached as a system, and all phases, disciplines and tools of that system must be of the latest technology and perform their parts efficiently and safely. This paper discussed modern techniques for the relining phase of the kiln maintenance system. The heart of this phase is the bricking machine and the supporting disciplines and equipment (access, alignment devices, transport systems, skilled masons, etc.) keep this heart pumping.

In the past 32 years, Pneumat-O - Ring International has delivered over 650 bricking machines and support equipment to more than 61 countries. Similar machines delivered by other companies would bring the number of machines to over 900. Feedback from the users of these machines has not only has brought about improved versions of the machine, but has confirmed that the pneumatic cylinder bricking machine method is the most efficient and safe way of installing refractory in today's kilns.

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