Geometry Measurements OF Kiln Shell in Dynamic Conditions

القياسات الهندسية أثناء عملية تجديد الفرن

Eng. Zbigniew Krystowczyk, Geoservex, Poland

وصف المقال في العدد السابق القضايا المعقدة والمتعلقة بضبط الفرن أثناء التشغيل . ثم تعرض المقال إلى أن قياس حالات غطاء الفرن وتحليل سبب التشوهات المحتملة هي إجراءات لا ترتبط مباشرة بعملية ضبط الفرن من حيث المبدأ . غير أنها من الممكن أن تكون مرتبطة بها ويرى مؤلف المقال أنه يجب تحليل أسباب التشوهات من قبل شركات التحليل المختصة عند القيام بضبط الفرن .

In the previous article I have described issues of complex kiln alignment in dynamic conditions. I have then mentioned that kiln shell measurements and the analysis of the origin of possible deformations are procedures that are principally not directly connected with kiln alignment. However, they may, and in the opinion of the author should, be performed by diagnostic companies on occasion of alignment.

TYPES OF SHELL DEFORMATIONS

There are several types of rotary kiln shell deformations and each of them has its specific source of origin.

Shell deformations may be divided as follows:
1. resilient (plastic) transient deformations,
2. local permanent deformations (deviations from circularity in the cross-section) •
3. eccentricity of shell (lack of collinearity between shell axis and rotation axis)

PLASTIC DEFORMATIONS

The first group of deformations is transient due to the fact that one of the causal factors is kiln shell temperature. Depending on the production process, these deformations may change in time. These deformations are of course measured with the help of a SHELFTEST device and provide information on the shell ovality at the support point (figure 1). This has a fundamental meaning for the refractory lining because excessive ovalization shortens the lifetime of the lining, and in extreme cases can lead to its destruction and prolapse. Ovalization may originate from excessive undertyre clearance, wearing out of the shell's sheet thickness or overheating of the shell during the production process. However, the measurement of this parameter does not provide information on the source of the problem. This is the reason why kilns cannot be aligned on basis of the SHELLTEST measurement. Also known is the parameter called relative ovalization, measured

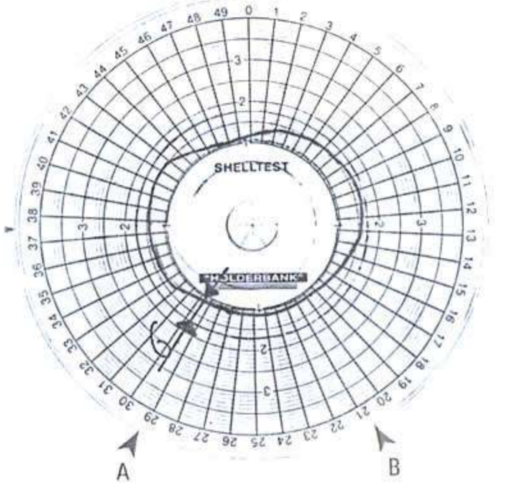

Fig. 1

Tire migration, undertire clearance and relative ovality

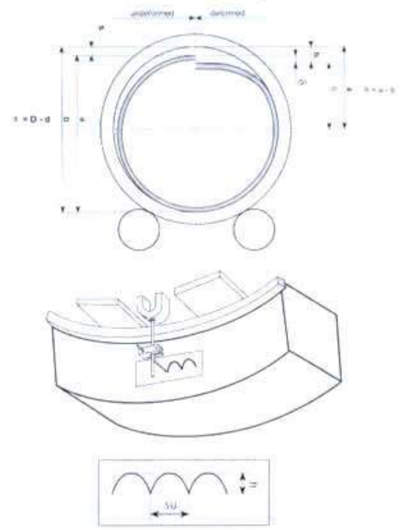

Fig. 2

SECTIONS POSITION DRAFT FOR KILN SHELL DEVIATION SURVEY
(VIEW FROM THE AIR)

EXEMPLARY CEMENT PLANT

Kiln No 1

Date of survey : 7.04.2004

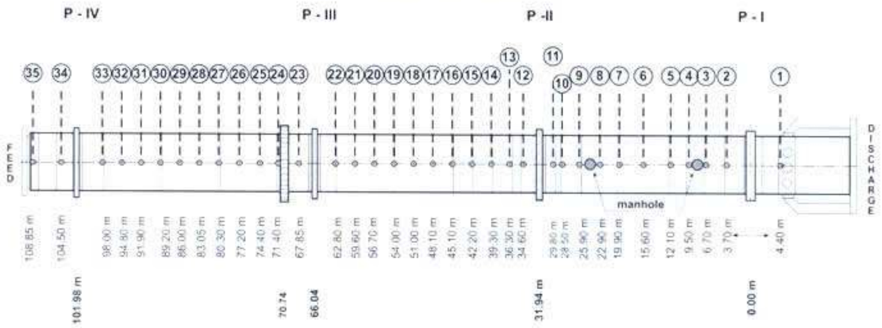

Fig. 3

in relation to the tyre. A rather commonly known magnetic device is used for the measurement (figure 2). It is therefore possible to evaluate ovalization without performing the SHELLTEST measurement.

PERMANENT DEFORMATIONS

The second and third group represent deformations of a permanent nature. Their cause is usually the overheating of the shell, often connected with the kiln's emergency standstill. Both local deformations as well as eccentricity have a significant effect on the lifetime of the refractory lining. They can cause deflexions of the brick placement line and in consequence their falling out as well as the crushing of individual brick placement zones.

Determining these deformations requires a certain measurement-calculation system. Since the kiln user is usually interested in knowing deformations on the whole shell, the quantity and allocation of measurement sections should be agreed upon. An exemplary allocation is illustrated in figure 3. Since our interest is focused on deformations between supports, obvious is the fact that remote measurements should be carried out for this type of analysis. Precise laser rangefinders are perfectly suitable for this type of measurement. Distance changes in individual cross sections are measured with their help. Measurement results are illustrated in figure 4. The measurement alone is however only half the task. The raw measurement result is the sum of local deformations and eccentricities of that cross section. In order to distinguish these two factors, one of the approximation statistical methods should be applied. Details of determining these deformations belong to know-how of diagnostic companies and are

DIAGRAM 2

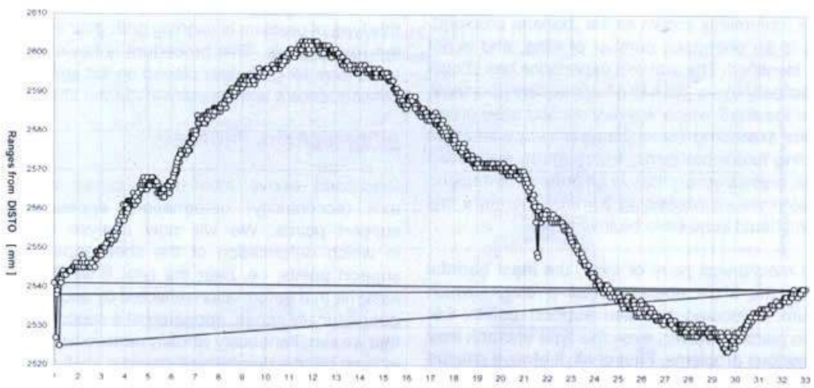

Fig. 4

usually the effects of years of trials and experience. The research group of the company GEOSERVEX has developed a method of determining permanent shell deformations with an exactitude from +/- 1.5 to +/- 2.0 mm, depending on the conditions of the shell's external layer. This is an accuracy that allows to carry out a detailed analysis of both deformation causes as well as countermeasures, which will be discussed later. Exemplary results drawn up with the help of this method are illustrated in figures 5 and 6.

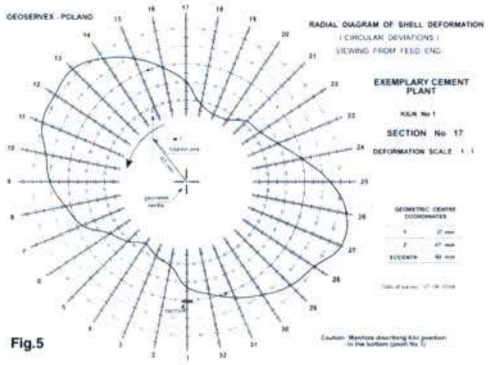

Fig.5

MECHANICAL CONSEQUENCES

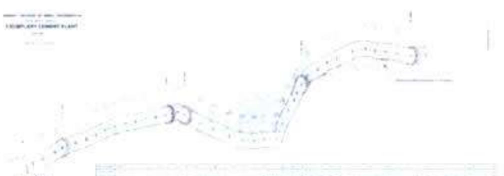

Fig.6

OF PERMANENT SHELL DEFORMATIONS

As already mentioned earlier, the main cause of shell deformations is its overheating. In consequence, deformations cause refractory bricks to fall out and lead to recurring local overheating of the kiln shell. Furthermore, once overheated and deformed, the shell has the unfortunate tendency of deepening the deformation causing incremental cranking. This problem, commonly known as the „banana problem", applies to an enormous number of kilns, and is not always identified. The author's experience has shown that practically every kiln has a fragmentary geometric crank of the shell, which in every second case grows to a value exceeding 15mm, being already a situation portending future problems. Every fourth diagnosed kiln shell reveals eccentricity in an order of 30mm and local deformations exceeding 30mm. Therefore this problem should in no case be trivialized.

From a mechanical point of view, the least harmful effect on the kiln's operation has a crank, which maximum is located between support points, i.e. between piers. However, even this type of crank may cause serious problems. First of all, it always caused axial movement of tyres, i.e. so-called wobbling – figure 7. Wobbling, however, has an effect on

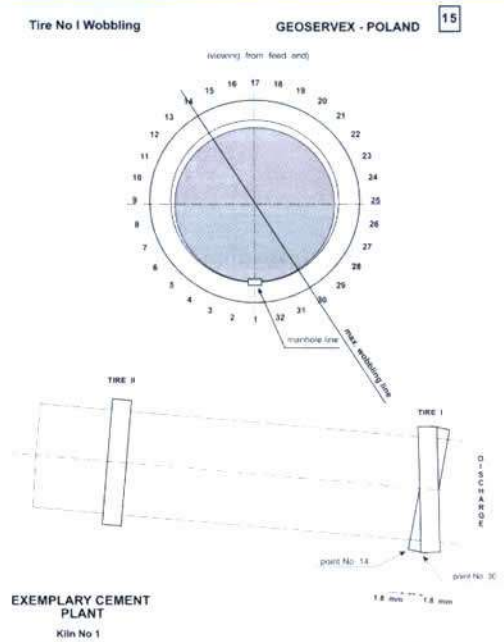

Fig.7

the wear of both under-tyre shims as well as tyre stopping blocks. Furthermore, an inevitable effect of wobbling is variable and irregular pressure on support rollers, and therewith on their bearings. In extreme cases, when wobbling exceeds 15mm, the roller's foundation frame may knocked out. The author had the opportunity of documenting such case.

The second very negative consequence of shell crank is the cyclic meshing change of the pinion and girth gear. It is easy to imagine that if shell eccentricity in the drive transmission zone equals hardly 5mm, its run out equals 10mm - Fig 8. Therefore, with the assumption that girth gear is aligned on the shell – the change in root clearance value during the kiln rotation also equals 10mm. This is a value much too high to meet the tolerance specified for the meshing of the majority of modern kilns. A countermeasure for this type of problem is aligning girth gear in relation to the rotation axis. This procedure is however difficult to perform for girth gear placed on flat springs and in consequence it is necessary to cut the shell.

HIDDEN CRANK PROBLEM

Discussed above have been cases when shell axis (eccentricity) deformations appear between support points. We will now analyse a situation in which deformation of the shell appears at the support points, i.e. near the tyre. If we theoretically assume that deformation reflected by eccentricity in a geometrically sense, appeared at a support point and that we simultaneously virtually remove bearing rollers at such point – then we will observe shell run-out, i.e. crank. In reality however, rollers supporting the tyre and directly the kiln shell exist at such point. There

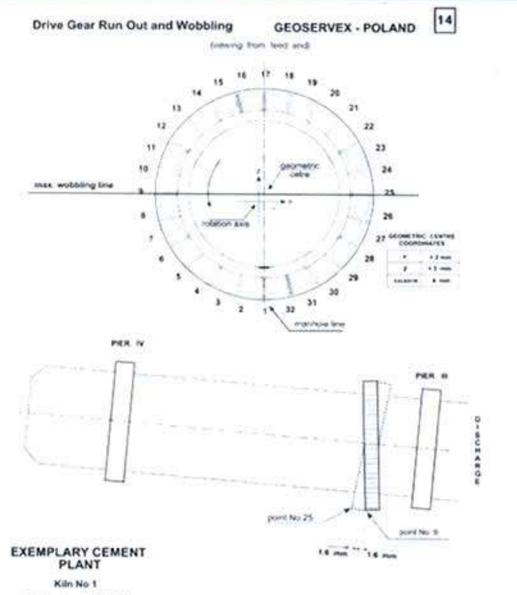

Fig.8

is therefore no possibility that geometric eccentricity occurs, in spite that there is force in the shell structure that has a nature of a crank. Such crank is commonly called a MECHANICAL HIDDEN CRANK. The question arises if it is possible to discover this type of crank if it is hidden? The answer is positive. This crank is hidden in a geometric sense. However, as mentioned above, there is force in the shell structure that effects the support bearings changing the deflection of their shafts. These changes are rather small, but can be measured with the help of digital pin gauges capable of registering data continually. The measurement method and result is illustrated in figure 9. If shaft deflection changes of both rollers on one pier originate from a hidden crank, then the diagrams of these changes will be sinusoids of the same (within error margins) periods and amplitudes. Assigned to each sinusoid can be the eccentricity parameter „e" which classifies the roller deflection. It is accepted that if the parameter „e" does not exceed 0.15mm then the deflection change is acceptable (for FLS construction rollers).

A separate case of a hidden crank is a so-called thermal crank. The cause of its occurrence is irregular temperature distribution on the shell's circumference near the tyre. If there is a high temperature difference measured in one cross section of the shell near the support point then we can anticipate a thermal crank. The term „high" is of course considerably imprecise but has no specific criterion here. Every kiln reacts specifically to such effect. From experience we can claim that a difference of 80ºC can already cause a thermal crank significantly deflecting roller shafts. The phenomenon discussed here is specifically dangerous because its appears rather suddenly, is a result of process control, and has an effect on the mechanical condition of the kiln (which is not always understood by technologists). Significantly exceeding tolerance for deflection changes of roller shafts may in consequence lead to a temperature increase of the bearing, and in an extreme case to cracking of the roller shaft.

Deformations of the kiln shell have an enormous effect on the kiln's operation, and knowledge of them provides kiln operators with the opportunity of taking countermeasures. Therefore, as mentioned earlier, the measurement of these parameters should be performed periodically, just as is the case with alignment. In the opinion of the author, it is in the interest of the kiln user to require that diagnostic companies perform procedures of complex alignment and measurements of kiln shell deformations with detecting phenomena connected therewith as a standard in the field of widely understood rotary kiln alignment in dynamic conditions.

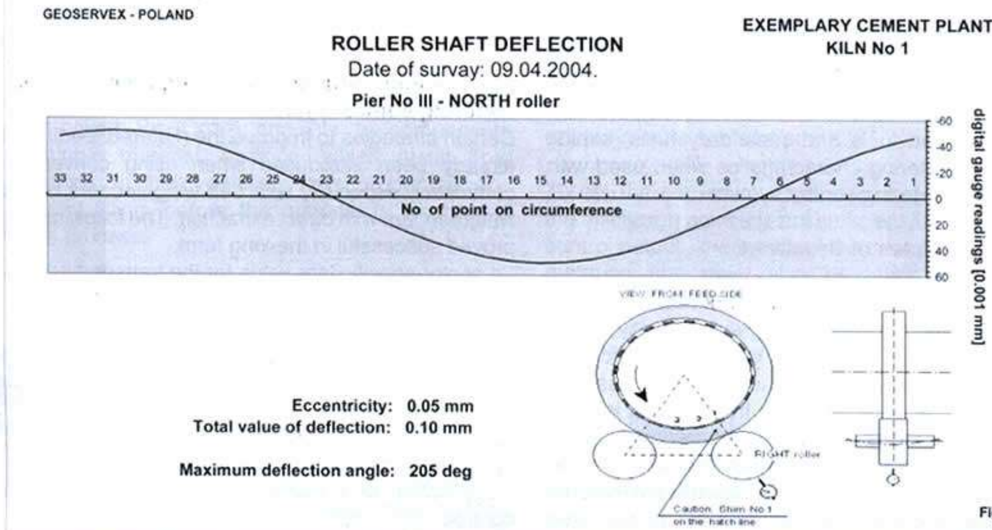

Fig.9