CRYING 'ZWOLF'

Albrecht Schall, VDZ, discusses the 'Zwolf' and the role of maintenance in ensuring that cement kilns operate effectively.

There is an old piece of German cement industry shorthand sometimes still used – plant personnel will occasionally report that 'The Zwolf' (short for: 'Zwangsläufige Ofenlängsführung' or 'forced longitudinal kiln guiding/hydraulic thrust device') of the kiln has broken down.

Of course, everyone knows about the kiln hydraulics that push the kiln up and down (Figure 1), but the use of the term 'Zwolf' is less common. When reviewing old cement industry literature, it becomes apparent that plant personnel from 60 – 70 years ago were battling with similar issues.

One engineer, working in the maintenance department of a plant 57 years ago wrote the following: "The Zwolf (forced longitudinal kiln guiding) has already proven itself at two rotary kilns. Of these two, the first, which was built in 1912, quite small in diameter, was considered to be ready for scrap before the installation of its 'Zwolf' in March 1953, with the result that the management decided that new tyres and rollers would be purchased, because the 'Zwolf' had fixed the quite serious situation at the two tyre stations."[1]

It is, historically speaking, remarkable that this process occurred exactly 100 years after the invention of the rotary kiln in 1853 by two English engineers, G. Elliot and W. Russell.

Today, it is no longer surprising when children operate their cell phones or when we hear about the ever-increasing wonders that electronic controls can produce. Everything in human life and in nature works better when the controls are working properly.

Among the thousands of rotary cement kilns, which are 50 – 200 m long and have to withstand internal temperatures of up to 2000˚C, tyre durability seems to benefit from a slow walk back and forth on the support rollers. The number of tyre stations of rotary kilns can vary between 2 – 12.

From an engineering point of view it is important to understand that where the tyre rests on the rollers, undefined forces and stresses cross the mechanical systems. It is also necessary to accept that there will never be exact static calculations for rotary kilns for reasons of static indeterminacy, and even the best computer programme cannot resolve the issue completely. A rotary kiln with only three tyres tends to behave similarly to a wooden table where the fourth leg is supported by a piece of cardboard. The reason for this is that a heated rotary kiln causes a constant change of forces and pressure on the support roller, for which no engineer is able to come up with valid rules.

Figure 1. Refurbishing a hydraulic kiln thrust roller.

Figure 2. A VDZ expert team measuring the surface of a kiln support roller.

A rotary kiln drum filled with hot, rolling material is dimensionally unstable. As was written years ago: “It is not plastically formable like a big sausage; The real operational behaviour is changeable over time and partly plastic, somewhere between a rigid barrel and a big sausage.”[2]

Today’s requirements are that the tyre is dimensionally stable. Tyres and rollers can be calculated quite well, and with preventive maintenance methods it is possible to successfully avoid even tyres with diameters up to 6.2 m and larger having low ovalities. This stability helps to improve the life of the brick lining in the kilns considerably.

The meaning behind movement

Why is an upward and downward movement of the rotary kiln actually required? Answer: The same areas on the roller and tyres are constantly being pressed together. This compresses the materials up to the point where the cylindrical shape of the tyre transforms into a convex shape and the roller transforms into a concave profile. Finally, the tyre is locked into the roller – axial floating of the tyre on the roller is not possible. With the kiln length shrinking during a kiln shutdown, the tyre fixation and/or the roller bearing housing can be damaged (Figure 2).

The down-force of the inclined rotary kiln should also be mentioned here. If the incline, for example, is 4%, by a rule of thumb it can be assumed that approximately 4 t per 100 t of kiln weight are pressed downhill. According to the current state of rotary kiln technology, inclined and slightly angled rollers (skewing effect) keep the kiln in position. If the downward force is just as large as the skewing effect of the dry or very scarcely surface-lubricated (graphite block lubrication) rollers, the kiln rotates in place. Therefore, the friction condition of the skewing effect (skew of the roller) is in reality an equilibrium condition. Increasing the dry friction with chalk dust drives the tyres slowly skewing upwards, and oil drops (which are not recommended) or the use of graphite lets the kiln slide down again. This is where human reliability matters, but this cannot be described as a controlled condition.

Furthermore, only cylindrical rollers are used in this context, and there are three functions which are imposed on the ‘unfortunate’ rollers:

- Carrying heavy and fluctuating loads.
- Keeping the down force at bay.
- Transferring longitudinal walking movements.[3]

A mind of its own

In the very narrow pressure surfaces between the rollers and tyres (pitch points) there are permanent biaxial stresses which are particularly dreaded in the presence of edge pressures, as well as being hard to avoid. High specific surface pressure is in addition overlaid by thrust forces. The resulting structural destruction is well known, as well as the possibility of breakage of the thrust rollers. Their over-dimensioning reveals clearly that the rotary kiln designers cannot calculate all the effects of the forces. Even with modern thrust controllers it can repeatedly be seen that the kilns often have their own dynamics, a fact that becomes even more obvious when one takes a careful look at the diagrams of the kiln movements in the control room.

"The kiln doesn't do what we want, it does what it wants!" – This complaint can often be heard at cement plants. The objective perspective from the green table should be: "A disciplined, longitudinally controlled kiln should lead to highly polished cylindrical running surfaces." This probably applies to a number of well-maintained rotary kilns, but why is it that there are still quite a number of kilns which are not working as they should, even with the best longitudinal kiln guiding?

Many years prior, the unnamed cement plant professional quoted earlier encountered the same issue still seen today. He wrote: "Now is the time to think ahead: Would it not be worthwhile investing in good service or purchasing an efficient kiln control system that finally frees us from the ghost of the tortured rotary kiln? A control system that protects the costly kiln equipment, guarantees uptime, eliminates mistrust in the rotary kiln operators and builds trust between the maintenance and process department? Shouldn't it be regarded as technical backwardness that a rotary kiln with uneven, slanting, i.e. skewing rollers can become a problem kiln overnight when the engineers and supervisors are not able to prevent it?"[4]

Years of experience with the 'Zwolf' in a well-maintained condition have proven that cylindrical rollers can be maintained, but foolproof systems remain wishful thinking. Poor kiln maintenance and inadequate understanding of the kiln overall still leads to concave rollers and convex tyre surfaces on mistreated kiln systems, even with the best equipment (Figure 3). When jamming in the movement between the tyre and roller is removed, maintenance can then focus on the drive, power consumption and the prevention of bearing failures.

Conclusion

Cylindrical tyres and rollers are a must for modern kilns, and the kiln hydraulic system must be adjusted so that the tyres move completely across the support rollers. Good operation and maintenance practices (Figure 4) can compensate for ever-dwindling numbers of cement plant personnel. Also, suppliers with modern surveying equipment can help to identify developing issues with the kiln support system quickly and cost-effectively. Early detected and repaired problems can bring considerable savings in kiln maintenance costs. ■

References

1 – 4. 'Was Chemie-Ingenieure und Chemiker von der Zwölf wissen sollten / What chemical engineers and chemists should know about the Zwolf', (1954).

Figure 3. Concave roller; VDZ team during an early assessment.

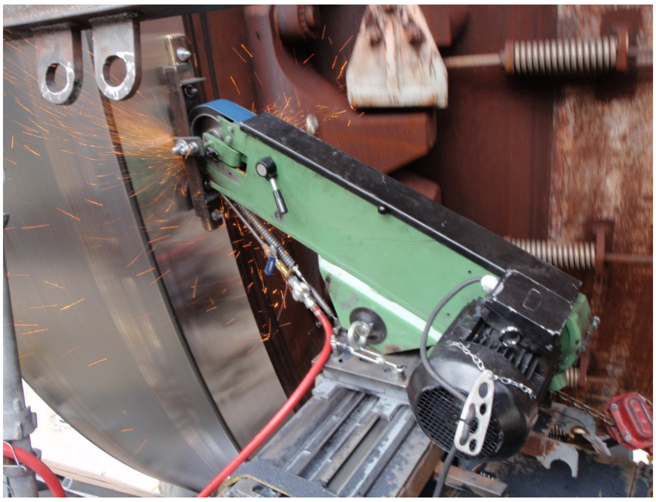

Figure 4. Kiln tyre during refurbishment. Surface on tyre for hydraulic thrust roller.