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MODELLING OF REFRACTORY BRICK FURNITURE IN ROTARY-KILN USING FINITE ELEMENT APPROACH

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Refractory brick lining in rotary kilns is an essential part that controls availability of a kiln operating in extreme conditions and temperatures above 1000 °C. Severely damaged lining will eventually lead to an unplanned production stop, usually lasting 1-2 weeks. A brick lining experiences various degrading mechanisms during its service life. Knowing and avoiding critical situations is of great advantage to the brick's life length. Rotary kilns operate at high temperatures which make the process challenging to model and numerical methods have poorly been used by the industry. This work is focusing on a global mechanical behavior of the brick lining at room temperature, using the finite element method by commercial software LS-Dyna. Fundamental challenges for a brick lining are presented. Approximation of true kiln geometry and a method of sequenced bricklaying of an iron-ore pellet rotary kiln are shown. Stresses in the brick lining at room temperature in static and dynamic cases are evaluated.

Common dimension of a kiln used for iron-ore pellet production is 30-45 meters in length and 5.0-7.5 meters in diameter, which is supported by two pairs of rollers. It is usually lined with a single layer of refractory bricks, see Figure 1. [1]

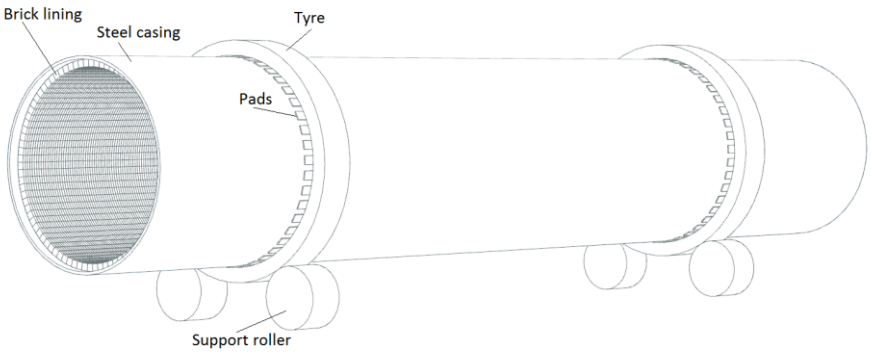

Figure 1. Illustration of a typical short dry-kiln used in iron-ore pellet industry (D_{outer}=7 m, L=40m).

The total operational mass of a large rotary kiln is at least 1 500 metric tons (including steel casing, refractory furniture, pellets and slag). It is well-known and understandable that cross-section of a rotary-kiln casing is not perfectly circular, but is flattened due to gravity force [2-3]. Due to ovality the steel casing and the brick lining will undergo repeatable deformation while rotating since they are tightly fitted together. In other words knowing true geometry of steel casing is necessary in order to correctly reflect behavior of the refractory furniture. Finite element model is used to virtually reproduce the behavior of the bricks. Method of simulating the sequential bricklaying is schematically represented in Figure 3.

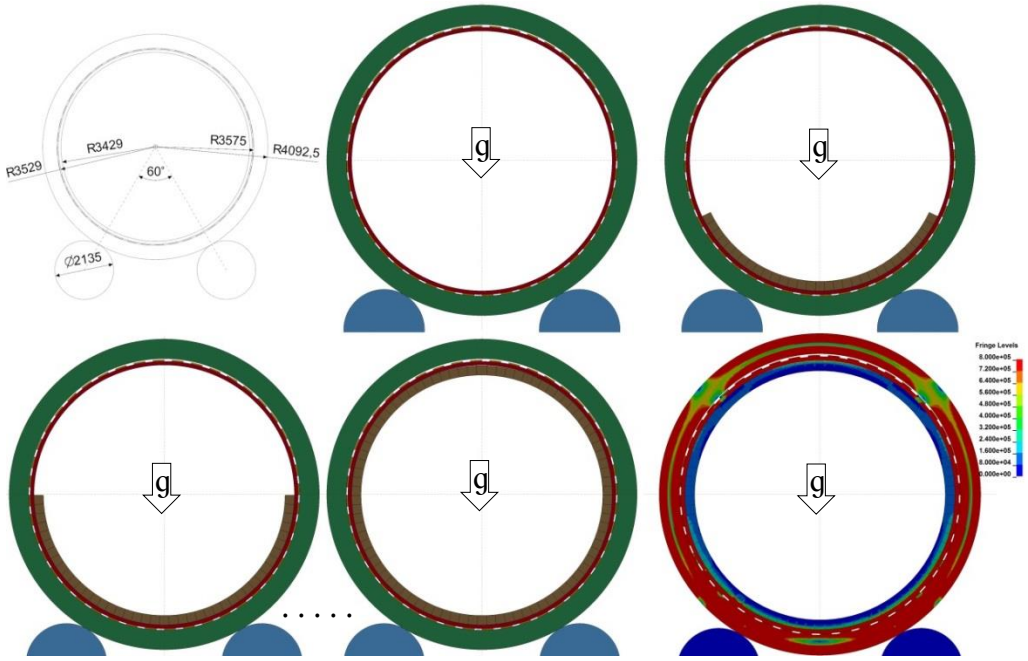

Figure 3. Illustration of the bricklaying sequences using the finite element method.

Maximum von Mises effective stresses in the brick lining in static case at room temperature are below 2 MPa, which is also confirmed analytically. Rotation causes bricks to move relatively each other and change their initial position sporadically; local stresses tend to increase by at least factor 5 compared to the static case. Future goal is to include stresses contributed by thermal expansion. Preliminary analytical calculations indicate that thermo-mechanical loads are above factor 10 higher the loads at room temperature [4]. The model is planned to be used for recognition of violation of technical limits of the brick lining.

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