The foundations of rotary kilns for firing refractory materials are usually only designed for static loading, it being assumed that the furnace does not have a dynamical influence on the foundations and may heat the latter uniformly up to 50°C.

In order to check the validity of these assumptions the Leningrad Branch of the "Foundation Project" Institute carried out a survey of the foundations of 11 rotary kilns at the Veliko-Anadol'sk Chamotte Works and the Nikitovka, Chasov Yar, Yamsk, and Dokuchaevsk Combines.

The diameters of the furnaces vary from 2.5 to 3.6 m, the length from 40 to 90 m, the diameter of the coolers from 2.2 to 2.8 m, and their lengths from 21 to 36 m. The furnaces and the coolers are arranged with an inclination of 3 to 4%. The operating rate of rotation of the furnaces is 1 to 1.3 rpm, and of the coolers 2.3 to 3.5 rpm. The foundations are made of monolithic reinforced concrete.

Nine furnaces have been set up on foundations consisting of wall-type supports of height 6 to 8 m. The coolers are situated under the casing of the furnaces and are inclined in the opposite direction to the inclination of the furnaces. Two furnaces are supported on solid and wall-type supports. Four supports of each of these furnaces are solid; one support—at the hot end—is wall-type. The coolers are situated beyond the discharging ends of the furnaces, with an inclination in the same direction as furnaces (see Fig. 1). The characteristics of the furnaces surveyed, the foundations, and the ground conditions of the site on which they are constructed are given in Table 1.

Damage to the concrete and wear of the mounting were found on the inner surface of the walls and the cross bars of the wall-type supports situated around the hot end of the furnaces. On the wall-type and solid supports there were spots of machine oil which is inadmissible.

To obtain an estimate of the thermal conditions of the foundations we measured the temperature of the concrete of the supports (Table 2). The measurements were made at a temperature of the surrounding air of about 25°C.

The greatest actual value of the additional heating of the concrete of the supports of the furnaces Nos. 2-5, which were set up in buildings, considerably exceeded the temperature usually adopted in design, and reached 130°C. The heating of the supports was nonuniform; the greatest temperature of the concrete occurred in the upper part of the wall; below, it was considerably lower. The temperature drop over the height of the wall was about 80°C. The concrete of the cross bars in the middle under the casing of the furnace was heated to the highest temperatures; the temperature fell off towards the edges of the supports. The internal surfaces of the wall-type supports were heated more than the exterior surfaces. The sections in which damage to the concrete of the supports occurred were situated at the regions of greatest heating. The temperature of the concrete of the supports set up in the open did not exceed 80°C.

The thermal action of the furnaces on the supports must be considered not only in the calculation of stresses, but also in the choice of materials [2]. The temperature of the concrete of the supports No. 1 of all furnaces did not exceed 60°C, and the thermal influence of the furnaces on these supports can be ignored in the choice of materials.

The concrete of the supports is subjected to cyclical thermal stress. Apart from the heating and cooling cycles of the concrete connected with the starting up and stopping of the furnace, the supports are subjected to variable thermal influences due to seasonal changes in the air temperature, and also to the temperature fluctuations in the furnaces.


Vibrations measurements, made by means of an oscillograph and other equipment, showed that the foundations vibrated with several frequencies. The principal frequencies are 1.6 to 2.8; 10 to 13 and 3 to 8 cps, corresponding to the number of interlockings per second of the teeth of the top gear with the teeth of the driving gear of the reductor, the number of rotations of the electric motors of the drive mechanisms and the proper vibration frequencies of the supports.

Vibrations were recorded in the vertical (Z axis), transverse (X axis), and longitudinal (Y axis) directions. The position of the points of measurements of the support vibrations are shown in Fig. 1. The greatest vibration amplitudes of the foundations found during working conditions are given in Table 3.

The maximum amplitudes of the vibrations of the supports were recorded in the transverse direction and amounted to 312 μ at 3 to 8 cps. The vibrations of the supports during a revolution of the furnace were not constant in magnitude.

In the longitudinal and vertical directions the vibration amplitudes proved to be considerably smaller than in the transverse direction. During the starting up of the furnaces and during working conditions individual shocks were registered.

The foundations not only vibrate, but are also displaced in a transverse direction (X axis) with a frequency of 1.0 to 1.3 vibrations per minute, corresponding to the number of revolutions of the furnace per minute. The displacements are due to the fact that the axis of the furnace is usually not ideally straight and the casing is also not perfectly round, and, as a result, horizontal forces arise during the operation of the furnace; these tend to displace the supports of the foundation in a direction perpendicular to the axis of the furnace.

![Fig. 1. Solid (a) and wall-type (b) foundations of rotary kilns: 1) furnace casing; II) cooler casing; 1) - 5) are the numbers of the supports of the furnace or cooler; the + signs indicate the points at which the vibrations were measured; the ○ symbols indicate the points at which the temperature of the concrete was measured.](image-url)