progressive production techniques; the transfer of heating units to natural-gas firing; improvement in the use of equipment at present in operation, elimination of idle periods and spoilage, specialization by plants, shops and individual production lines; study and introduction of advanced methods of organizing labor and production in each sector; improvement in the grading and sorting of parts, initiation and development of the production of new types of super-duty refractories.

When carrying out research with a view to improving labor productivity, attention should be given, apart from the basic production, to auxiliary and subsidiary shops where the reserves are often very extensive.

Labor productivity figures in the refractory industry are closely bound up with production costs.

The proportion of wages in the cost of refractories is more than 40%. A reduction in the amount of labor used by improving labor productivity is an important way of reducing the cost of refractories.

HEAT ENGINEERING

DEVELOPMENT OF HEAT ENGINEERING IN REFRACTORY INDUSTRY

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Before the Revolution heat engineering at refractory plants was at a very low technical level. The clay was dried in hearth dryers and parts were dried on stands. Clay was fired into chamotte in continuous and ring-type kilns, magnesite and dolomite in cupolas. Continuous, ring-type and gas-chamber kilns were used to fire parts.

It was only in the years of the first few Five-Year Plans that more efficient heating units were installed at refractory plants. The first tunnel type and rotary kilns were built from foreign design. Over this period drying drums, compartment-type dryers and tunnel-type dryers with shelf cars were installed at a number of plants. The tunnel-type dryers with kiln cars first appeared at the Chasov-Yar Combine for drying chamotte parts after semidry pressing.

The tunnel-type, gas-chamber and some of the ring and shaft-type kilns built during this period were designed to operate on generator gas, while the other types were mainly heated by coal. Prior to this most of the ring type kilns used wood as the fuel.

As the new heating equipment was designed by research institutes and gradually introduced at the plants, ways of further improving it became clearer.

It was found that the best units for firing chamotte parts were tunnel-type kilns in which hot generator gas fed through burners, while the air required for combustion was fed along the tunnel through the cooling zone since it was then preheated to a high temperature.

In the kilns of this type built in shop No. 7 at the Chasov-Yar Refractory Combine the required firing temperature is easily attained and the productivity of the kiln is very high; the firing is efficient and the fuel consumption is low. In the tunnel-type kilns in which the air required for combustion passes through the recuperators fitted in the walls and roof of the cooling zone, the air is at a low temperature and this fact has resulted in great difficulties in reaching the temperature needed for firing parts. The kilns at the Chasov-Yar Combine are very economical to run on account of the fact that their section is large in size and the walls and roof in the dinas brick firing zone are very strong. This fact has been taken into account in designing new tunnel type kilns.

On the basis of acquired experience, a tunnel type kiln has been designed and constructed for firing chrome-magnesite parts at the Chasov-Yar Combine; it has a section 3.06x0.98 and is 153 m long. The kiln was put into operation in the post-war period.

When coal was introduced for heating ring-type kilns at a number of plants, the semigas firing boxes designed by Z. Ye. Dobrin were used and the amount of spoilage from slagging was thereby reduced.

The productivity of ring type and continuous kilns was considerably improved by intensifying the draft and taking other measures.

Tunnel-type kilns with rack-type cars are used for drying magnesian parts.

During these years work was begun on the designing and construction of plants for purifying the flue gases from the drying drums and rotary kilns. Battery cyclones were fitted to the rotary kilns at the Magnezit Plant to clean the flue gases.

A further increase in technical level of heat engineering at refractory plants relating to the post-war period took the form of improvement in the existing thermal equipment and the construction of tunnel-type and rotary kilns of improved design. A great deal of attention has been given to improving working conditions, mechanization and automation and removing dust from flue gases from the drying drums and rotary kiln.

There was considerable improvement in the operation of shaft type kilns for firing clay into chamotte through the use of a spherical compact which improved the distribution of the gas stream over the kiln section, the square section of the kiln was replaced by a circular one, the draft resources were intensified, the number of burners was increased and
their arrangement altered, the design of the unloading devices was improved, and thermal inspection and regulation of the operation of the kiln was automated. As a result of all this work, the efficiency of the shaft-type kilns was greatly stepped up, the quality of the chamotte was improved and the fuel consumption reduced.

Only high-efficiency rotary kilns are being designed at the present time for firing refractory raw material. The working machine for these kilns is easy to automate. When fired in a rotary kiln, clay and kaolin do not need preprocessing in many cases.

A disadvantage of the rotary kiln of standard design is the high temperature of the waste gases, which reaches 400-500°C when clay is fired, and 750-800°C when magnesite and dolomite are fired, the high fuel consumption and relatively large amount of dust carried away.

In view of this, the designs for rotary kilns provide for utilization of the heat from the outgoing gases by a water-heating device, waste-heat boiler or device for preheating and predrying the raw material. Study of an experimental plant has shown that if a chamotte firing rotary kiln is fitted with a shaft type preheater, the productivity of the kiln can be stepped up by 15-17% and the specific fuel consumption cut down by 13%.

The flue gas heat can be most efficiently used for preprocessing the raw material in rotary kilns with a preparatory conveyor grating. Research has shown that when magnesite and dolomite are fired in rotary kilns with a preparatory conveyor grating, the specific consumption of fuel is reduced by a factor of more or less 1-1/2.

Automatic control of the operation of rotary kilns is effected by a system stabilizing the basic parameters: pressure and fuel consumption (for gas and mazut), primary air, air surplus coefficient, amount of raw material fed to kiln, and so on.

To clean flue gases at the chamotte-firing plants built over the last few years use is made of electrofilters which trap at least 99% of the dust, and in the case of magnesite firing plants 2-stage flue gas cleaning systems using cyclones and electrofilters designed by NIIOGAZ.

High figures have been attained in rotary kilns in the specific removal of parts and time factor of the kilns: specific removal of chamotte is up to 30 kg/m hr, magnesite and dolomite 15-18 kg/m² hr, while the time utilization factor is 98%.

Over the last few years the drying drums in the clay drying sections have been automated and an effective cleaning system for flue gases has been introduced.

As dust traps, use is made of wet dust traps, electrofilters, foam filters, cyclones, washers, scrubbers, and so on. The efficiency with which the dust is trapped is 95-99.5% for electrofilters, and 90-97% for other systems.

Research carried out over the last few years has shown the possibility and advisability of using shaft-type mills for drying clay; in these mills the clay is ground and dried at the same time, which cuts down the cost of building and operating the plant, as compared with drying drums and disintegrators.

Ring-type kilns have been improved by the change to gas firing, a further intensification of the draft resources, and the use of lightweight dinas for the linings. The implementation of these measures has brought about an increase in the fire rate from 13-14 to 20-24 m/day.

The conversion of gas chamber kilns at the Magnezit Plant to ring-type kilns has more than doubled their efficiency.

The improvement of the ring-type and gas-chamber kilns has improved their operation, but has not made it possible to eliminate the fundamental defects in these units, among which are heavy working conditions for the servicing personnel and the difficulty of automating the operational regime. It has, therefore, become necessary to design tunnel-type kilns which can replace ring type and continuous kilns without having to reconstruct the building available. Tunnel-type kilns of this type, of high quality VIO for firing chamotte parts have been constructed at a number of plants in the Soviet Union, and also abroad.

The output of a kiln 60-66 m long with a section 3 x 1.9 m is 60-75,000 tons per year, while the specific consumption of referred fuel is about 90 kg/ton and the acceptable yield 98-99%.

The VIO has brought out an improved design for a tunnel-type kiln with a 3 x 2.1 m section, 120 m long, which is being built now at many refractory plants. This kiln can fire chamotte parts weighing up to 100 kg.

All the tunnel-type kilns under construction have dryers with kiln cars.

For firing dinas parts the VIO has designed tunnel-type kilns on the basis of post-war research; it is 157.5 m long and has a section 2 x 2.1 m.

These kilns, which have been built at the Krasnoyarsk Dinas Plant and in the Polish People's Republic can fire open-hearth parts and shaped coke parts weighing up to 12 kg. In 1958, on the basis of experience gained in the operation of these kilns, the VIO designed anew tunnel-type kiln with a 3 x 2.1 m section and length 180 m which could be used for firing all dinas parts, including the heaviest and most intricately shaped ones. In front of the kiln there was a tunnel-type dryer with kiln cars. Kilns are being constructed at the present time on the basis of this design at the Perovoural'sk Dinas Plant and also in the Polish People's Republic.

In 1950 the VIO designed a tunnel-type kiln with a length 156 m and section 3 x 1.1 for firing magnesian parts. The kiln is designed to make maximum use of the hot air for purposes of combustion, and also has other improvements. When firing parts to 1800°C the efficiency of the kiln is 60,000 tons per year with a high quality of output and specific fuel consumption of about 140 kg/t.

Kilns of this design are used at the Semiliuki Plant for firing high-alumina parts.

In view of the rise in the firing temperature for magnesian parts to 1750°C during the transition to manufacture of dense magnesite-chrome and periclase spinel parts, the kiln has been reconstructed in the following way: magnesite-chrome brick is now used for the suspension roof in the firing zone; the ventilation equipment has been made more powerful. A similar kiln is being designed for firing parts at particularly high temperatures, but the tunnel height is 0.75 m. The kilns are being built together with tunnel-type dryers with kiln cars in all these projects so that the greenware can be batched immediately onto the kiln cars after it has been pressed.

The VIO has also designed specialized tunnel-type kilns for firing chamotte lightweight parts after semidry or plastic pressing, for firing high-alumina and kaolin glass blocks, and for firing carborundum parts.