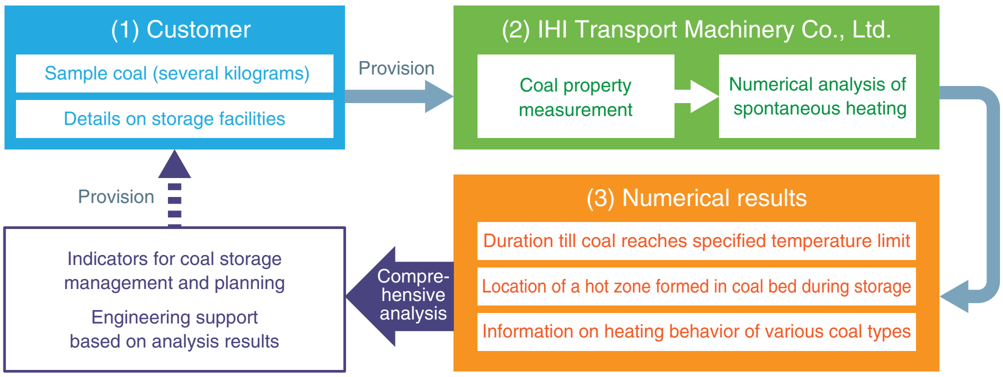
High-Accuracy Prediction of Safely-Storable Days of Low-Rank Coal

Prediction system of heat build-up in storage facilities to ensure safe storage of low-rank coal, a cost-efficient energy source

Compared to conventionally used coal (high-rank coal), low-rank coal has a lower calorific value, but it is less expensive. One effect expected from the shut-down of nuclear power plants following the Great East Japan Earthquake of 2011 was rising demand for low-rank coal, but low-rank coal has the disadvantageous characteristic of being prone to heat build-up during storage. The “coal storage facility heating prediction system” developed by IHI Transport Machinery Co., Ltd. (IUK) is capable of (1) simulating the heat generated in coal considering the kind of coal, (2) comprehensive assessing of the analysis results, (3) advising on the management and planning of coal storage including facilities.



Coal storage facility heating prediction system

Low-rank coal is prone to heat build-up during storage

Coal with a lower calorific value than conventionally used coal (high-rank coal = bituminous coal), is called low-rank coal (sub-bituminous coal). Low-rank coal is inferior in calorific value, but due to its higher volume of production and cost efficiency, it has been attracting attention for many years as an energy source that can replace conventionally used coal. A method called “coal blending” — in which low-rank coal is blended into high-rank coal at a predetermined ratio, so that low-rank coal is used as a fuel while the desired calorific value is maintained — is used in some cases. However, low-rank coal is difficult to handle (difficult to store and transport), so it is currently difficult for coal-fired power plants to adopt low-rank coal as a main fuel.

Coal left to stand at a certain temperature or pressure for many hours gradually reacts with oxygen in the air which causes it to get hot. For this reason, coal-fired power plants usually make a plan that stipulates a “use-by period” for coal kept in a storage place (generally a silo). Compared to conventionally used high-rank coal, low-rank coal is more prone to such heating. Nevertheless, specific factors in the heating of low-rank coal — storage conditions and storage period — as well as the specific heating behavior — how the temperature changes — have been unknown to date. This is why coal-fired power plants hesitate to use low-rank coal despite they are eager to use more from economic perspective.

IUK is engaged in the development and manufacturing of coal unloading and transportation facilities, which seamlessly perform a series of coal handling processes — unloading at a port, transportation, storage, and loading into boilers. As part of such activities, IUK has been working on the development of the prediction system with the objective of contributing to the safe handling of low-rank coal at power plants and elsewhere.

Data collection using 120 tons test silo

The development team addressed two major challenges. The first challenge was to construct a test storage silo used to verify simulation results. In order to obtain reliable data, it was required to install a number of thermometers in the silo and closely monitor temperature changes in the pile of coal. A silo at a coal-fired power plant is dozens of meters in both diameter and height and has a coal storage capacity of several tens to hundred thousands of tons. Of course, it is impossible to measure across such a large-sized silo. In order to reproduce actual situations as possible as we can for the acquisition of test data, IUK constructed an experimental coal storage silo with a diameter of 5 m, a height of 15 m, and a coal storage capacity of 120 tons at its Numazu Works (in Shizuoka). The duration of each storage test varied, ranging from several weeks to over 100 days.

The second challenge was numerical analysis, the core function of the new system. Spontaneous combustion occurs as a consequence of gradual oxidation, heat generation, heat accumulation, and moisture evaporation of coal. By conducting storage tests using the experimental coal storage silo, we were able to ascertain the mechanism of this phenomenon. Moreover, we analyzed the data, thereby completing a heating simulation program based on a proprietary algorithm (for more information, see “Storage and Handling of Low-Rank Coal” on page 17).

One advantage is the ability to provide facilities to solve problems

Currently in Japan, coal fired power generation only with low-rank coal, which has high sulfur content, is not recommended because sulfuric acid is produced in the boiler due to combustion, which then causes deterioration in ferrous structural members. For this reason, low-rank coal is usually blended with conventionally used high-rank coal at a ratio of 10% to 20%, as mentioned above. In this case, however, the consumption of low-rank coal is much lower than that of high-rank coal, so storing low-rank coal for a prolonged period of time is unavoidable. As low-rank coal is prone to heat build-up, safe management of low-rank coal in storage requires prediction of temperatures in a silo.

Some coal handling or steel making companies have this kind of simulation technology. However, IUK has an edge over such companies in that not only is it able to perform simulations, but it can propose measures to suppress heat build-up — for example, suppressing incoming and outgoing airflows, and installing additional monitoring equipment — and provide such equipment as a manufacturer. IUK has base technologies that help provide an account of reasons for problems and propose improvement measures as well as help propose and provide solutions to problems. It is therefore expected that there will be high demand for this new system from electric utility companies and power plants inside and outside Japan.

Experimental coal storage silo (IUK Numazu Works)

Communication with customers is a key

In future development, information obtained through our communication with customers engaged in coal handling will play a key role. This is because a wide variety of data — for example, the size, shape, and storage capacity of the silo; the places of origin of coal (coal types); operating conditions, etc. are required to perform high-accuracy simulations.

In addition, the policy for coal use varies from customer to customer. Some customers use coal giving priority to coal types prone to heat generation. Other customers only cool the pile of coal as necessary by cutting away part of the pile to prevent heating. We will quickly acquire information on such policies to give useful suggestion for each customer’s needs.

The safe control and management of coal-fired power plants and their continuous operation are essential to society as well. Above mentioned coal storage facility heating prediction system provides highly accurate guides necessary for coal storage management and coal use planning. In other words, the system provides behind-the-scenes support to supply stable and safe electric power. We will appeal these advantages in hopes that the system will be selected for use in actual silos to reduce electricity costs via adopting low-rank coal.

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