Performance of Furnaces with Intermittently Moving Stokers Operating on Crushed Peat

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PERFORMANCE OF FURNACES WITH INTERMITTENTLY MOVING STOKERS OPERATING ON CRUSHED PEAT

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Outstanding in the attempts at mechanizing the stoking of small steam boilers is a furnace with an intermittently moving stoker, the basic part of which consists of a flat blast grate successfully adaptable to many fuels.

The boiler of the P-3 locomobile with a capacity of 600 kilograms of steam per hour for servicing a peat-extracting unit is equipped with a furnace with an intermittently moving stoker. The unit operates on fires of machine-formed peat, a crushed fuel with approximately a 20 percent content of 0 to 5 millimeter particles and a 35 percent moisture content.

The volume of the combustion chamber (Figure 1) is 1.112 cubic meters and the height 1.3 meters. The level of the fire grate is located 260 millimeters below the bottom opening of the combustion chamber of the locomobile. The fire grate consists of non-collapsible T-shaped bars gathered in to bundles with tie bolts, and can be lowered from the working level and lifted again into place.

At the end of the grate is a small baffle plate and a slag plate whose inclination can be varied. The opening at the baffle for the removal of the slag is closed with a swinging door.

To protect the bottom opening from burning over the baffle and at the fuel gate there are protective vaults of one brick in thickness. Moreover, a water-cooled panel, through which all the water fed into the boiler passes, is placed at the level of the bottom opening.

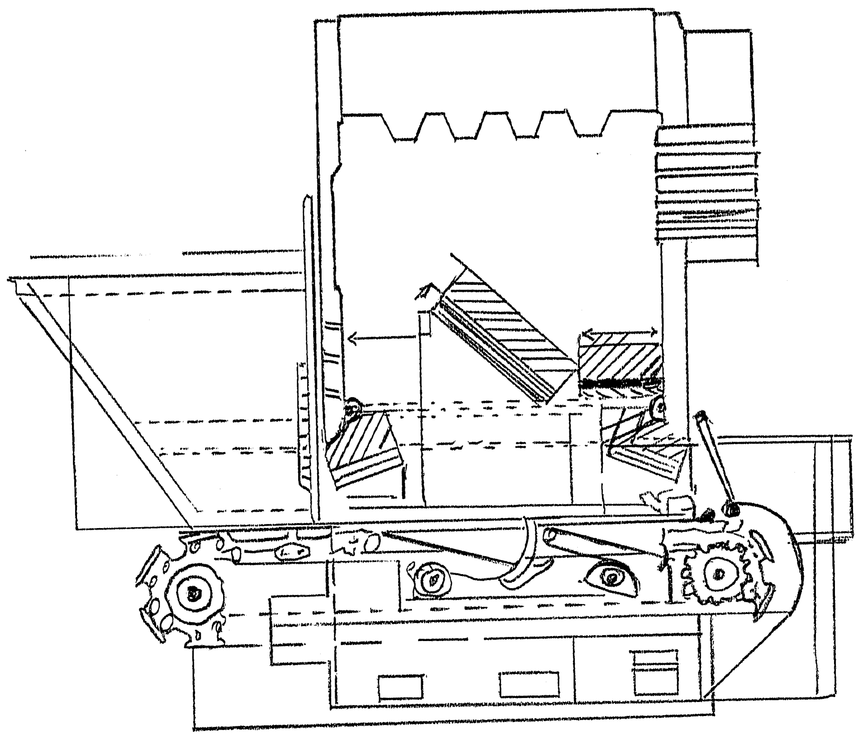

Figure 1. Furnace for locomobile with intermittent stoker and lowerable grates

1 -- bunker; 2 -- intermittent stoker; 3 -- moving chain, transporting the stoker; 4 -- lowerable grates; 5 -- protective vaults; 6 -- vault; 7 -- eccentrics for moving the grates

The reversing motion of the intermittent stoker is effected with the aid of belt drives with straight and cross belts, and two shift levers, controlled by a rack and pinion gear with lugs which moves with the stoker. The arrangement is similar to that used to change the direction of planer tables.

The shifting mechanism (Figure 2) has 3 pulleys on one axis. The center pulley -- a wide one (100 millimeters) -- carries the load; the idle (outside) pulleys -- narrow (50 millimeters) -- turn freely on the shaft. The stoker stands still whenever both belts are on the outside pulleys. If one of the belts -- either the straight one or the cross belt is transferred to the load pulley, the stoker moves forward or backwards, and can be stopped in any place by shifting both belts to the idle pulleys. For this purpose one of the shift levers is equipped with a hand grip.

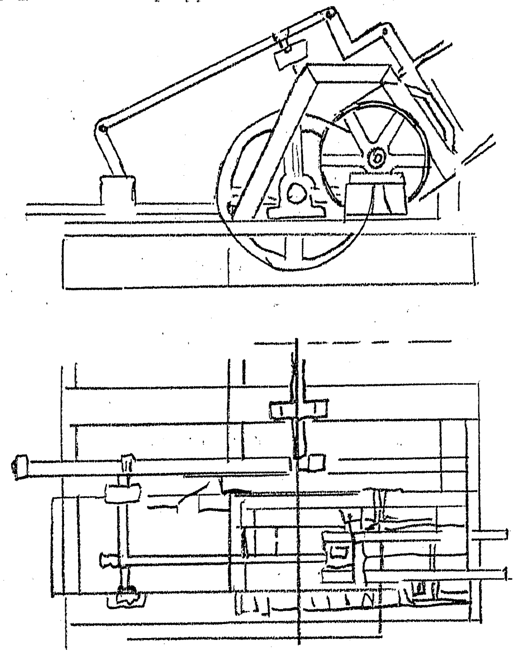

Figure 2. Reverse drive of the intermittent stoker

1 -- working pulley; 2 -- shifting lever; 3 -- shaft; 4 -- lever; 5 -- connecting rod; 6 -- shaft of chain wheel; 7 -- gear; 8 -- journal bearing; 9 -- shaft; 10 -- intermediate shaft; 11 -- connecting rod; 12 -- shifting lever; 13 -- lug; 14 -- forward lug; 15 -- idle pulleys

The gear rack has three lugs; the outside ones change the direction of motion of the stoker at the extreme forward (at the baffle) and extreme rear (in the fuel bunker) positions. The lugs do this by reversing the levers in one or the other direction, and at the same time moving a sliding block with figured slots. The block controls the motion of the shift levers. When these two outside lugs are employed, the stoker makes its maximum intermittent travel.

So that the stoker can work at short fuel-feeding motions, a third lug, located between the two outside lugs, can be brought into and out of the working position by pressing a pedal.

The stoker is stopped with the help of a clamp which turns on one of the rods of the reversing mechanism. Turned 90 degrees, this clamp, when the levers are moved alternately, goes into a slot in a fixed elbow and stops both transmissions on the idle pulleys.

The first trials of the furnace ran into the difficulty of organizing the combustion of the peat particles when the length of the grate panel was too short. Attempts to add fuel to that half of the fire grate approaching the baffle resulted in rapid removal of the hot part of the fuel bed to the baffle and cessation of combustion. This was due to the fact that the intermittent stoker adds fresh fuel not on top of the already burning fuel, but first replaces the lower, burning part of the fuel bed. If the speed with which the fuel bed is ignited is less than the speed with which the stoker moves the intensely burning part of the fuel bed toward the baffle, combustion ceases.

It became possible to operate the furnace on peat particles only when the feeding of fuel was accompanied by short strokes of the stoker. (The total length of the feeding motion is 360 millimeters (190 millimeters in the bunker and 170 millimeters in the furnace).) When feeding is done in this fashion, a mound up to 400 millimeters high piles up at the beginning of the grate. The fuel then dries out and tumbles down on top of the burning fuel beds. A second method, fostering improved operation of the furnace on crushed peat, was to partially separate pieces smaller than 5 millimeters out of the fuel in many tests.

All the tests made on the boiler equipped with a furnace with stationary grate bars (before the grate bars were made capable of being lowered) revealed the dependence of the frequency of the intermittent motions on the moisture content of the fuel. As the moisture content increased, it was necessary to reduce the number of motions since each of them disturbed the combustion.

At 46 percent moisture content it was necessary to eliminate those motions which move the hot part of the fuel bed toward the baffle, and allow only the motions which added fuel while the slag was removed manually. In all trials in which the moisture content of the fuel was greater than 30 percent, except trials conducted with lowerable grate, for the most part the cleaning of the grate and the removal of slag was done manually.

The reduction of the dimensions of the stoker and the bringing of its height up to 15 - 17 millimeters, effected at the very beginning of the work, reduced the breaking-up of the fuel bed during the stoking motion, but did not solve the problem of fully mechanizing the cleaning of the grate (speed of the traveling stoker -- 0.12 meter/second).

Tests on the furnace with peat of higher moisture content of 38 to 45 percent, at which the boiler performance was very low, showed that it was essential to further improve the preparation of the fuel for combustion. For this purpose, the vault in the boiler was considerably lowered, as shown in Figure 1 (before this the arch was considerably higher). This arrangement helped increase the power of the

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furnace using peat with a moisture content of 42 to 46 percent and simultaneously increased the efficiency of the boiler by 55 percent (η_k = 0.55), the increased efficiency occurring during the burning of dry peat with a moisture content of 23 - 30 percent (W^P = 23 - 30 percent).

Cleaning the grate of ash and cinders with the aid of the stoker was possible only when the moisture content of the peat was less than 30 percent. When the moisture was increased, the frequency of long travel, during which the work of the fuel bed is undisturbed (the fire does not get to the baffle), had to be reduced sharply. In connection with this it is necessary for the fireman to clean by hand, with a skimmer, that part of the intensively operating fire grate closest to the baffle.

It was essential to insure the chance of cleaning the grate mechanically, and moreover, to achieve further improvement in the preparation of the fuel for combustion.

The possibility of adding fresh fuel on top of the already burning fuel with the aid of the intermittent stoker, and the possibility of thus ensuring "unlimited" combustion, can be achieved in the case when the stoker, moving forward toward the baffle, passes not in the immediate vicinity of the fire grate but some distance above it. Under these circumstances the ignited part of the fuel bed closest to the grate does not become displaced by the stoker. The stoker at the same time places fresh fuel on top of the ignited fuel at the grate.

To realize the described process of adding fresh fuel on the ignited fuel with the aid of the intermittent stoker, the groups of fire bars comprising the grate were replaced by bars capable of being lowered (author's certificate No 91770 of 24 May 1950 in the name of N. M. Pyatyshkin). As the hot fuel lying on the grate bars is lowered together with them, fresh fuel is placed on top of the burning fuel. The bars are lowered with the aid of eccentrics placed in the ash pit. The grate bars rest on cast-iron journals and their lowering is effected in the same manner as the lowering of swinging grate bars. The lowered grate bar does not open the opening into the ashpit, inasmuch as the vertical walls along its edges contain openings for the passage of air.

This arrangement improved the preparation of the fuel and made it possible to completely clean the fire grate and remove the slag by means of the stoker, entirely eliminating manual cleaning. With fully mechanized cleaning of the grate, several experiments were made with peat having a 34.2 percent and a 36.8 percent moisture content.

During these tests, one of which was conducted with a nearly normal load and the other with the boiler overloaded, the forward grate bars were left lowered all the time; the rear bars were lowered by the machine operator before each long travel, and after the transition into short travels were returned to the horizontal position. Since the hole formed by lowering the grate bars was filled with glowing coke, and the fuel delivered to the baffle by the stoker during the long travel was dried, the combustion was unimpaired after the long travel. It was also unimpaired when it was necessary to make several (2 - 3) short shakes travels to the baffle for the purpose of removing large pieces of slag. The slag formed a bank about 200 millimeters high on the slag board. From time to time, after a

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series of long travels by the stoker, pieces of slag detached themselves from this bank and fell on the ground.

Before the final test to raise the dependability of the operation of the transmission cross belt, which controls the forward travel of the stoker, the driving pulley of this belt was increased approximately 50 percent. This raised the frequency of the motions somewhat, but simultaneously reduced the fuel feeding per stoker movement, since the speed of the stoker during the forward motion was increased.

During the final tests of the furnace with lowerable grates, the percentage of peat particles smaller than 5 millimeters was between 19 and 28 percent, the moisture content between 34 and 37 percent, and the ash content of the dry mass between 15 and 16 percent.

When a fixed fire grate and fuel with an increased moisture content (above 38 percent) were used, long movements of the stoker strongly impaired the combustion, and often disrupted it. Because of this, when using fixed fire grates and a high moisture content peat (above 42 - 43 percent) it was necessary to forego slag removal by mechanical means and perform this operation by hand.

With lowerable grates, long movements did not affect the process of combustion and permitted fully mechanized removal of slag from the grate.

Experience showed that best results are obtained when the stoker makes 200 - 300 short motions an hour to feed the fuel, regardless of the type of grate (fixed or lowerable).

As contrasted with fixed grates, for grates with lowerable bars the number of long movements of the stoker does not depend on the moisture content of the fuel, but only on the cinder content and the properties of the cinders.

To provide completely mechanized removal of slag from the grate having lowerable bars, there should be only 12 - 15 motions (when A^c = 14 - 17 percent) per hour by the stoker.

The maximum amount of heat evolved at the grate was found to be 1300 - 1350 X 10^3 kilocalories per square meter/hour. With moisture content higher than 30 percent there was a high dependence of the heat evolved on the initial moisture content and on the method employed in operating the stoker.

With moisture content between 37.9 ÷ [sic] 45.2 percent, it was possible to improve the performance of the furnace considerably by changing the method of operation; the heat evolved at the grate was raised to a mean value of Q/R = 850 X 10^3 kilocalories per square meter hour and maximum value of 1100 X 10^3 kilocalories per square meter hour (all tests were made with cold air).

The increase in the number of short feeding movements of the stoker was accompanied by a steady, gradual increase in the heat evolved at the fire grate, regardless of the parallel increase in the moisture content of the fuel.

It is therefore possible to conclude that the heat evolved at the grate, and hence the steam productivity of the boiler of the P3 Locomobile, are substantially influenced by the number of short movements of the stoker per hour, and that as the moisture content increases the number of movements per hour should increase. Moreover, tests permit comparison of the following characteristic peculiarity of an experimental furnace with that of a hand-fired furnace.

In a hand-fired furnace the heat evolved at the grate increases with the quantity of added fuel only up to a certain point, determined by the fuel's moisture content, which normally should not exceed 35 - 40 percent.

As the moisture content of the fuel is increased, an increased addition of fuel may extinguish the furnace. With the moisture content higher than 40 - 42 percent, the performance of the hand-fired furnace becomes unstable and necessitates reduction in output.

A different picture is presented by the furnace with intermittent stoker when fuel is added in short movements.

When it is fed in short movements, the main mass of the fuel is in the forward part of the grate, forming a "mound" about 400 millimeters high.

The slope of the mound, directed toward the baffle, is lower than the angle of repose, forming a rather large surface in contact with the products of combustions, which are evolved at the horizontal part of the fuel bed, situated between the mound and the baffle. Thus the slope of the mound is equivalent to a dryer, preparing the raw fuel for feeding to the hot horizontal portion of the fuel bed. This permits raising the moisture limit above that permissible for hand-fired furnaces. In the case of peat particles with maximum moisture content of 46 percent the heat evolved at the grate was the same as when the moisture content was 28.7 percent.

Losses from incomplete chemical combustion in the latest experiments with lowerable grates were approximately 4.5 percent; it appears that this loss is dependent, although slightly, on the method of operating the stoker.

Losses due to incomplete chemical combustion are somewhat lower when the number of motions per hour is increased. When the number of motions are decreased chemical losses are increased. However, this relationship is not fixed or regular enough.

The total loss from mechanically incomplete combustion amounted to 7 - 8.7 percent, which figure includes fuel dropped in delivery 0.7 to 3.9 percent, slag 0.8 to 1.3 percent, and carried away 1.9 to 7 percent. The efficiency of the furnace was 86 to 88 percent.

The furnace has been operating continuously and successfully since April 1951 in the P-3 Locomobile at the Derazhnyanski Peat Enterprise of the MMTP USSR, using the peat particles from machine formed peat.

From the testing and operation of the furnace, it is possible to make the following conclusions:

1. When there is adequate power and fully mechanized maintenance of the fuel bed with crushed peat from machine-formed peat, the furnace can operate reliably at the same coefficients of performance as that at which run-of-the mill lump machine-formed peat burns in ordinary internal furnaces with cross bars.

2. The furnace can be recommended for the mechanization of the combustion of peat particles under small boilers in industrial installations.

3. Lowerable fire bars, from which a grate 3 - 4 meters or longer can be formed, permit burning fuel with a higher moisture content and completely mechanized cleaning of the grate.

4. Further work to perfect the equipment should be done along the following lines: make the shifting of the lowerable grates occur automatically with the shifting of the stoker, provide separate regulation of air flow to the various groups of bars, and further simplify the stoker transmission.