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SECOND CYCLE OF TESTS ON UNDERGROUND GASIFICATION OF COAL IN THE KU

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SECOND CYCLE OF TESTS ON UNDERGROUND GASIFICATION OF COAL IN THE KUZBASS

– as translated from RUSSIAN

Второй цикл опытов подземной газификации угля в Кузбассе

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SECOND CYCLE OF TESTS ON UNDERGROUND GASIFICATION OF COAL IN THE KUZBASS

B.F. GRINDLER

In the May 1st issue of "Leninskii shakhter" [Leninsk Miner] B.F. Grindler, scientific supervisor and chief of operations on underground gasification of coal, reported that the seam was ignited on April 27th at 10 p.m. after 8 h of cold tests on the coal panel and equipment. 12 h after ignition fuel gas was obtained from all three parts of the prepared panel.

In the present paper the author gives a profound analysis of the earlier trials and develops a detailed picture of the second cycle of tests. The entire Soviet society is paying close attention to this work.

In the course of underground gasification of the Zhurinsk seam in the Leninsk mine in 1934 we were able to observe, for the first time in the world, a continuous 6-month long formation of fuel gas from a coal block ignited underground; also for the first time in the world, the underground-produced gas was used for 38 days to drive a steam boiler satisfying all the requirements of the Leninsk mine. However, these first tests indicated that both in the selection of the test section and in the performance of the trial itself we failed to take into account certain circumstances which had an adverse effect on the course of the underground gasification of coal (UGC).

This shortcoming was not due to general technical incompetence or negligence, as it appeared only in the course of the trial, in a process that at present cannot by any means be regarded as fully mastered or studied. Also, together with the adverse consequences for our first trial, the above shortcoming gave us and the whole UGC sector something very valuable: it taught us a great deal, and -- with a very minor expenditure of time and means -- helped to orient us in a number of aspects of the problem; it served as a lesson showing how UGC should not be carried out.

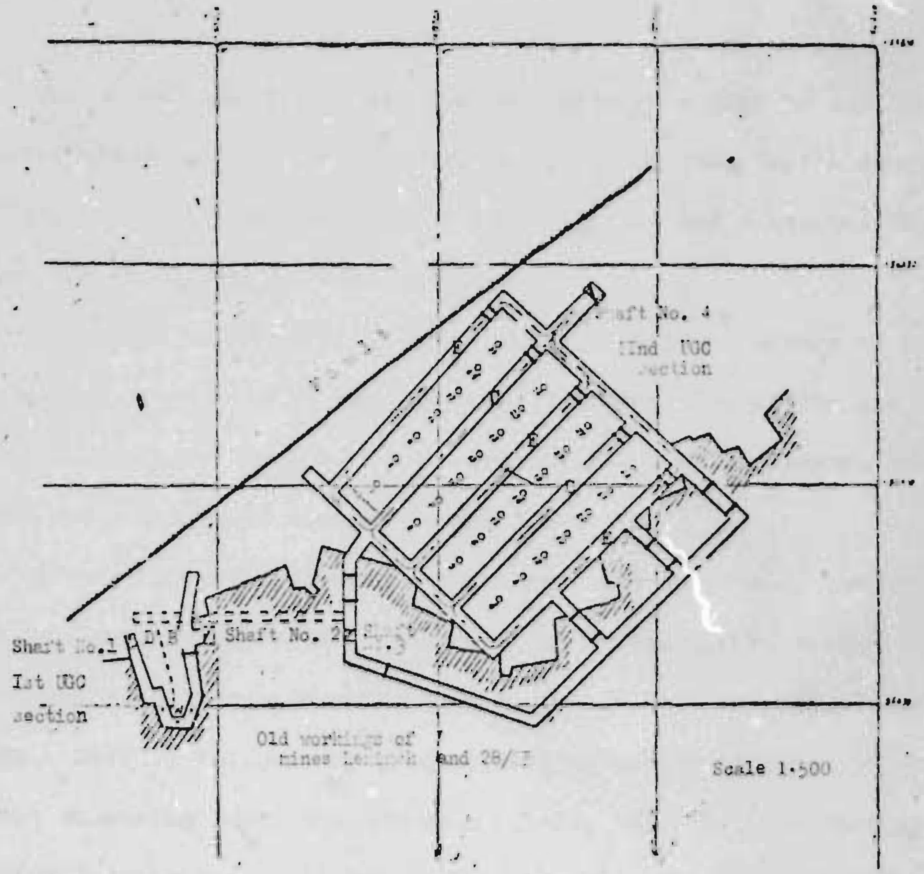
This refers in the first place to the configuration of the test section. The coal block used for the first trial (see illustration) was taken in the natural state in which it had been left after being worked from three sides by the Leninsk mine, following the fire of 1928-1929. According to the original plan, proposed by us in 1932 (see "Ways and means of putting the idea of an underground gas generator into effect" at Leninsk, Ugol' Vostoka, No. 4, 1933), we aimed at checking

S.I. Drago's concepts and hence selected a scheme in which ignition was carried out in places indicated by the crosses; fresh air was introduced via shaft No. 2 and the gas was pumped off through shaft No. 1.

If Drago's idea that the combustion would move from shaft No. 2 toward shaft No. 1 through the block were confirmed, the UGC process in our section would have lasted for over a year. However, owing to the insufficient amount of air supplied by the blower set up on shaft No. 2, there was only enough oxygen for maintaining combustion along one long side of the panel adjacent to shaft No. 2. This promoted the development of gasification under our conditions, but at the same time it also promoted spread of the combustion in the direction of shaft No. 2 and burning out of the coal along line A-B.

At the same time a hazard appeared with respect to the mine yard of shaft No. 2, protected only by a clay bulkhead constructed to allow safe exit of personnel from the shaft after ignition. When, after 5½ months, the mine yard and the lower part of shaft No. 2 burnt and collapsed, and the coal block was burnt out along the drift to a distance of about 4 m (see broken line), the remaining part of the block could not stand up to the ever-increasing pressure of the settling roof from side A-B and cracked up. Short flows of air were then established between shafts No. 2 and 1 and combustion proceeded along the line B-D.

Drago's scheme of preparation of the section as carried out by us thus proved to be unsuitable. We might in fact speak of a greater distance between shafts 2 and 1 (along B-D) and of a more obtuse angle, but even then, since the air flow should have passed (starting from shaft No. 2) along the fire face, the latter -- and consequently the normal course of the entire process -- would always be threatened by collapse of the roof, which could deflect the flow from the surface undergoing gasification and even completely block up all passages.



Plan of the UGC test section in the Zhurinsk coal seam. Leninsk-Kuznetskii, western Siberian territory.

Therefore, our first and most important conclusion at the end of 6 months of the trial, conclusion perhaps most important for the UGC sector in general, was that the methods of section preparation and the configuration must be such that the circulation of air and the gases is least threatened by:

a) collapse of the roof in the "worked out" space, and

b) establishment of "short circuits" between the air and the gas-removal shafts (or pipes), promoting ignition and even combustion of the gas.

The second conclusion was the very harmful effect of any flooding, even short-lasting, such as occurred twice in our case in the course of the 6 months during the drilling of control holes and disturbed the process for 15-20 days on each occasion.

The third very important point is that it is necessary to prevent in some way the variations in the qualitative composition of the gas, observed both in our case and in other test sections (e.g. at Lisichansk and at Shakhty) as a result of changes in the air regime.

After a decrease or even a temporary interruption of the fresh-air injection the process rapidly changes in the direction of a rise in the proportion of fuel constituents, i.e. a rise in the calorific value of the gas. This is followed by gradual cooling and degradation of the gas quality, requiring additional amounts of air, etc. A graph showing the character and the amount of the fuel components, and also the calorific value of the gas, will be represented by strongly broken curves corresponding to times of changes in the regime.

It is self-evident that the gas consumer cannot accept such variations, especially when they go in the direction of lower calorific value, and thus the gas must be made and distributed with some more or less average composition.

Another factor that has to be mentioned is one specific mainly to the severe Siberian climate: we cannot inject directly to the fire face air at a temperature of minus 30 or 40 degrees, since anything that affects the high temperature of the process must eventually be reflected in the composition and calorific value of the gas.

The rext conclusion, emerging from observations on the boiler operation, is that the nozzle construction and the regulation of the gas combustion in the furnace must be such as to avoid a repetition of cases, which occurred in our trial throughout the boiler's operation on the UGC gas, where a considerable proportion of the gas components, and especially carbon monoxide, failed to burn and were lost through the stack of the boilerhouse.

To avoid the above shortcomings, which appeared -- as already stated -- only in the course of the observations during our first trial, we have developed a scheme published in Tekhnika of September 24, 1934 and explained by us at the first technical party conference on UGC, held on November 3, 1934 in Leninsk.

To what extent does this scheme satisfy us today and, what is most important, what is suitable for the gasification of seams in their natural conditions of occurrence underground?

We shall first consider what we have left in the scheme as definitely satisfactory and recommendable for all cases of underground gasification of coal, namely:

1. Simultaneous gasification of several panels with individualized admission of air to each panel (or to each panel group) and with individualized withdrawal of gas from them.

This construction or preparation of an underground gas generator makes it possible, by alternating certain changes in the regime in each panel, to obtain in the gas holder (or a mine working replacing it) gas of more or less constant make-up and eliminates the cycle of variation observed earlier.

This idea cannot be quarrelled with and there were no objections to it at the conference. Mining engineer A.S. Kuznetsov, chief of the work on UGC at Shakhty in the Azov-Black Sea territory, is also in favor of it (see Tekhnika of December 18, 1934, No.118), and his opinion, the opinion of an engineer with solid experience in underground gasification of coal, counts for a lot with us.

2. Distribution of the panels in such a way that the fire face in each of them is on the line of the strike and the gasification of the panels proceeds along the rise of the seam.

This method of panel distribution and gasification we now retain only for gently dipping seams; the limiting dip of a seam to be gasified by this scheme is determined in each individual case in dependence on the coal's thickness and hardiness and on the character of the roof rocks.

For steep seams we consider it necessary to start the ignition from a side perpendicular to the seam's strike, and the gasification scheme for seams of this kind should differ considerably from one that can be adopted for gently dipping seams and, in particular, from the scheme suggested for the second cycle of trials in the Kuzbass.

3. Drainage and emptying of the water. Since it has now been shown in full that water, i.e. the excess moisture in coal, is a very unfavorable factor degrading the gasification results, wherever the seam

has water-bearing rocks higher up or when water can enter it (during the summer after rainfall, in the spring owing to the thawing snow, etc.) it will be necessary to provide along the seam's rise draining excavations and to connect them with water drifts and with the mine draining pit, or to lead the water into lower-situated workings. The water-emptying shafts or pits should be below the section marked down for gasification. In certain cases between ignition and the end of the opening up and preparation of the panels it may be useful to leave some time free for drying of the coal.

4. Prevention of the establishment of "short circuits" between the air and the gas-removal shafts. Our scheme, discussed at the technical party conference, fully satisfies this requirement, extremely important for the UGC process.

However, the main disadvantage of this scheme is the fact that it does not ensure the continuous injection of air to the fire faces from the side of the "worked-out space" after the roof had collapsed into this space.

Mentioning this as the principal flaw, which got many fully deserved comments and criticisms during the conference, we must admit that it is one of the weak and insufficiently developed aspects of the scheme.

Equally, we must admit that when the air is injected according to our scheme, i.e. with frontal blast from a shaft situated below the panels marked out, it would be difficult to do anything about the low temperature of the air going to the fire faces.

Taking into account the criticisms levelled at the scheme by certain workers (comrades Tseitlin, Ioganson [Johanson?], Zolotov, etc.) during the conference, we pondered over it and introduced a number of fundamental changes and corrections. With all these modifications the scheme now determines the character of the preparation of the second test section, especially as it has been basically improved and admitted to be highly interesting at a conference in the technical division of Podzemgaz on January 29, 1935.

Specifically (see the figure for the second section, shafts 3 and 4), the changes consist in that the air is sent to the fire face not from the ignition end, and not from the side, but through workings made in the coal block and active until this coal has burnt out completely.

However, if the fresh air came in as in the first trial, i.e. through unprotected drifts, then the combustion, moving mainly against the flow, would lead to burning and collapse of the walls and to a disturbance of the gasification process. To avoid this, we came to the conclusion that the fresh air must be brought to the gasifying surface through pipes, and these pipes, or rather conduits, should be assembled so that, as the fire faces migrate and during the collapse occurring in the gasified space, their length decreases appropriately and ensures a steady supply of air, by displacement of the outlet orifices.

The presence of such air conduits, embedded in bulkheads every 7.5-15.0 m, apart from the main purpose of stopping propagation of the combustion toward the incoming air also hinders the establishment of "shorts" between two flows sweeping the long sides of a panel in opposite directions, even if the panels contain fissures, as was the case in one of the last tests in the Krutovsk section in the Moscow basin.

Let us now see how the second test section has been prepared.

In the first place, it lies in the direct vicinity and almost touches the first (see figure); it is limited on one side by the fault line and on the second, and partly the third side, it rests on the old Leninsk mine workings.

Shaft No. 3, lower along the dip is intended, according to the scheme, for emptying water. In our case, after it had been used to intensify the preparation and cutting-in of the panels, it remains as an auxiliary shaft for work on opening up the first trial section (see the working marked out with a broken line), and also for communication with the drift going round and with inspection crosscuts, so that we can get as far as possible into the panels to be gasified.

Shaft No. 4 should serve for both air and gas conduits. These consist of steel seamless pipes 22 mm in diameter (300 mm at the flanges), laid along the shaft and then along horizontal workings.

The two air conduits are brought to bulkheads in drifts C and are there cemented in. Steel pipes D-300 mm*, 4.5 m long, are then built into the bulkheads, the latter being provided at 7.5 m intervals. Between the ends of these pipes, protuding 2 m from each side of the bulkheads, we put in pipes of the same diameter, made from roofing tin, 3 m long and lined on the outside with thick wooden boards. The individual pipe units outside the bulkheads are held up by wooden supports cladded with clay.

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*Translator's note: 300 mm in diameter?

As the fire face moves in and the roof collapses, the integrity of the air conduits is disturbed and the roofing tin sections burn out and collapse as the bulkheads are reached by combustion, and this is the whole point and the whole "secret" of this invention.

The gas-removal takes place in three drifts; up to the bulkheads the gas moves through the free cross section of the excavations, and from the bulkheads it is drawn up to the surface by three independent exhausting ventilators, entering the gas holder and mixing in there before going to the pipeline leading to the boilerhouse.

Apart from the gas holder, the second test section has a cooler and a tar trap, the purpose of which is to remove from the gas water vapor, which strongly degrades its quality, and to remove tar, which condenses upstream of the gas-pumping ventilators.

Since in the new plan on the second test section we have envisaged three gas exhausts in one and the same shaft, these being heated to 100-110°C in their uppermost part, and two air conduits, we have here all possibilities for the preliminary heating of air going down to the face, i.e. for maintaining a high-temperature process.

As can be seen from the drawing, the section with a total seam area of 60 x 60 m is cut through along the line of the strike by two arch-shaped drifts without bracing and five similar drifts along the rise, not counting the special-purpose working going round. These drifts form 4 bands or panels 58 m long and 9 m wide. The middle two panels are the main ones and the end panels are auxiliary.

Fresh air is injected by two blowers through other air conduits, laid on the outside of the main panels. Leaving the pipes, the air sweeps the two short sides (which in all panels are ignited before the start of gasification) and, already in the form of gas having a certain composition, is drawn up by a single central ventilator set up on the surface.

Depending on the character and the results of the process taking place in the two main panels, part of the air is drawn off from drifts C to the two auxiliary faces of the end panels by two independent ventilators placed in series with the ventilator working on the main panels.

The regulation and alternation of the decreased or increased air supply to the main panels and to each auxiliary panel should provide the optimal conditions for maintaining at all times zonal gasification of coal and, as already mentioned, for obtaining in the gas holder a gas of constant composition and constant calorific value.

While the preparatory work on the first test site was done without sufficient means, materials, or manpower, lasted nearly 2 years, and cost about 80,000 roubles, including the costs of the tests themselves, the preparation of the second section is done exclusively by the percussion*

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*Translator's note: Not clear. This term may mean anything from a blow to a detonation. However, it does not mean "explosion".

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method. It started in December 1934 and will be completed in May 1935.

The volumes of work in the two cases are of very different magnitude. Thus:

Mining work -- the number of shafts sunk in the new section is twice as large as before, the number of drifts 8 times as large, and the number of pipe conduits 12 times are large.

The number of ventilators set up will be 6, as opposed to 2 in the first section. The number of boreholes will be 28, as opposed to 14, and moreover, in the new section there will be 20 brick bulkheads 2½ bricks thick and 12 bulkheads 1½ bric. thick, whereas the first section had no bulkheads at all.

Consider the cost structure of the preparation of the second test section. The total is around 165,000 roubles. This includes 10,940 roubles on buildings and structures, 93,540 roubles on mine workings and drilling, 54,200 roubles on equipment and assembly, and 5900 roubles on miscellaneous expenses.

[Line missing from the Russian text] ... coal extracted as 15,330 roubles, we get the total planned costs as 149,250 roubles.

Repeating our earlier calculations that the fire face moves 15 cm per day, we get the daily gas production as 9.0 x 5.0 x 4 x 0.15 x 1.2 x 3000 = 100,000 m^3. Taking the same mean calorific value as before, i.e. 1750 cal*/m^3, we obtain about 175 million calories per day.

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* Translator's note: Presumably "kcal" in every case

We have intentionally repeated all those calculations that we accepted earlier. We shall now compare them with calculations carried out by engineer Khlebnikova (an employee of Podzemgaz) during our visit to Moscow last February.

"Since the Zhurinsk seam easily undergoes self-ignition and cracks up, we postulate a high-temperature generator process; moreover, large quantities of coal entering into the process will first undergo low-temperature distillation, so that we shall have not a pure generator gas but a mixed one, or a semigenerator gas, plus gas from low-temperature distillation of the coal" -- thus wrote Khlebnikova at the beginning of her investigation.

She then went on to make the following assumptions:

1) 10 kg of coal is gasified per hour per m^2 of coal block surface area.

2) 4.5 m^3 of gas is obtained per kg of coal.

3) The fire-face area in the gasifying panels is 220 m^2.

4) The gas removed per hour amounts to 9800 m^3.

5) The gas composition is as follows:

carbon dioxide	11.10%
carbon monoxide	12.80%
methane and unsaturated hydrocarbons	1.80%
hydrogen	17.25%
hydrogen sulfide	0.30%
nitrogen	55.55%
water	1.20%
	100.00%

6) The calorific value of the mixed gas obtained on a dry air blast is 1035 cal/m^3. Since this gas will be additionally mixed with about 85 m^3 of low-temperature distillation gas per hour, the latter's composition being:

carbon monoxide 5.2%

hydrogen 12.0%

methane 60.0%,

the final calorific value of the gas should be taken as 1145 cal/m^3.

7) The amount of air required for the process is 7000 m^3/h.

We shall now give Khlebnikova's figures recalculated for a period of 1 day* and compare them with those adopted on the basis of our first trial.

* Translator's note: There is an almost illegible line in the Russian text at this point, but the meaning is probably as given above.

Gas production: According to Khlebnikova:

(9800 x 85) x 24 = 237,000 m^3

Our figure: 100,000 m^3.

No. of calories obtained in the gas:

According to Khlebnikova: 275 million

Our figure: 175 million.

This shows that our figures are not high.

If we compare the calorific power of the gas (1145 cal/m^3 according to Khlebnikova and 1750 cal/m^3 according to us), the difference is due to the fact that Khlebnikova assumed the use of an exclusively dry blast, while under our conditions the course of the process was, and should have been, strongly affected by the presence of moisture.

The first trial, carried out in 1934, was not organized at all well as regards the control services and observation of the process. We shall not go into the reasons for this shortcoming, but to avoid the situation during the second trial we adopted the following measures:

1) Two mining engineers, comrades Zolotov and Makhin, were sent to Leningrad to attend special courses on UGC; so were comrade Shevel'kov, a combustion engineer, and comrade Odinokov, a chemical engineer.

2) Three laboratory assistants were trained in the gas-analysis laboratory of Central Siberian Mine Safety Station.

3) Courses were organized to prepare 12 active members of the Young Communist League for sample collection and measurements of the amounts of gas, temperatures, etc.

4) Acquisition of thermocouples, gas analyzers, etc. was ensured in good time.

Podzemgaz promised us considerable help in this undertaking, and some assistance has already been received. Here we expect to get additional thermocouples, high-pressure gas blowers, gas counters, etc. Here too we shall apply for specialists to set up the control and measurement instrumentation.

We hope that the second cycle of trials -- carried out under completely different conditions of preparation, air supply, gas withdrawal, and maintenance -- will yield new data which, together with the results obtained at other test sections, in other regions, will serve for the fastest possible solution of the great problem of underground gasification of coal, bequeathed to us by Lenin himself.

END OF PAPER