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EXPERIMENTS IN FAST DRILLING IN THE TUYMAZANEFT' OIL FIELD

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The Party and the Government have decided to increase the production of oil in the East. To carry out their decision successfully it is necessary to increase the number of operating drills, and to accelerate the speed of well drilling.

Drill operators of the Tuymazaneft' understood the importance of this requirement and developed large-scale competition for drilling wells more rapidly.

The cross section of the structure in Tuymaza shows that limestone and dolomite make up from 75 to 80 percent of the formations, with the exception of a small part of the upper layers composed of sandstone, clay, gypsum, and anhydrite.

Generally, the rocks were very solid and hard, and drilling speeds in this region were comparatively low. For instance, in 1941 the record commercial speed for rotary drilling was 180 meters per drill per month in wells sunk according to the following standards: 12-inch lead-in casing, 250 meters long; 6-inch operating-column casing; over-all depth 1,150 meters.

In 1943-44, the commercial speed increased to 255 meters per drill per month (working in carboniferous formations), when the Tuymaza enterprise received additional equipment and technicians from the southern regions.

In June 1944, Foreman Kupriyanov, drilling Well 62 with an obsolete turbine drill and using pumps driven with internal combustion engines and a steam engine winch, achieved the record drilling speed of 532 meters per drill per month, working through a carboniferous formation. The

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problem of speed became particularly acute when Devonian formations were encountered.

In Tuymaza, the Devonian deposits are located at a depth of 1,650-1,800 meters; a cross section of the structure shows up to 70 percent silicified rocks, which are solid and hard (Myachkovskiye and Podolskiye formations, lower strata of the Tul'skiy and upper strata of Turneyskiy layers, etc.).

Wells are drilled through Devonian formations according to the following standards: A 12-inch lead-in casing, sunk to a depth of 250 meters, followed by 6-inch tubing which reaches the oil-bearing layer at a depth varying from 1,650 to 1,800 meters are used. Sometimes 10-inch casing and 6-inch tubing are used, although not frequently.

Drilling through Devonian formations started in Tuymaza about the end of 1944 and during the next 3 years the following average and record commercial speeds were reached.

The first test well (100) drilled through the Devonian formation was completed in May 1944 by Foreman Tripol'skiy at a commercial speed of 265 meters per drill, the standard being 150 meters per drill.

In 1945 the average commercial speed in Devonian-formation drilling was 198 meters per drill and the record was 405 meters per drill (Well 1,237, Foreman Kupriyanov).

In 1946 the average commercial speed was 269 meters per drill and the record, 467 meters per drill (Well 412, Foreman Kupriyanov).

A radical change in drilling speed was brought about in 1947, when, following an appeal made by the leading drillers of Tuymaza, a strong impetus was given to the quest for higher drilling speeds.

In order to increase the drilling speed in Tuymaza, emphasis was placed upon two points: first, on the improvement and the expansion of the scope of rotary drill operation by incorporating individual drive for the rotor and, second, on the rational study and application of turbine drilling.

On 16 June 1947, a mixed crew, composed of Komsomol members and others under Foreman Alekseyev, completed the drilling of Well 134 at a speed of 134 meters per drill, using a rotary drill.

On 22 July, the crew of Foreman 1st Class Balabanov, completed the drilling of Well 132 at a speed of 512 meters per drill.

In August, Foreman Knutov's crew completed Well 621 at a speed of 560 meters per drill, the standard speed for 1947 being 310 meters per drill per month.

Table 1 shows the characteristics of the wells and their basic equipment.

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Table 1

Equipment	Well 134 Foreman Alekseyov	Well 132 Foreman Balabanov	Well 64 Foreman Knutov
Lead-in casing: Diameter (in)	10	12	10
Length (m)	210	230	250
Diameter of bit (in)	9 3/4	11 3/4	9 3/4
Depth of well (m)	1,678	1,767	1,764
Power of electric motors (kw)	1,260	840	960
Drill	UZTM	UZTM	UTZM
Pumps	3, ZTS NB-32-300	2, Type C-350	2, ZIS NG-30-320
Rotor driving gears	Individual PIR	Usual type through winch	Individual PIR
Drilling instrument	5-in (new)	1,100 m, 6-in 667 m, 5-in new	5-in (new)

Drills were equipped with all the necessary control and measuring instruments.

All wells were drilled with domestic bits produced by the Factory imeni Stalin, Types ZIB-7 and ZIB-8, size 11 3/4 inches and by the Verkhne-Sergiuskoye Factory, Types ZT and ZS, size 9 3/4 inches and Types ZK and ZT, size 11 3/4 inches.

Technical and production data on this work are shown in Table 2.

Table 2

Indexes	Well 134	Well 132	Well 64
Depth of well (m)	1,678	1,769	1,764
Time of drilling (days)	101	103.5	98
Commercial speed of drilling (m/drill./mo)	470	512	540

Table 2 (Contd.)

Indexes	Well 134	Well 132	Well 64
Mechanical speed (m/hr)	1.54	1.38	1.43
Number of bits used	142 (9 3/4-in)	80 (11 3/4-in)	126 (9 3/4-in)
Work per bit (m)	11.8	22.1	14.0
Time of one drilling operation (hr)	7.6	26.3	9.8
Productive time (%)	88.2	85.1	90.6
Time of mechanical drilling (%), included in productive time	42.8	51.6	52.6
Time lost (%)			
Repairs	3.9	8	5.1
Accidents	0.9	1.4	2.2
Reorganization	7	5.5	2.1
Total	11.8	14.9	9.4

Foreman Alekseyev (Well 134) made an improvement in the technical operation of rotary driving, which enabled him to obtain the highest mechanical speed of the rotor. By using a 9 3/4-inch bit and a weighted base, he increased the axial load to 10-12 tons in hard rocks; the usual load in Tuymaza is 8-10 tons. The use of a weighted base prevented accidents with drilling tubes. By using the PIR equipment the rotor reached 230 revolutions per minute in soft and medium rocks, 130 in hard rocks, and slowed down to 70 revolutions per minute in very hard species.

Well-flushing and composition of argillaceous solution were given great attention. When drilling through hard varieties of rocks, one pump was operated with an output of 25-27 liters per second; the usual output in Tuymaza being 14-16 liters per second. When drilling through soft and medium rocks, two pumps were used and the output reached as high as 45-47 liters per second. Under these circumstances the speed of ascending flow varied 0.7 to 1.2 liters [sic] per second. The diameter of particles extracted in this operation reached 15 mm. The TsIIMF[neft' together with the foreman worked out a drilling diagram and a technological system, which enabled the crew to obtain record achievement.

Foreman Balabanov drilled soft and medium rocks in Well 132, with an axial load of 10 tons, a rotor speed of 130 revolutions per minute, and a pump output equal to 36 liters per second. The axial load was increased to 12 tons in solid rocks, maintaining the same rotor speed and pumping capacity; in hard and very hard rocks the load was increased to 14 tons, and the capacity of the pump was maintained, but the rotor was slowed down to 80 revolutions per minute.

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Great care was taken by the crew at the beginning of drilling operations. During the first 20 minutes the bit was operated under a load which did not exceed 7 tons, and then the load was increased to normal.

When drilling, the crew paid special attention to the work of the bit. Bits were considered worn out when their mechanical speed dropped to 40 percent of the initial speed in the same kind of rock. The foreman and the crew decided that they should not let the bit wear down to a point where complete loss of mechanical speed resulted, because it caused considerable waste of time and necessitated further enlargement of the well.

Adequate operation of drilling tubes and correct axial loads was obtained by using a 6-inch weighted base, 50 meters long; in addition 6-inch drilling tubes, 300 meters long, were placed under the extension. These drilling tubes were further extended with 5-inch drilling tubes. After every 300 hours of operation, the tubes were inverted; the lower 5-inch tubes were used on the top of the column and the upper tubes at the bottom. This prevented possible accidents with tubes. At regular intervals the quality of argillaceous solution was checked on the spot, and the results verified in the laboratory.

The mechanical speed achieved, 1.38 meters per hour, made it possible to save 360 hours on the drilling operation. A considerable amount of time was saved by the crew through their use of small machinery. Repairs were made by the entire crew and not by the mechanic alone. Foreman Balabanov found that Gall's chains with a small pitch were more efficient and their repairing was easier. He himself modernized the drill and rotor by arranging sprockets and chains with a small pitch. As a result, the time spent on chain repairs was considerably reduced. As a result of many years of working together, Foreman Balabanov's crew set an example of perfect teamwork. (some of the drillers have worked since 1939.)

The work of Foreman Knutov, as well as the work of Foremen Alexeyev and Balabanov, is conspicuous because of the technological achievement of accelerated drilling speed with lower pump capacity (a maximum of 27 liters per second). In this case, the highes percentage of productive time is reached (90.6 percent). The time of mechanical drilling increased considerably (from 42.8 percent for Foreman Alexeyev to 52.6 percent for Foreman Knutov). Consequently, Foreman Knutov established the record speed for rotary drilling in Tuymaza.

Analyzing his work, one may conclude that his record speeds were the result of: the well-organized Stakhanovite work of the drilling crew; application of forced drilling operations; the absence of complications during the work, the decrease of accidents by working with adequate clayey solutions, and the establishment of an axial load on the bit by means of a weighted base; the minimum use of machinery; the rational and efficient use of the new equipment, and the care given it by the drillers.

It is necessary to point out that in Tuymaza the question of accelerated drilling did not arise spontaneously. The movement was headed by engineers and technicians of the Bashneft' Combine (Comrade Shmarev), of the Trust (Comrades Nifantov and Repin), and of the Office of Drilling (Comrades Patyukaev, Maslov, Sleptyan, Kuryshev, Shenovich). At the start of every accelerated drilling project, some new problem arose, the solution of which made a better performance possible.

At the same time that rotary drilling was being perfected in Tuymaza, operations started with turbine drilling. Quite recently in the beginning

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of 1947, this method, which had been interrupted in 1944, was again applied. Starting in May 1947 turbine drilling has been developed on a large scale.

Turbine drilling in Tuymaza was delayed by lack of: a pump unit supporting high pressures, and good-quality parts for pumps, including self-packing pistons; powerful pump drives; high quality spare parts for turbine drills; qualified turbine drill operators and of mechanics.

All these difficulties were surmounted when:

1. The Type U8-1 pump, forming a part of the drilling unit UZTM, the Type ZIS-NG 30-320 pump, made by the Factory imeni Stalin, and the Type R-20 pump were received; the "Borets" factory started to produce good-quality spare parts for pumps, and the Leningrad Rubber-Engineering Factory produced good self-packing pistons;

2. Powerful driving gears and 290-kw electric motors, made by the Leningrad "Elektrosila" Factory, were received:

3. Good-quality spare parts for turbine drills were received from the Factory imeni Molotov; and

4. Workers from an experienced shift, who had worked on turbine drilling since 7 November 1946, were trained as foremen.

After the authorization of the State was obtained in May 1947, turbine drilling began to play a leading role in Tuymaza.

One of the first turbine drills, that was used on Well 305 (Foreman Bikbov, using turbodrills for the first time), began drilling in the winter of 1947 with ZIS-NG-30-320 pumps. It completed a depth of 1,621 meters with a commercial speed of 355 meters per drill per month. This was an average speed, according to the office, of 240 meters per drill and an average mechanical speed of 2.26 meters per hour. This exceeded the mechanical speed of record rotary drills but, unfortunately, included a high percentage of unproductive time, due to poor assembly of the pump framework, unsystematic work in erecting the pump, and other causes dependent on the drilling office workers.

At another turbine Well 131, bored under more or less normal conditions, drilling began on 21 June 1947 under the old turbodrill Foreman, Khuriyanov. It was bored with a record speed for Tuymaza of 670 meters per drill per month.

This well was bored to 150 meters with a 28 turbodrill bit, 15 3/4 inch [sic] diameter under a 12-inch casing, and from 150 to 1,762 meters in depth with 11 3/4-inch bits with a gradual lowering of the 6-inch operating tubing, i.e., in conformity with the construction plan. The cross section of the well corresponds with the above-mentioned profile characteristic for the Tuymazin structure. The drilling equipment does not differ from the equipment used for rotary drills.

The following basic equipment, was received: Type S-350 2-piece mud power pumps, with 290-kw electric motors made by the "Electrosila" Plant and a standard four-speed winch made by the Plant imeni Schmidt. A 5-inch second-grade drilling tool with SHPO locks was used. Drilling was done by three Type T14M 9 3/4-inch turbodrills, made by the Plant imeni Molotov in 1946, these are standard equipment for all well drilling.

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During the entire drilling operation only one pump, operating at a normal capacity of 34-35 liters per second, was used. The second pump worked intermittently, during periods when the main pump was under repairs. Selection of bits was made according to types of profile encountered and in conformity with geological and technical nature of the rock penetrated.

The drilling outfit had only a minimum of mechanized equipment and measuring instruments. The argillaceous solution had a specific gravity of 1.23, viscosity of 21 seconds, and mechanical impurities /[sic]/ not exceeding 0.2-0.6 percent. Drilling was carried on from zero to 112 meters with one 15 3/4-inch bit with an axial load of 5-9 tons and a manometric pressure of 50-60 atmospheres. To eliminate jerking and bouncing of the tool, the foreman installed 25-meter extensions on the turbodrill in the first cutting operations. In the interval between 110 and 696 meters, drilling was done by ZIS-7 and ZT-11 3/4-inch bits with an axial load of 10-12 tons and manometric pressure of 60-65 atmospheres.

In this interval 11 bits were worn out, which represented 53.3 meters of drilling per bit. Twelve drilling operations with ZIS-8 and ZK 11 3/4-inch bits were performed in the interval from 696 to 796 meters, i.e., in the hardest species of Tyachkovskiye and Podol'skiye formations, without a single case of unproductive drilling such as occurs at times with low speed rotary drilling. The minimum mechanical speed achieved in this interval was 2 meters, at 706-meter depth. In this interval the axial load reached 15 tons. When a depth of 728 meters was reached, the well was enlarged in the interval from 110 to 150 meters and a 12-inch casing was lowered to 150 meters. Cement was then poured around the casing up to the top of the well. The interval from 769 to 1,000 meters was drilled with an axial load varying from 10 to 12 tons. Because of a considerable increase of pressure (over 80 atmospheres), the foreman changed the pump cylinders, increasing the output to 29-30 liters per second under a pressure of 60-70 atmospheres.

The minimum mechanical speed of drilling was 4 meters during the first hour of operation, but after 4 to 5 hours of work it dropped to 2 meters per hour. This was a signal to discontinue drilling and to lift the bit.

The time lost by foreman Kupriyanov was partly compensated by an increase of speed in lowering and lifting operations and by a greater mechanical speed. By not lifting the ZK, ZT, and ZIS-8 bits wear out, the necessity of enlarging the well was avoided. Bores had to be enlarged when ZIS-7 bits were used, because of the rapid wear on the body. This situation is completely unsatisfactory for turbine drills, since they do not stand a normal load. For normal turbine drill operation, great attention must be paid to the quality of the solution of clay and its purity. With a muddy solution the turbine may be clogged and stopped. This fact was taken into consideration by the crew, and no turbine was obstructed during the entire drilling operation.

Owing to the good quality of turbodrills, availability of spare parts and proper maintenance by the chief mechanic of the Ogzav crew, the turbodrill did not run idle at any time. The technical and economic indexes obtained for this drill are shown in Table 3.

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Table 3

Indexes	Well 131 Turbodrilled by Foreman Kupriyanov	Well 132 Rotor-drilled by Foreman Balabanov	Well 64 Rotor-drilled by Foreman Kmrtov
Depth of bore (m)	1,762	1,764	1,767
Diameter of main shaft (in)	11 3/4	11 3/4	9 3/4
Duration of drilling (days)	79	103.5	98
Commercial speed (m/drill/mo)	670	512.2	540
Technical speed (m/drill/mo)	804	609.3	596
Mechanical speed (m/hr)	2.59	1.38	1.43
Number of drilling operations	87	80	126
Work per drilling operation (m)	20.2	22.1	14.0
Productive time (%)	83.4	85.1	90.6
Mechanical drilling time (%)	35.9	51.6	52.5
Mechanical drilling time (hr)	684	1,282	1,237
Time of lowering and raising operations (%)	22.9	14.5	19.1
Time of lowering and raising operations (hr)	434	361	449
Time lost due to accidents (%)	--	1.4	2.2
Time lost due to complications (%)	--	--	--
Idle time (%)	8	5.5	2.1

As may be seen from Table 3, the mechanical speed of turbine boring is almost double the record rotor speeds. The following wells, located within a distance of 500 meters from each other, were drilled: Well 132 in 1,282 hours with a consumption of 80 bits at a cutting rate of 22 meters per bit; Well 131 in 680 hours with a consumption of 87 bits and a cutting rate of 20.2 meters per bit. Consequently, merely from the standpoint of mechanical speed, twenty-five 24-hour days were saved, not counting the great reserves of available mechanical drilling time. As shown above, the Nyachkov strata, which is very difficult to counterbore because of the peculiar hardness of the rock, took 54 hours for penetration compared with

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122 hours spent at Well 132. The mechanical speeds corresponded to 2 meters per hour as compared to 1.1 meters at a lower rate of rotor revolutions.

The conclusion reached by drillers on t necessity of reducing the rate of speed of the bit in drilling very hard rock must be considered open to question.

The results of the work of Foreman Kupriyanov's crew are not accidental. The crew of Ordinary Foreman Bochkarev (drilling with a turbine for the first time) on Well 303 used standard UZTM equipment and two U8-1 pumps. They reached a depth of 1,466 meters in 68 drilling operations (projected depth, 1,640 meters). Fifty-six drilling days were required, working with increased axial load amounting to 22 tons, with an argillaceous solution output of 36 liters per second, and a manometric pump pressure of about 90 atmospheres; 440 hours were spent in mechanical drilling at an average mechanical speed of 3.3 meters per hour.

In order to discover the maximum possibilities of rotary drilling in Tuymaza, drilling was begun on Well 102 by Foreman Balabanov; and for purposes of comparison with turbine drilling, a turbine-drilled Well 82 was begun 500 meters away by Foreman Knutov (boring a turbine-drilled well for the first time). In spite of the fact that boring began on Well 82 5 days later, by the 39th day Foreman Knutov's crew had overtaken Foreman Balabanov's. Moreover, it was significant that at turbine-drilled Well 82 only 48 bits were used up, while at rotor-drilled Well 102, 74 bits were used. This conclusively proves the advantage of the turbine drilling.

In January 1947, Drilling Office No 2 of the Tuymazaneft' Trust was operating only one turbine drill out of a total of 11. In the second and third quarters of the year, the situation was as follows: four turbine drills out of 11 operating in June, six in July, eight in August and September. The result was an immediate and general increase of efficiency in Office No 2.

The average drilling speed achieved in 8 months by Office No 1 was below the planned figures; this average was 276.7 meters per drill per month, while for the same period the average of Office No 2 was 323.8 meters per drill per month.

For the same period the average speed of the turbine drills of Office No 2 was 415.8 meters per drill.

In the Tuymazaneft' Trust, the average mechanical speed was 1.25 meters per hour for rotor drilling and 2.1 tons per hour [sic] for turbine drilling during the first 8 months of 1947. During the same period of time the commercial speed was respectively 323 meters per drill, and 445 meters per drill (Table 4).

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Table 4

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Average
Average drilling speed including turbine drilling (m/drill/mo)	167	264	213	250	320	439	392	380	323
Average speed of turbine drills (m/drill/mo)	387	380	268	324	411	521	418	539	445

Special attention must be paid to the fact that in rotary drilling, record speeds are achieved by the most qualified foremen and well-trained crews, while in turbine drilling, high speeds are reached even by foremen using turbine drills for the first time. At the present time 60 percent of the work in Tuymaza is done with turbine drills.

It is apparent from the above that turbine drilling in the Tuymazaneft' Trust showed higher efficiency indexes than rotary drilling, using equivalent equipment under similar geological conditions.

Therefore, since the well-known experiment at Krasnokamsk, the technical and economic advantages of turbine drilling has been proved.

In Tuymaza, as well as in Krasnokamsk, the rational development of vertical turbine drilling made it possible to ease the problem of drilling groups of wells by using the method of inclined, continuous turbine drilling. The great depth of wells and a relatively small network provide favorable conditions for drilling groups of wells; this is particularly important in Tuymaza where setting up and assembling drills is very difficult in winter. There is reason to believe that in Tuymaza, just as in Krasnokamsk, speeds of turbine drilling of orientated wells will surpass those achieved for vertical wells when operational methods are worked out.

A council of the leading drill foremen of the trusts of Bashneftekhimrazvedka, Ishimbayneft', Krasnokamskneft', and Kuybyshevnefterazvedka was convened by the Ministry and held in Ufa 25 and 26 September 1947. Summarizing the results of the fast drilling competition, initiated by the Tuymaza Stakhanovites, the council pointed out that: A speed of 500 meters per well per month may be reached by all crews drilling through Devonian formations and using domestic equipment. This speed does not necessarily represent the limit. The speed of turbine drilling is considerably higher than that of rotary drilling. Improved industrial technique, more powerful drills, and better instruments, all results of the postwar reconstruction of Soviet industry, made it possible to reach the speed of 500 meters.

The higher speeds achieved were due to the following conditions: drillers studied new techniques and applied them without hesitation; and the teamwork of drilling crews, headed by Foreman Balabanov, Alekseyev, Kuntov, Kupriyanov, Nazarov, etc., real organizers of collective Stakhanovite production, was highly efficient.

The council decided that the major tasks for the future were:

1. Dissemination of the results of the experiences acquired in fast drilling to all drilling crews. This should increase the average drilling speed through Devonian formations to 500 meters per drill per month, and

through carboniferous strata to 700 meters.

2. Application of forced rotary drilling, and using the equipment to its fullest capacity by:

a. Increasing the speed of the rotor to 130 revolutions per minute when standard equipment is used and to 320 when a PIR driving gear is used.

b. Increasing the speed of the argillaceous solution output to one meter per second.

c. Using a weighted base to increase the axial load on the bit.

3. Selection of cutting bits which would be adequate for the various types of rocks.

4. Improving the control of the quality of the argillaceous solution.

5. Maintenance of proper working conditions.

The effectiveness of turbine drilling, after having been proved in Krasnokamsk, was once more proved in Tuymazaneft' and Stavropol'neft', the principal Eastern regions. Further application of this method throughout the Eastern oil industry is required.

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