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EFFICIENCY OF RECOVERY OF GAS AND OIL IN THE GRAHAM POOL, CARTER COUNTY, OKLAHOMA

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The Graham pool occupies a somewhat curving strip of land some eight miles long from northwest to southeast, with an average width of less than one mile, centering in Sec. 31-T.2S.-R.2W, near the old village of Graham, Oklahoma. It is a perfect example of anticlinal accumulation of gas and oil in a steep fold. Oil and gas are produced from a series of sands of lower Pennsylvanian age. The fold has a structural closure in excess of 2,000 feet, and oil accumulation extends to a depth of more than 1,000 feet vertically down the flanks, which have average dips in excess of 25 degrees. Encroachment of edge water up these steep dips has been very slow, and no water is produced in the field except in a very few edge wells. The crest of the structure, occupying the upper 250 feet of closure, is occupied in all producing sands by dry gas with very little oil. The crest area occupies about 240 acres, as compared with 2,500 acres producing oil from the same sands lower on the flanks of the fold. This situation makes possible an interesting comparison of the original quantity of oil and gas contained in the sand, and the relative efficiency of recovery of the two fluids.

The 24 dry gas wells now nearly exhausted have produced and sold an estimated total of 11 billion cubic feet of gas, measured in terms of volume at two pounds above atmospheric pressure of 14.4 pounds per square inch. That is an average of 458 million cubic feet per well, or 46 million per acre. The average aggregate thickness of sand logged in these wells below the casing point is about 70 feet,—usually made up of many thin strata separated by thicker bodies of shale. Forty-six million cubic feet of gas at pressure of 16.4 pounds per square inch would occupy only 860,000 cubic feet of space at a pressure of 770 pounds per square inch, the maximum initial reservoir pressure recorded in this pool. Eight hundred and sixty thousand cubic feet of gas (at original pressure) per acre is 19.7 cubic feet per square foot of surface, and would occupy 28 per cent of the total volume of a sand 70 feet thick. That is probably very close to the actual total pore space in these sands. The gas wells in the Graham pool therefore appear to have achieved almost complete drainage of the reservoirs they tapped.

The oil wells of the Graham pool, while not so close to exhaustion as the gas wells, have given up much of the greater part of all the oil recoverable from them by the ordinary methods now in use, without repressuring or flooding. Their ultimate total yield of oil by present methods can be closely estimated, and probably will approximate an average of 10,000 barrels per acre, which is only 0.23 barrels (about 1 1/3 cubic feet) per square foot of surface. This is less than 3 per cent of the volume of oil sand logged in these wells, and probably not over 1/8 of the volume of effective pore space in those sands. The average total thickness of pay sand logged in the oil wells of the field is only about 45 feet, partly because many of them are situated much lower structurally than the gas wells and were not drilled so far through the productive series.

At first glance these figures would suggest that present methods of recovery would bring to the surface only 1/8 of the oil actually present in these sands before discovery of the field. However, these same oil wells have sent about 12 billion cubic feet of gas to casinghead gasoline plants, and have probably yielded about 10 billion cubic feet besides that,—mostly before the casinghead plants were built. More than half of this total yield of 22 billion cubic feet of casinghead gas has been used for power, heat and light in the field. Part of the remainder has been recompressed and sold as dry gas outside the field, after extraction of its gasoline content.

Twenty-two billion cubic feet of casinghead gas from 2,500 acres represents about 8.8 million cubic feet per acre at 2 pounds above atmospheric presure, which would be only 186,000 cubic feet at the original reservoir pressure of 770 pounds per square inch. That is 4.27 cubic feet per square foot of surface, approximately three times as much volume as was represented by the recovered oil itself. The oil and casinghead gas probably were in mutual solution in the reservoir, and the volume of this solution may not have been exactly the same as the sum of the volumes above computed for the component oil and gas separately. Nevertheless, the fact remains that if there had been no oil with it, the casinghead gas would have accounted for two or three times as much of the pore space in the sand as does the oil actually recovered.

It appears from the above figures that the oil and casinghead gas producible from the oil wells of the Graham pool by present methods represent less than 45 per cent of the probable volume of pore space in the oil-bearing portion of the reservoir from which production is now being obtained. The recovery of casinghead gas is probably very much more nearly complete than that of liquid oil, and the fluid remaining in the reservoir is therefore probably at least 75 per cent oil by volume,—or would be so when brought to the surface. If that is true, there is left in the sands in this field oil to the extent of more than 40 per cent of the total pore space of the reservoir rocks producing in the oil-bearing portion of the field. That is more than three times the volume of oil which will ultimately be recovered from the field by present methods. Those methods are therefore effecting less than 25 per cent recovery of oil. Gas recovery, on the other hand, has been shown to be very nearly 100 per cent effective.

Unfortunately for the gas producer, the high efficiency of his recovery of gas does not mean that the average gas well is worth proportionately more than the average oil well. The average recovery of oil per acre at Graham, about 10,000 barrels, represents a gross value of some $15,000.00 at the prices which have prevailed in the field; whereas the average recovery of gas, 46 million cubic feet per acre, at the price of 10 cents per thousand, has been worth only $4,600.00. The far greater expense of producing the oil only partially balances the account. On the other hand, the average prices received for the two fuels in this field have not been far from proportional to their heating value, as a cubic foot of oil contains roughly a thousand times the fuel value as a cubic foot of dry gas at atmospheric pressure.

Due to the occurrence of most of the gas of southern Oklahoma as an accessory product in pools developed primarily for their oil yield, the spacing of gas wells has unfortunately been controlled in most cases by the spacing of adjacent oil wells. This has averaged nearly ten acres per well in the Graham field. It is practically certain that much wider spacing of gas wells would have accomplished almost the same recovery, and would have been many times more profitable to the producer. On the other hand, available data indicate that the spacing of oil wells in this pool has been little if any too close for optimum profit.