MAGNETIC TESTING OF STEEL IN THE PETROLEUM INDUSTRY

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Old methods of drilling and producing oil wells by rule of thumb, brute force, and a great expenditure of money, have given way to scientific methods. This has been brought about both by economic pressure and by recent developments of a scientific nature. Such scientific developments as geophysical exploration, bore hole inclination recorders, and mud analyzers are now well-known in the drilling field. Top and bottom hole dynagraphs and depthographs are scientific aids to the production department.

Recently a new scientific development of considerable importance has been made available to the oil industry. This is a magnetic method of measuring fatigue in steel. It is of particular importance to the oil industry, as alternating stresses are applied to steel goods in both the drilling and producing departments, which causes the development of fatigue and subsequent failure of the steel. In the drilling department fatigue is largely responsible for the failure of drill pipe which is used in drilling wells. This failure of the drill pipe often occurs in uncased holes where it is very difficult, expensive, and sometimes impossible to fish out the broken pipe. In the production department sucker rods used in pumping wells are subjected to alternating stresses which cause ultimate failure. The use of magnetic testing permits the development and extent of fatigue in the steel goods to be measured and permits the fatigued steel to be removed from service before failure occurs. By this method it is possible to remove badly fatigued material from heavy service before failure occurs and place such material in lighter service where it may be used for a long time without failure.

This magnetic testing has been commercially developed by the Magnetest Corporation of Long Beach, California. It is now commercially available for the testing of sucker rods and developments are now being made so that it will be available for testing drill pipe and other steel goods at a later date.

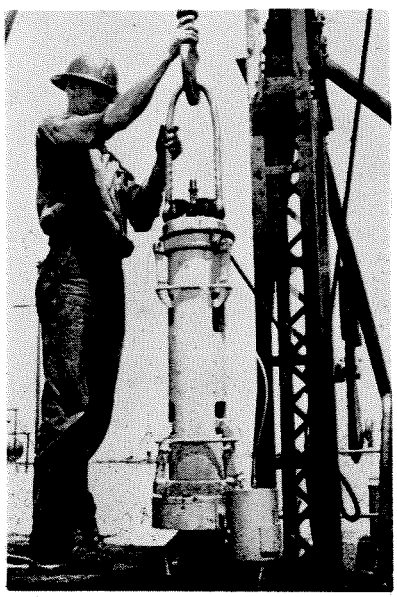

Fig. 2 — EQUIPMENT AT WELL HEAD

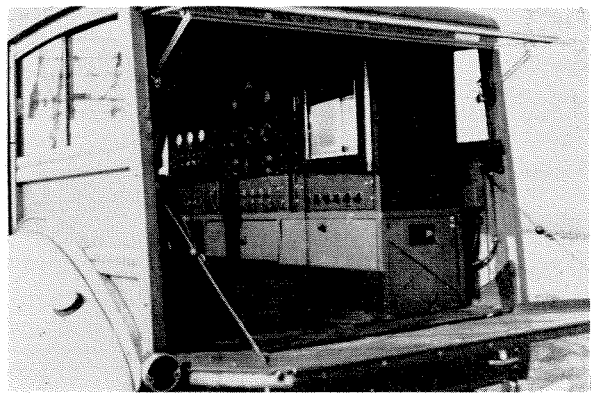

Fig. 1 — TESTING TRUCK

MAGNETIC FLUX ANALYSIS

The method used in testing for fatigue in steel makes use of the change in the magnetic properties due to the development of fatigue. The steel to be tested in magnetized with an alternating current. The magnetic flux thus produced induces a voltage in a pick-up coil. Variations in the induced voltage in this pick-up coil are indicative of variations in the magnetic properties. Since the voltage variations are small, resort is had to a bridge method and sensitive instruments to measure the change. This small voltage change is amplified and recorded on a chart so that a record may be obtained of the condition of the material.

The testing equipment is made up in a portable form so that testing may be carried on at the well. The photograph in Figure 1 shows the appearance of the interior of the testing truck, with the testing and recording equipment. The photograph in Fig. 2 shows the type of equipment used at the well. In this case the testing coil is attached at the well head, and the rods are tested as they are pulled from or lowered into the well by the usual methods.

When recording, two records are made since it has been found that the voltage changes indicative of the changes in the physical properties of the steel occur both in amplitude and in phase changes. The chart, therefore, shows both the amplitude and the phase of the voltage changes. On the accompanying chart there are shown records which have been made of sucker rods. The upper curve is indicative of the amplitude changes, and the lower curve is indicative of phase changes. Fatigue development on the chart is indicated by an upward deflection of the upper or amplitude curve, accompanied by the phase angle indicated on the lower curve which is indicative of fatigue.

The charts shown here are taken from records made on well tests. On the upper chart are shown characteristics of new rods together with changes which occur due to fatigue caused by bending the rods and by certain metallurgical changes caused by chill spots on the rods. The center chart indicates a char-

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case of war is now assured to be plentiful and no shortage of it could be expected as happened during the World War.

In addition to chemicals of the above type, a large variety of other similar materials is obtained from petroleum which find wide applications in various industries and in everyday life. Sulfonic acids of different types are used as detergents, emulsifying agents, and for other purposes. Naphthenic acids found in petroleum are utilized in the form of their various metallic salts in the manufacture of paints and lacquers or as emulsifiers and demulsifiers. Resins, such as bakelite, are synthesized from materials which are or may be obtained from petroleum. Manufacture of rubber from butadiene, a hydrocarbon which is obtained by thermal decomposition of certain petroleum hydrocarbons, is one of the very latest achievements. The resulting rubber is in many respects superior to natural rubber and should find wide application in the tire and other related industries.

PLACE OF DISTINCTION

The above outline barely scratches the surface of the petroleum industry and falls short in fully presenting its various aspects. Nevertheless, it is sufficiently complete to illustrate the complexity of problems which the industry has to meet at the present time and to permit some insight in its future trends. Petroleum is rapidly achieving the place of distinction as the major source of all types of organic chemicals and is already in direct competition with coal tar, from which such chemicals have usually been obtained. Rapid development of our knowledge of organic compounds other than aromatic promises the developments of new and hitherto unknown materials of commerce. This will inevitably lead to an increased everyday comfort directly traced to the petroleum industry which has already given innumerable benefits to mankind. The "flowing gold" of today will continue to be the "flowing gold" of tomorrow, far more beneficial than metallic gold which has only an artificial value as a medium of exchange but which can hardly be considered an asset unless it can be converted into other goods.

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acteristic chart which was obtained from a well test. In this chart the development of fatigue is clearly shown in the rods. To those acquainted with oil production problems the appearance of fatigue near the upset will indicate clearly the case where rods break immediately adjacent to the upset. In the lower chart is shown the characteristics of a number of rods which broke in service. In this case the rods were first run on an experimental basis to determine the characteristics of the rods which later broke in service. By means of charts such as these it is possible to determine the rods which have fatigued the most, and to remove them from service before failure occurs.

Besides the author, who is the inventor of this method of magnetic testing, several other alumni assisted in this development. Among these alumni are Louis Kolb '39, who assisted in the early development, and Don Clark '29, who assisted in the metallurgical coordination of the work. Patent work for the Corporation is being handled by R. M. Bruce '22, who was formerly in the General Electric Company Patent Department. Field development work was assisted by efforts of A. C. Tutschulte '31, in the cooperative work between the Magnetest Corporation and the Associated Oil Company. A great deal of assistance was, also, furnished by Professor Sorensen, particularly in connection with the personnel.

MAGNETIC TESTING
SUCKER ROD CHARTS