Use of Chemical Dispersants to Control Paraffin Problems and a Method for Determining the Treatment Requirements

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INTRODUCTION

Paraffin deposits have hampered oil well production ever since the discovery of oil.

Over the years, although the oil industry has been plagued with this problem, they are content to live with it, only recognizing it when they are confronted with production downtime due to paraffin buildup. Excessive paraffin deposition creates production problems, such as:

1. Loss of production
2. Down time in removing paraffin
3. Unnecessary wear on production equipment with use of mechanical methods of paraffin removal
4. Cost for removal of tank bottom buildup
5. Loss of efficiency in operation of LACT and hydraulic pump unit systems
6. Increased accumulation of BS&W content of produced oil

With the above problems eliminated, costs due to paraffin buildup can be reduced considerably.

The chemical dispersant, used in the following laboratory studies and actual field tests, does not contain arsenic, chlorinated hydrocarbons or other material generally considered harmful to refinery catalysts. It is compatible with and can be used in conjunction with most chemical additives now being used in wells or collecting tanks. This dispersant is available in 4 forms:

1. Sticks, 1-3/8 in. diameter by 18 in. long, used primarily for down-hole treatment in flowing and pumping wells.
2. Granular, 10-30 mesh, used in a manner similar to a propping agent in fracturing treatments.
3. Spherical Balls, 5/8 in. diameter, may be used by dropping into the annulus of pumping wells or in surface, flow line, or by-pass feeders.
4. Liquid is suitable for continuous injection into the annulus or flow lines and can also be metered into the power oil in hydraulic pumping systems.

LABORATORY AND EXPERIMENTAL FIELD FINDINGS WHICH LEAD TO THE CHEMICAL DISPERSANT CONCEPT AND THEORY [1]

The dispersant concept is an approach that uses a chemical to reduce the tendency of paraffin crystals to grow in clusters, and these clusters to clump as they separate from solution, forming a paraffin deposit.

A paraffin problem has been defined as any predominately organic deposit which hampers the production of crude oil. This broad definition (Fig. 1) was required by the complex and variable chemical composition of crude deposits. Studies have revealed that many deposits contain rather large amounts of wax and asphaltic materials.

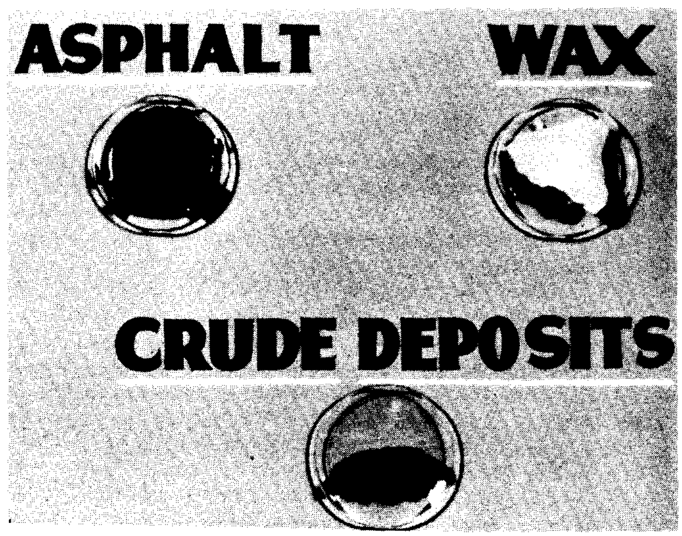


FIG. 1

Fig. 2 is a photomicrograph of paraffin crystals precipitated from an untreated solution of kerosene and of a partially refined paraffin. A large number of individual crystals have formed a starlike bush. The bushes tend to interlock and are bunched together because of the starlike cluster structure. Attachment to rough metal surfaces and growth of deposits probably occur through a somewhat similar process. This may explain why an increase in surface roughness will generally make paraffin deposition worse.

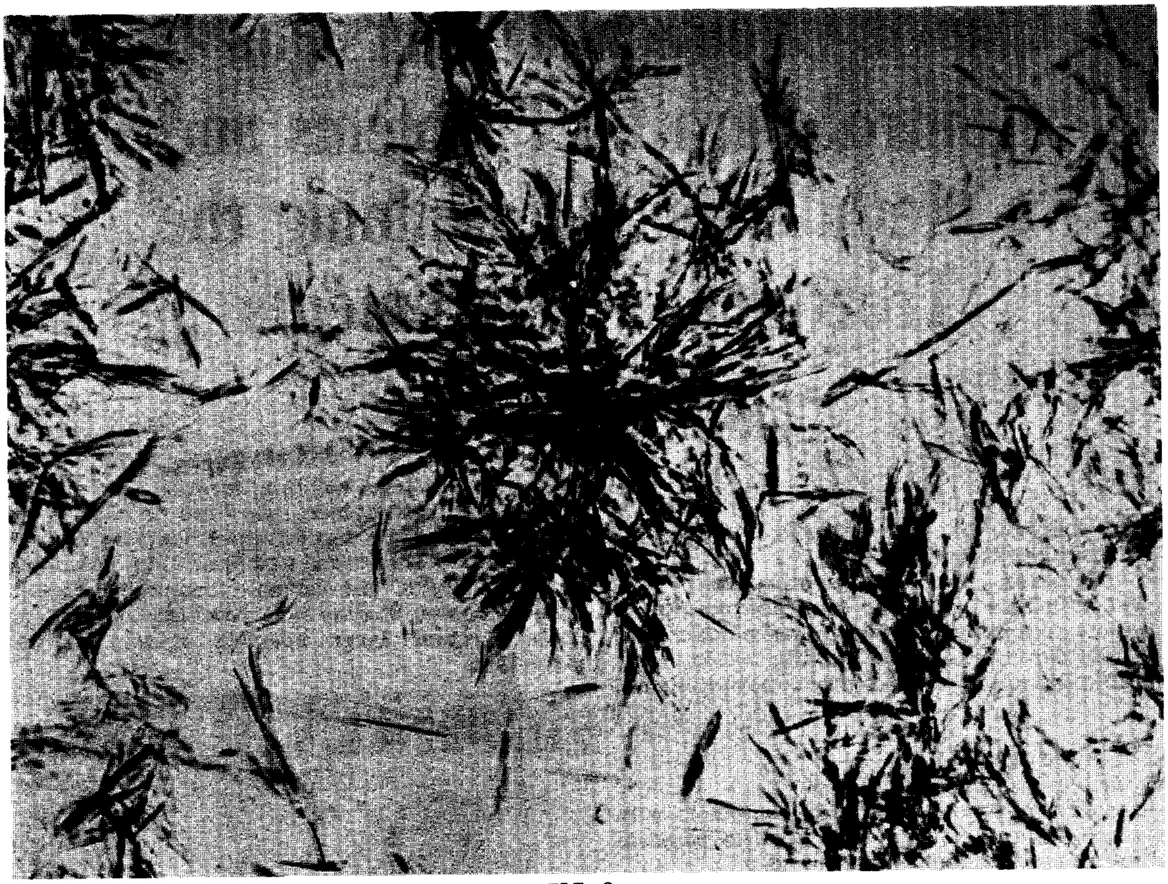


FIG. 2

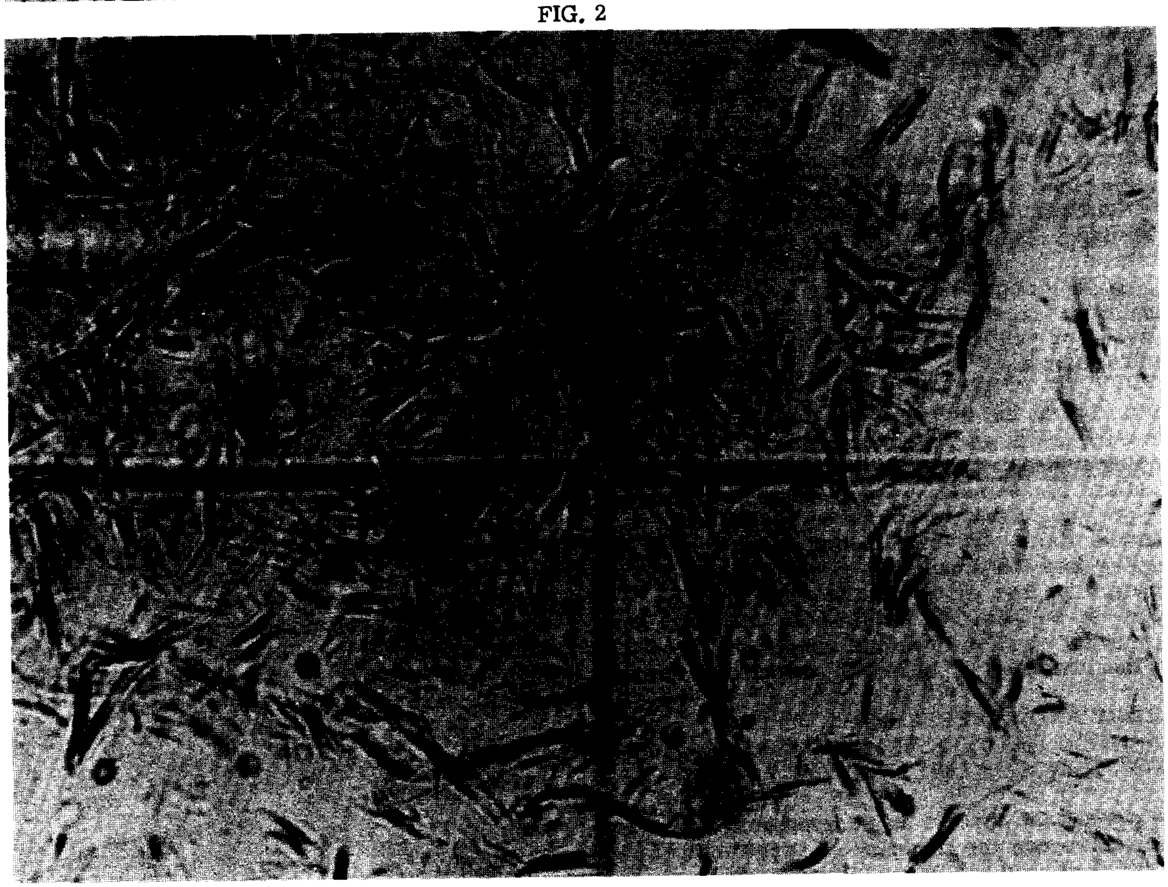


FIG. 3

The photomicrograph, shown as Fig. 3, shows crystals of paraffin which were precipitated from an identical solution under the same conditions except that a chemical dispersant was added. In this instance, the individual crystals are almost identical in length and general appearance to those in the last slide, but their tendency to form starlike bushes and to agglomerate has been greatly reduced. Because the crystals no longer cluster, they are more readily kept in suspension and have much less tendency to adhere to solid surfaces.

The dispersant concept was further studied using a laboratory deposition cell.

In the experiment illustrated in Fig. 4, a 7% solution of semi-refined wax with a cloud point of 82° F. was circulated at 92° F. Temperature of the cooling water was 40° F. This was the same wax as shown in the photomicrographs. As the experiment proceeded, the flow rate decreased, indicating that paraffin was being deposited. After the addition of a chemical dispersant, the flow rate increased, approaching the value observed at the beginning of the experiment. In other experiments without a chemical dispersant, deposition continued (as indicated by the dashed line in Fig. 4), sometimes resulting in complete plugging of the pipe.

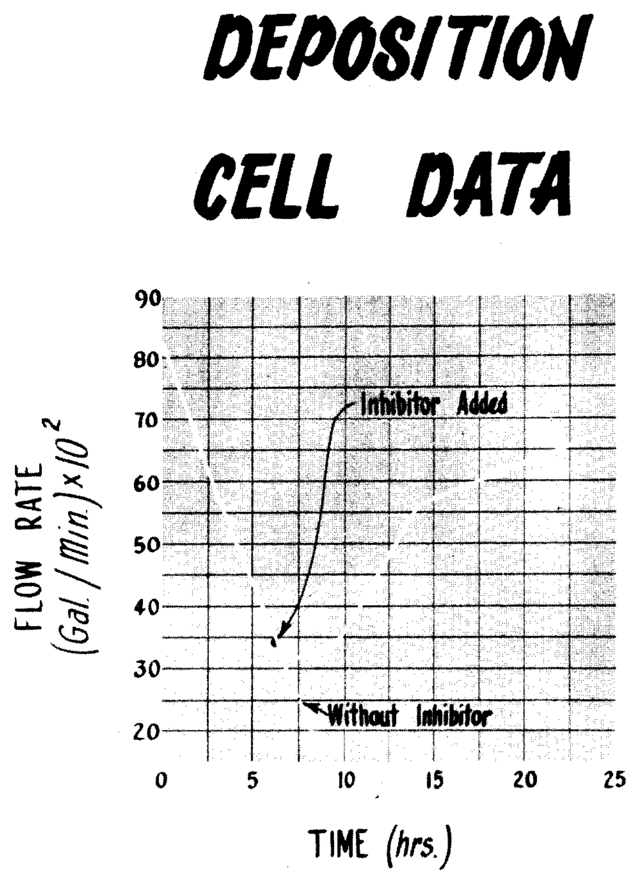


FIG. 4

This chemical dispersant is not a paraffin solvent and does not increase the solubility of paraffin in the oil to any appreciable extent at the very low concentration used. Therefore, dispersion of the paraffin has to be explained in some other manner.

On the left side of Fig. 5, paraffin in solution, some paraffin starlike crystals out of solution, and paraffin deposited on a pipe are shown. Suspended and deposited paraffin seems to be in some type of dynamic equilibrium with wax which is dissolved in oil. This is indicated by the equilibrium lines A and C. B represents the bush clusters mechanically attaching themselves to and being sloughed off from the existing deposits. All of these processes are forced by well conditions in the direction of continuing deposition. These equilibria are shifted by the addition of a chemical dispersant as shown on the right side of Fig. 5. The paraffin separating from solution is now in a form which does

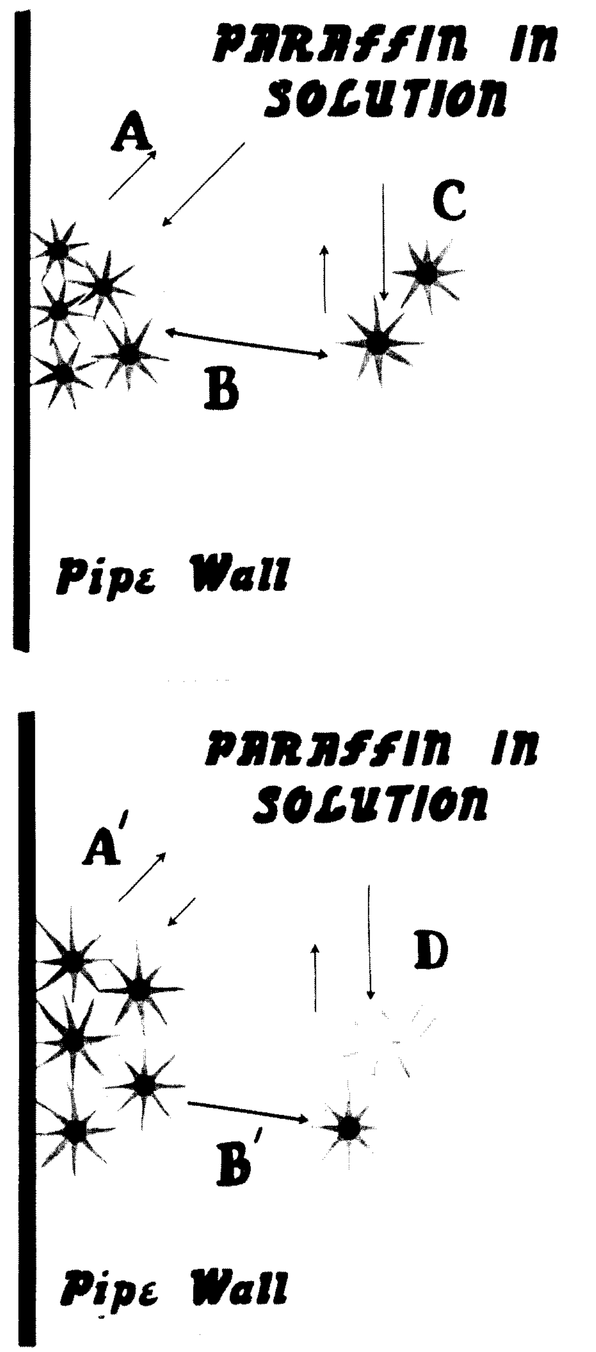


FIG. 5

not tend to adhere to the well equipment or existing deposits of paraffin. This includes paraffin dissolving from the deposit A prime. Eventually, most of the paraffin will be suspended in the crude oil as shown by equilibrium process D. Mechanical sloughing off, as depicted by B prime, will also contribute to removal. Deposits, therefore, will gradually be removed, even though there is very little, if any, increase in solubility or decrease in the amount of wax separating from solution.

Fig. 6 shows how a chemical paraffin dispersant lowers the melting point of wax in asphalt. As can be seen by the white line, even very high concentrations of the dispersant do not lower the softening point of paraffin or wax to any appreciable extent, indicating only a normal interaction between the 2 solid substances. Because of this, the dispersant must be affecting some substance in crude deposits other than the waxes. However, the black line shows that small amounts of dispersant have a considerable effect on the softening point of asphalts, indicating a strong interaction.

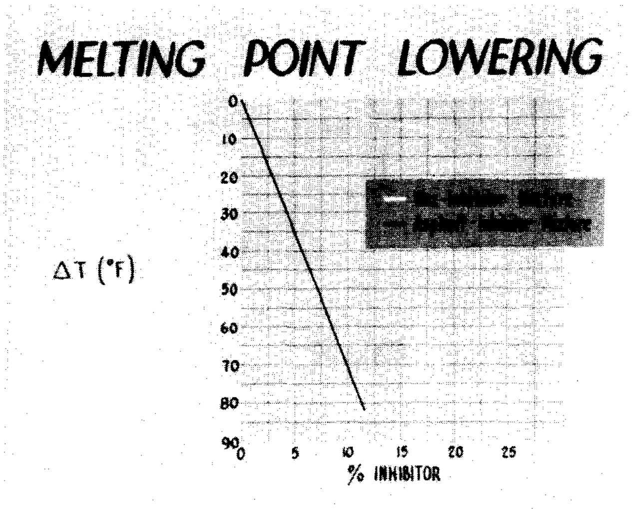


FIG. 6

The paraffin crystals shown in the first photomicrographs (Fig. 2) were deposited from a partially refined wax containing asphalt. Notice they appear to be formed around some sort of nucleus. Colloidal asphalt particles could easily serve as such nucleating agents.

An artist's concept (Fig. 7) illustrates a typical crude paraffin crystal and also shows an inhibited paraffin crystal that suggests a chemical dispersant probably acts by attaching itself to the collodial asphalt particles. After interacting with the dispersant, the asphaltic material no longer serves as a nucleating agent, and the paraffin coming out of solution forms single, more easily dispersable crystals.

Because of the encouraging laboratory data, actual field applications were conducted to confirm the proposed theory. For field use, a solid material was compounded. This material was designed to have a high melting point and slow solubility in crude oil, coupled with the maximum action to reduce crystal clustering.

The exploration of the laboratory work in conjunction with successful field tests, proved that a chemical dispersant was available which could inhibit the formation of paraffin deposits during oil production.

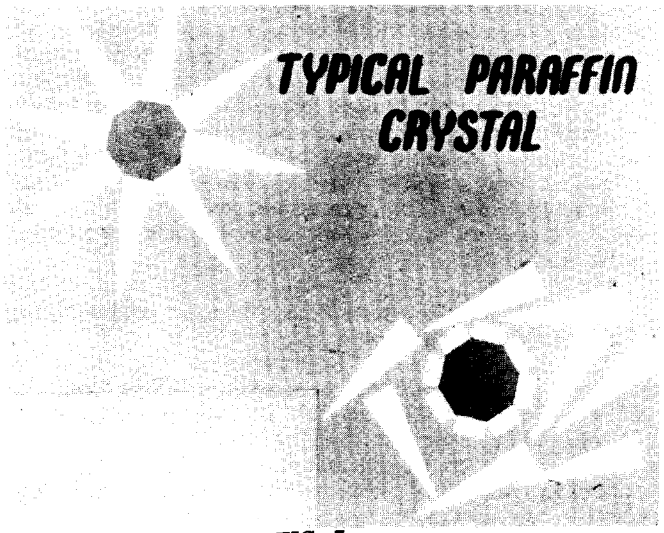


FIG. 7

PARAFFIN PROBLEM AREAS

Paraffin problems (Fig. 8) are widespread geographically and occur in almost every area where oil is produced.[2] In a survey of 69 areas in 19 states, it was found that 59 areas representing 18 states reported paraffin problems. Some areas are affected more severely than others, in addition to there being considerable variations found within the same field.

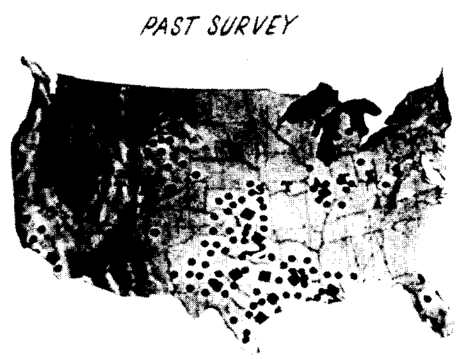
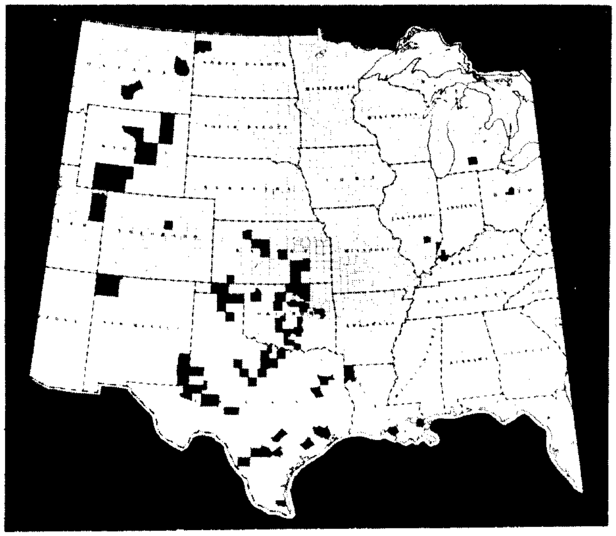


FIG. 8

A more recent survey (Fig. 9) shows 15 oil producing states and approximately 87 oil producing counties where paraffin problems exist.

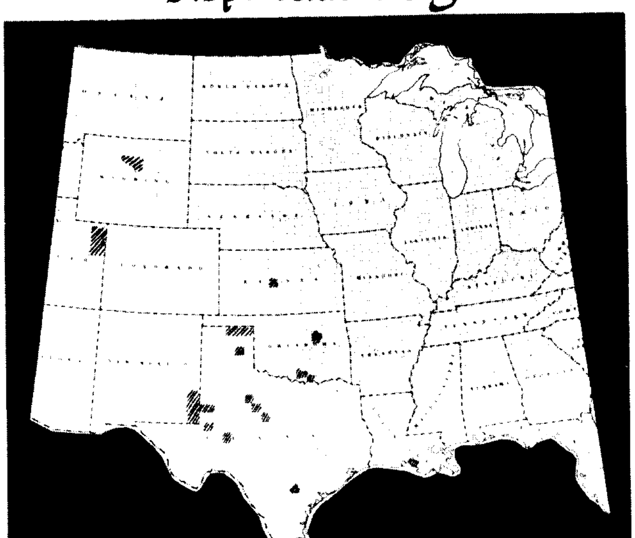


■ Paraffin Problems

FIG. 9

The chemical dispersant treatment (Fig. 10) is now being used in 20 of the above 87 counties effectively and economically preventing paraffin deposition.

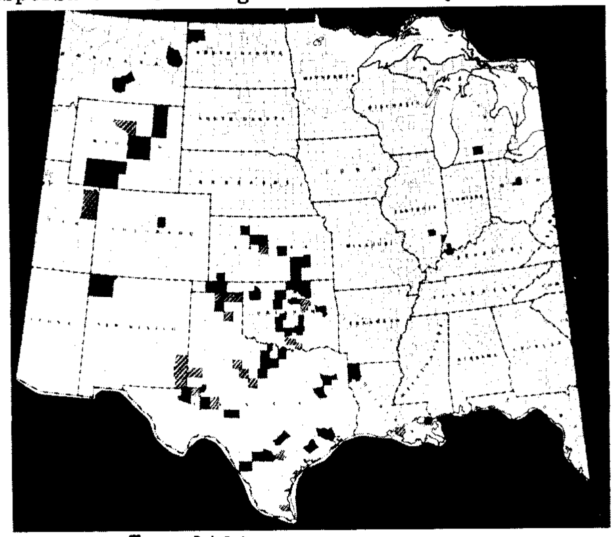
Present Chemical Dispersant Usage



▨ Chemical Dispersant Used

FIG. 10

Areas where paraffin problems have been found are shown in Fig. 11 and shows where the chemical dispersant is now being used successfully.

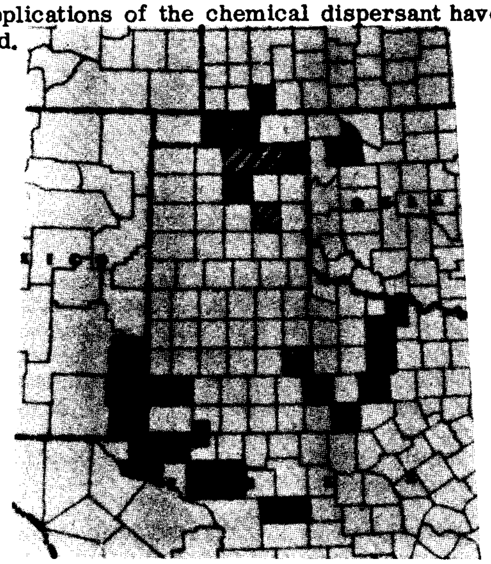


■ PARAFFIN PROBLEMS
▨ CHEMICAL DISPERSANT USED

FIG. 11

A number of supervised field tests are now being conducted in California, Michigan, Ohio and West Virginia -- conclusive results will be made available later.

An enlarged section of the previous map (Fig. 12) shows the area which perhaps will be of greatest interest to West Texas operators. It should be noted that out of 27 areas surveyed in this particular geographical location, there are 13 areas where successful field applications of the chemical dispersant have been reported.



PARAFFIN PROBLEMS

CHEMICAL DISPERSANT USED

FIG. 12

FIELD APPLICATION OF CHEMICAL DISPERSANT

The following presents new data[3] covering successful field application. All of these treated wells are now operating without interruption since the paraffin buildup problem has been minimized. Three field applications have been cited in previously published literature.[1]

Formation Placement Using Granular Form of Dispersant

Fig. 13 shows field results obtained by using the granular form of the dispersant. A Gray County, Texas, well "A", shown by the lighter line, was fractured with 1,000 lbs. of chemical dispersant; while well "B", shown by the darker line, was fractured without a chemical dispersant. Apparently, production declined in well "B" due to paraffin buildup, but not in well "A". After the time period shown in Fig. 13, it was necessary to remove paraffin from well "B", but no increase in production was noted. No difficulties from paraffin have been reported from well "A".

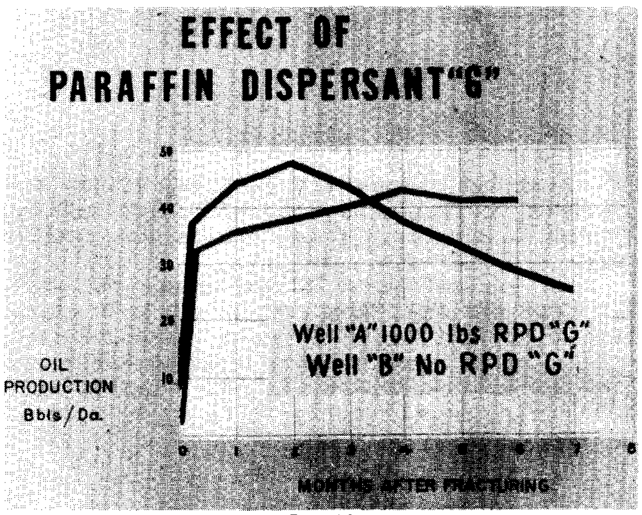


FIG. 13

Flowing Well Treatment Using StickForm of Dispersant

Chemical dispersant was used in several wells in Creek County, Oklahoma. Prior to starting this treatment (Fig. 14), it was only possible to produce the monthly allowable if rods and tubing were pulled and steamed each month. The bottom hole temperature of these wells was about 80° to 85° F. Since stick treatment, the wells have not been pulled, and they remain capable of producing about 38 BOPD, although the state allowable was only 12 BPD.

It should be noted that paraffin control costs dropped after the use of the chemical dispersant from about $150.00 per month to about $3.00 per month.

Down-Hole Annulus Treatment Using Ball Form of Dispersant

These wells shown in Fig. 15 required hot oil treatments every month. To bring the production to the level shown in well "1", represented by the dotted line, 12 lbs. of chemical dispersant were used and in

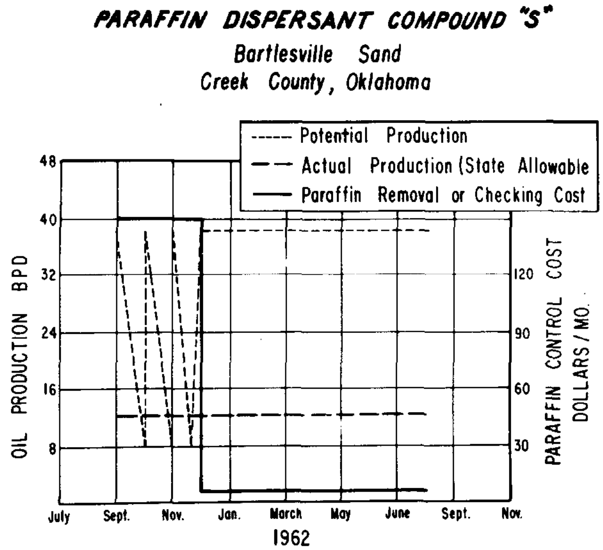


FIG. 14

well "2", represented by the solid line, 35 lbs. of chemical dispersant were used. This is a field example of removal of paraffin which corresponds to the laboratory data. After 2 or 3 months, the dispersant had apparently dissolved and production started to decline. Ten lbs. of chemical dispersant per month in these wells has maintained production.

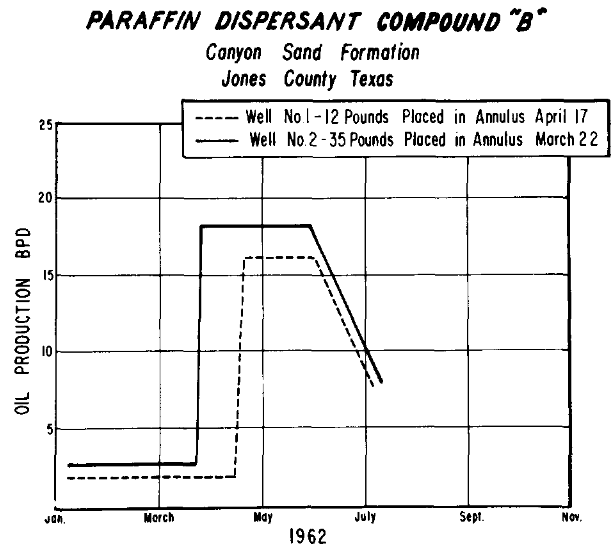


FIG. 15

Chemical Feed Pump Treatment Using Liquid Form of Dispersant

One operator in Ector County, Texas, spent $12,000 per year on an eight-well hydraulic pumping system, producing 130 BOPD, as a result of paraffin deposition. This included hot oil treatments, steaming flow lines, and pulling and repairing pumps because of paraffin plugging.

A program (Fig. 16) of paraffin control was started by using a chemical feeder to inject 1/2 gal. of chemical dispersant and 1/2 gal. of corrosion inhibitor per day. Remedial work caused by paraffin was no longer necessary after starting the program. The paraffin control cost of approximately $360 per year, has given a yearly savings of over $11,000 on this one lease. Additional production was also obtained because of fewer shutdowns.

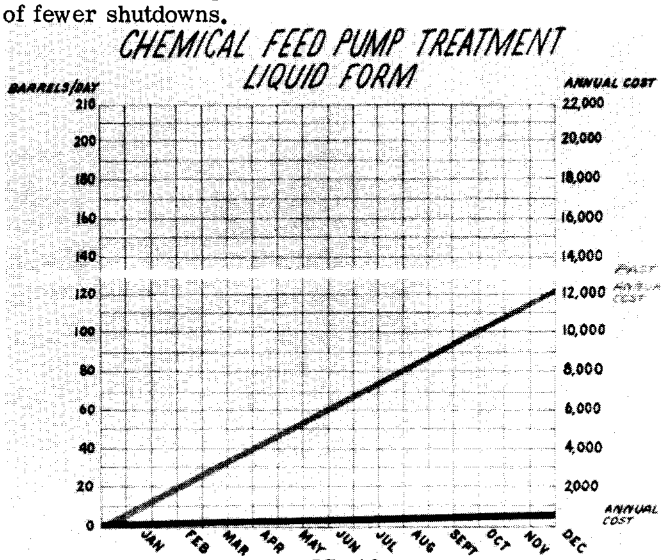


FIG. 16

Flowing Well Treatment Using Stick Form of Dispersant

In the LaSal Vieja Field, Willacy County, Texas, a gas lift well was treated with one stick of chemical dispersant (Fig. 17) per week, placed through a lubricator on top of the Christmas tree and spotted with a tubing stop at 2,000 ft. Paraffin deposition occurred from 1,800 ft. to the surface. Prior to the chemical dispersant treatment, this well required 2 to 3 days' down time each month to cut paraffin with a wire line. One chemical dispersant stick each week has reduced cutting time to 4 hr. since the paraffin has been softened by the addition of chemical dispersant.

The operator has increased the treatment to 2 sticks per week, feeling that the paraffin problem could be eliminated completely. Cost of the treatment is approximately $10.00 per month.

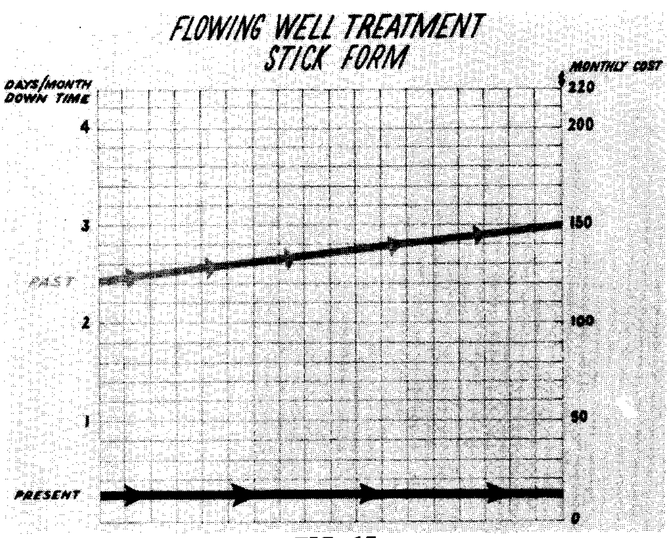


FIG. 17

Hydraulic Pump System Treatment Using Liquid Form of Dispersant

In the North Cowden Field, Ector County, Texas, a hydraulic pumping unit, with 4 wells, continues to be treated with chemical dispersant at a cost of about $15 per week (Fig. 18). Chemical dispersant is injected using a small metering pump, into the suction of the power oil pump. A check of the system revealed no paraffin buildup. In using the chemical dispersant, the pressure was reduced 200-300 psi., with a production increase from 200 BOPD to 300 BOPD. Prior to the liquid chemical dispersant treatment, it was necessary to run 1 in. and 2 in. soluble plugs plus a different paraffin treating material every week, at a cost of $70.00 per week.

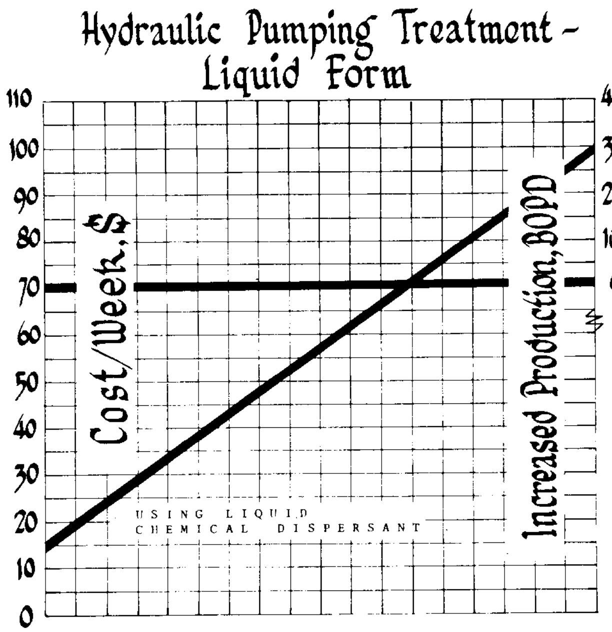


FIG. 18

Hydraulic Pump System Treatment Using Ball Form of Dispersant

In the North Ambrose Strawn Field, Gaines County, Texas, producing from the Strawn-Limestone with a BHT of 135° F., hot oil treatment was required every two months on a hydraulic pumping unit. The purpose of this treatment (Fig. 19) was to eliminate the paraffin deposition forming upstream and downstream of the triplex and bottom hole hydraulic pump. The operator found that 1 lb. of the chemical dispersant per pumping day afforded maximum protection. It was introduced by an in-line feeder system on the suction side of the hydraulic pump. A check on all the lines in the system showed no paraffin forming and the system, with a 300 BOPD Triplex throughput operated efficiently keeping Triplex pump pressure at 900 psi instead of 1,200 psi, resulting in considerable savings to the operator.

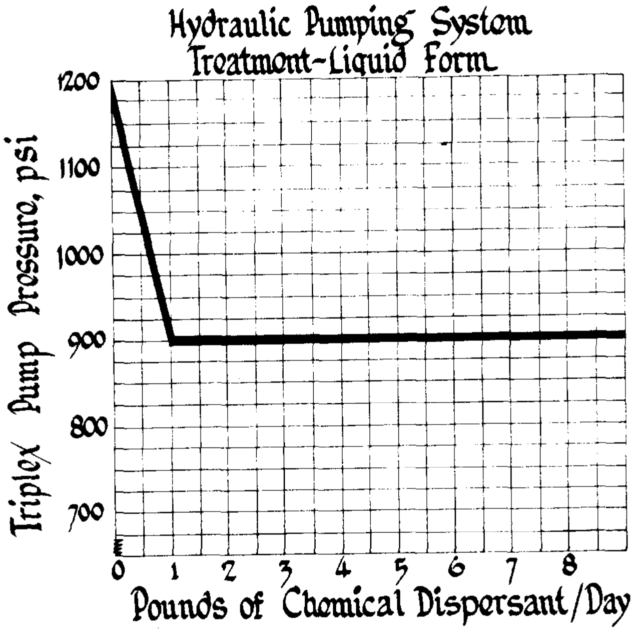


FIG. 19

Flowing Well Treatment Using
Stick Form of Dispersant

In St. Mary County, Louisiana, producing from a shaly section in the Eugene Field with a BHT of 180° F., an operator used 2 sticks of the chemical dispersant treatment per week by placing them in a storm choke at approximately 4,300 ft. Paraffin started building up from about 1,400 ft. to the surface. Since using the chemical dispersant, the tubing and 1,200 ft. of flow line have been free of paraffin. Cost to the operator is $120.00 per year. Prior to chemical dispersant treatment, cutting of paraffin was necessary every 25 to 30 days, at an annual cost of about $432.00. Savings amounted to $312.00 per year.

Flow Line Treatment Using
Ball Form of Dispersant

In Jones County, Texas, producing from the Fry Sandstone formation, under waterflood at a BHT of approximately 100° F., chemical dispersant was used successfully to prevent paraffin buildup in flow lines.

The paraffin problem is now being handled by using 3 lbs. of the chemical dispersant per week at a cost of approximately $120.00 per year, compared to approximately $1,560.00 per year for hot oiling services.

Annulus Treatment Using
Stick Form of Dispersant

A Skinner sand well (Fig. 20) with production of 38 BOPD in Northwestern Oklahoma, was completed open hole. If rods were not pulled every 30 days, a complete stripping job was necessary after 90 days. After a stripping job, this well was treated with 1 stick of chemical dispersant every 14 days. After 5 sticks had been dropped, considerable quantities of paraffin were pumped to the storage tanks. Production continued unhampered, after the fifth stick, at 38 BOPD for 92 days. The operator eliminated at least 2 pulling jobs and a possible stripping job by using the chemical dispersant material. The operator, well satisfied, can now put other wells on this type of treatment.

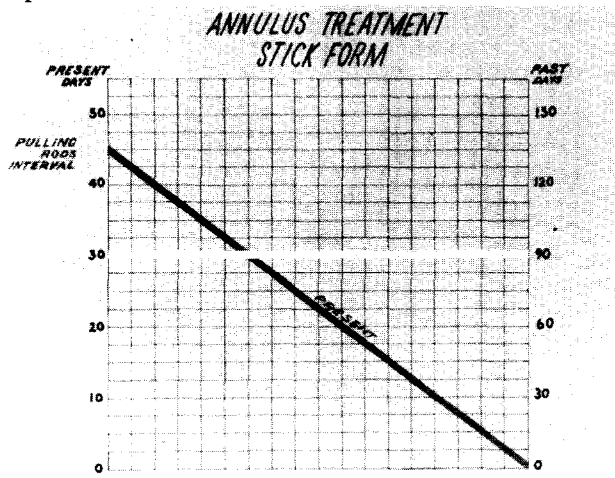


FIG. 20

Hydraulic Pump System Treatment Using
Liquid Form of Dispersant

In West Central Texas (Fig. 21), an operator for 2 weeks had been injecting, with a chemical pump, 1/2 gal. per day of the liquid chemical dispersant into the power oil intake of a seven-well system. Prior to the use of the chemical dispersant, production averaged 15 BOPD with all wells operating. Approximately 100 bbl. of power and produced oil are handled per day by the system. Operating pressures decreased substantially and production increased to an average of 25 BOPD. Treatment was reduced to 1 qt. per day, and production has remained constant. The system continues producing 25 BOPD, using only 3 of the 7 wells.

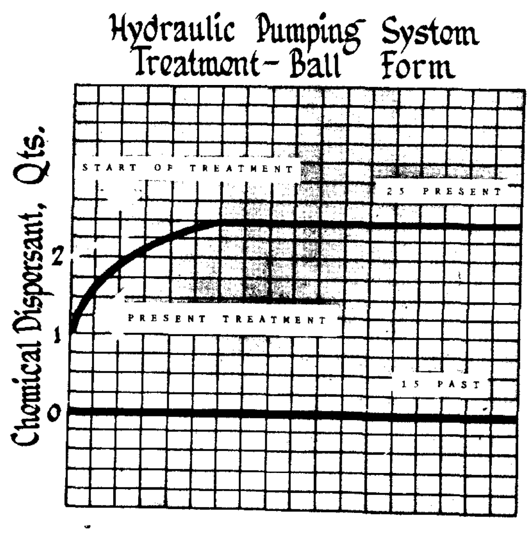


FIG. 21

Lubricator By-Pass Treatment Using Ball Form of Dispersant

Paraffin problems are handled economically on a well which produces from the Green River formation in Unitah County, Utah, by using a lubricator by-pass system charged with chemical dispersant. (Fig. 22). Five lbs. of the ball chemical dispersant were used at the start of the treatment giving 25 days of protection against paraffin deposits. Pressure on the flow line was reduced from 300 psi to 200 psi. The pressure began building up again after the chemical was exhausted. The operator recharged the lubricator with an additional 5 lbs. of the chemical dispersant and the well, again, returned to paraffin free production with pressure reduction from 300 psi to 200 psi.

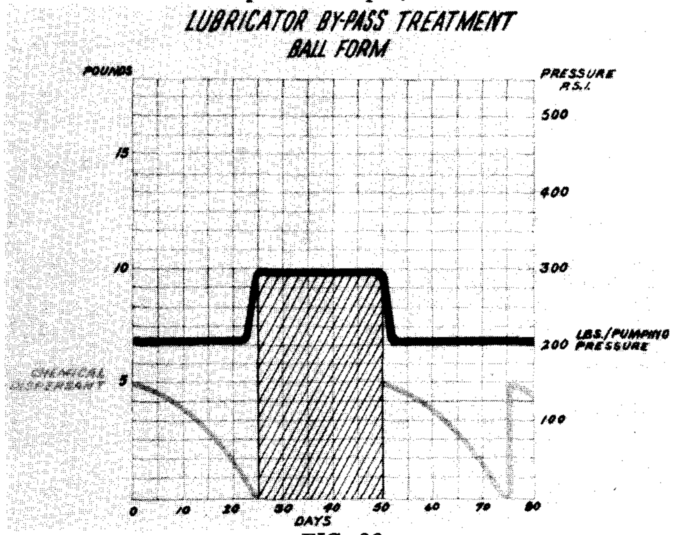


FIG. 22

Lead Line By-Pass Feed Control Using Ball Form of Dispersant

A company in Wichita, Kansas, uses the ball form chemical dispersant to control severe paraffin problems in the lead lines. Paraffin deposits had been a problem for 3 years prior to the use of the chemical dispersant. Many paraffin solvents had been tried with no success.

The first well to be put on a chemical dispersant treatment was a 3700 ft. well, in a waterflood, producing 103 BOPD with no water. A normal cleanout, 3 times a week, consisted of heating the lead line and stripping soft deposits. With the loss of 1 day's production, a conservative estimate of the cost to the operator would be $350.00 a week. The chemical dispersant was fed through a valved by-pass feeder into the lead line close to the well head. The well was shut-in and the by-pass and lead line valved off. The chemical dispersant was poured into the by-pass feeder. The upstream valve of the by-pass was opened and the well started. This pressured the by-pass, forcing the chemical dispersant down the lead line. The first test (Fig. 23) for the chemical dispersant came with the lead line pressure at 600 psi. The chemical dispersant was added as described through the by-pass feeder and within 2 hrs. the pressure decreased to 20 psi, the normal working pressure. This was the only relief from this problem in 3 years. At the present time 3 more problem wells have been put on the chemical dispersant treatment with complete success.

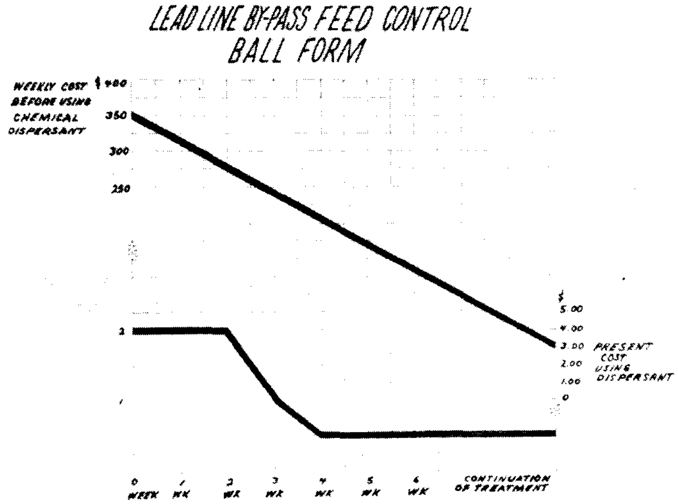


FIG. 23

Treatment for the initial test was 2 lbs. per day for the first 2 weeks, 1 lb. per day for the third week, 1/2 lb. per day for the fourth and fifth weeks, and at the present time 2 lbs. are added every 3 to 4 days.

A $1.60 treatment cost per 400 BOPD replaces the loss of production, the cost of firing and cleaning the lines 3 times a week, and the cost of 2 qts. a day of a different paraffin treating material. This trouble-free operation cost $2.80 per week as compared to a $350 weekly loss.

Thus, there is available a single compounded chemical dispersant that can handle practically any paraffin problem throughout oil producing areas. This compound, available in 4 forms, permits ease of application for proper placement depending on where paraffin buildup occurs.

IMPORTANCE OF PROPER USE

Some reports indicate these chemical dispersants have not worked effectively. Further analysis of such reports resulted in the following observations:

1. The paraffin problem had not been properly defined to enable precise chemical placement. The chemical did not reach the proper place at the proper concentration.
2. The production system had not been cleaned prior to the introduction of the chemical dispersant.
3. Treating instructions, as prescribed, had not been followed.

Although the paraffin problems were being handled by the chemical dispersant method, occasionally it has been reported that it was not economically feasible. An example was found in the North Ambrose Strawn field, in West Texas. A solid form of chemical dispersant was used in a hydraulic pump system at the rate of 1 to 2 lbs. per day during warm weather and the operator was well satisfied with the results. During the winter months it was decided that hot oilings were more economical, since the maximum concentration of dispersant used was at the economic break-even point.

METHOD FOR DETERMINING TREATING REQUIREMENTS

The solubility rate of the chemical dispersant is a rather complex function of several factors. The factors were carefully evaluated in the laboratory and the following presentation describes the results. These studies indicated that there is a relationship between the aniline point of an oil and the solubility rate of the chemical dispersant. The aniline point of an oil is the temperature at which a 1:1 mixture of the oil and aniline becomes completely miscible. This has been incorporated into the data to account for the solubility rates as a function of the type of oil. The data given in nomograph form is a graphic presentation by which certain unknown variables can be determined when certain other variables are given.

Undoubtedly, some exceptions will exist; however, the relationship should be adequate in most instances. It is probable that the aniline point of many of the oils will not be determined for field use of the nomographs. In such cases, a value of 175° F. as the aniline point should be used. This is an average value and many crudes will have an aniline point that will come fairly close to this, although some oils have been observed to have aniline points in excess of 200° F.

The nomographs are based on dissolving about 1 lb. of chemical dispersant for every 100 bbl. of oil produced during the "treatment interval". The amount of dispersant dissolved per unit of time will vary throughout the "treating period", decreasing as the volume of dispersant decreases. During the last quarter of the interval, about 1/4 lb. of the chemical dispersant should be dissolved for every 100 bbl. of oil produced. The "treating interval" is the number of days between addition of the chemical dispersant in either ball or stick form. This treatment should be adequate in most instances, although some cases will undoubtedly be found where a higher concentration of chemical dispersant is required. If it appears that a higher concentration is needed, either increasing the amount of "chemical dispersant added" or decreasing the "treating interval", or both, may be found effective.

Nomograph - Ball Form Dispersant

The nomograph shown in Fig. 24 is intended for use in by-pass feeder application.

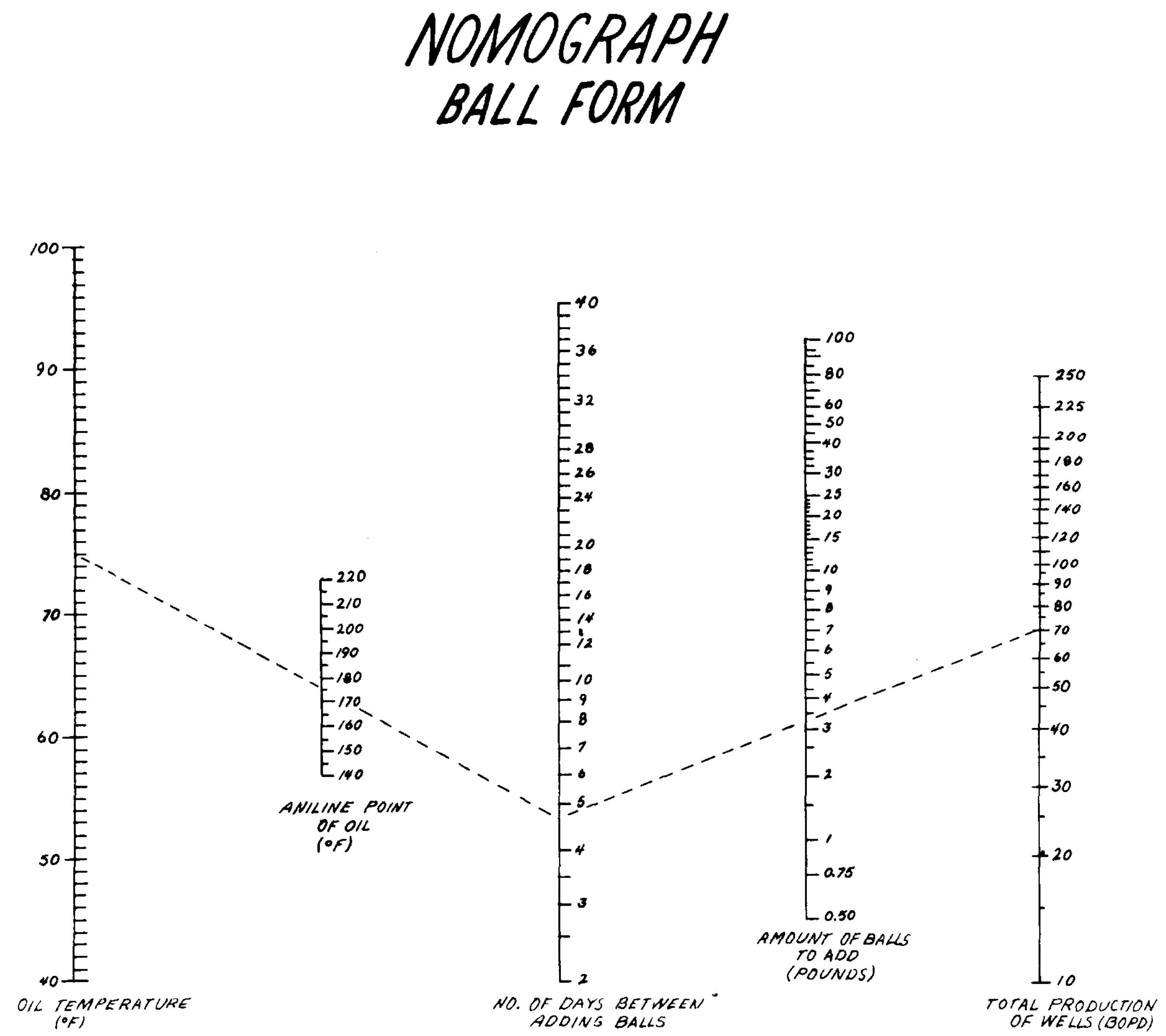


FIG. 24

The amount of fluid by-passed is not important as long as it is of sufficient quantity. At lease 1 bbl. of oil should be by-passed every day but 2 are preferable. A good rule of thumb would probably be about 5 to 10% of the total production.

The temperature of the oil passing through the by-pass feeder is the value to use in line (1) of the nomograph. This value may vary for a given well if the amount of fluid being by-passed or the existing temperature of the oil changes. If either of these factors changes after the treatment begins, the temperature of the oil should be checked and if it differs from the original temperature, the treating program should be alerted.

Only 2 factors are needed to use this nomograph: temperature and total production of the well in BOPD. Knowledge of the actual aniline point is helpful. If unknown, use the value of 175° F.

Factors other than solubility rate seem to influence the behavior of the chemical dispersant in down-hole baskets; so for these applications the quantity of balls to use per unit of time will still have to be determined by trial and error.

To use Fig. 24, draw a straight line through the temperature of the oil on line 1 and the aniline point of line 2 or use 175° F. if the aniline point is not known. Where this line intersects line 3, read the number of days that may elapse before more ball dispersant should be added, the "treating interval". This value may be rounded off to read to the nearest day. Draw another straight line between the "treating interval" on line 3 and the total production of the well in BOPD on line 5. Where this line intersects line 4, read the number of lbs. of balls, bed size, needed to be added at the end of each "treating interval". The dashed line on the nomograph (Fig. 24) illustrates how to arrive at a treating interval recommended for a well producing 70 BOPD. This oil, with an unknown aniline point, passes through the by-pass feeder at a temperature of 70° F. The nomograph recommends adding 3-1/2 lbs. of balls every 4 to 5 days. In practice, this could be rounded off to 4 lbs. of balls every 5 days or 3 lbs. every 4 days.

Sometimes the "treating interval" or volume used may be inconvenient or impractical. Figure 26 may be used for altering these factors. This procedure will be explained later.

Nomograph - Stick Form of Dispersant

The stick dispersant contains a small quantity of additive which improves the density and strength of the stick and increases its rate of solubility.

After the stick has been in contact with oil for a time, the binding material forms a film of oil insoluble material on the stick. This coating slows the solubility rate, but <u>does not</u> stop the stick from dissolving. It also shows solution rate at temperatures below 120° F to the extent that an insufficient amount of the chemical dispersant will be dissolved unless a large number of

NOMOGRAPH
STICK FORM

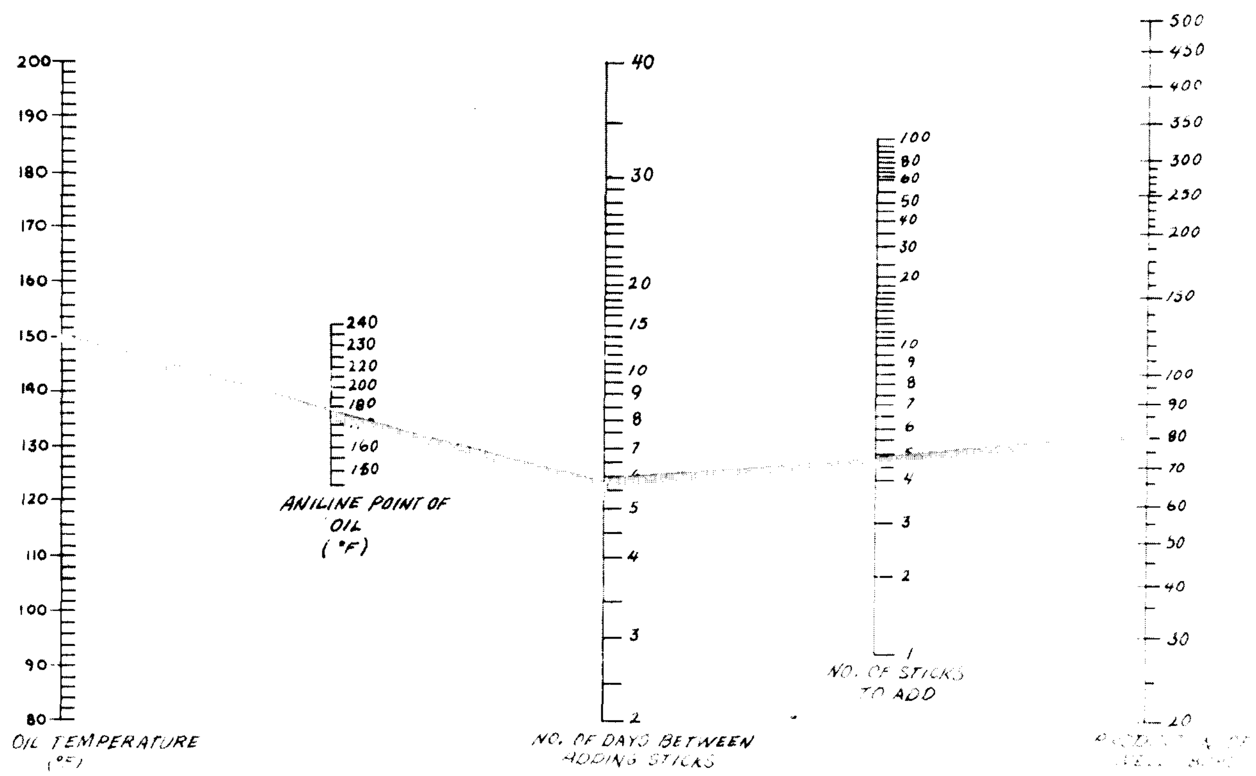


FIG. 25

sticks is used. The use of the chemical dispersant "S" is practical in down-hole application at temperatures up to 180° F. Sticks should not be used for most flow line application. Some exceptions may be found when oil temperature in the flow lines are higher than 100° F.

The coating formed by the binding material acquires a dark color when contacted by crude oil. In the past, the black coating had been mistaken for paraffin forming on the sticks and the users believed that the coating prevented the sticks from dissolving. This is not true and there should be no concern about the coating. It is not detrimental.

How to Use Nomograph - Stick Form Dispersant

The use of the stick dispersant nomograph is shown in Fig. 25. Draw a straight line connecting the oil temperatures on line 1 with its aniline point on line 2, or use 175° F if the aniline point is not known. If the sticks are being dropped to the bottom, use bottom hole temperature. If they are being caught on some device before hitting bottom, estimate the oil temperature at this point as accurately as possible. Where the line through the oil temperature and aniline point intersects line 3, read the "treating interval" in days. Draw another line between the "treating interval" on line 3 and the production of the well in BOPD on line 5. Where this line intersects line 4, read the number of sticks or pounds of chemical dispersant, (since 1 stick equals about 1 lb.) to add at the end of each "treating interval". The example illustrated by the dashed line shows that for a total production of 80 BOPD of an oil of unknown aniline point, 5 sticks should be dropped every 6 days if the sticks are being caught in the well where the oil temperature is 150° F.

NOMOGRAPH ALTERING TREATMENT

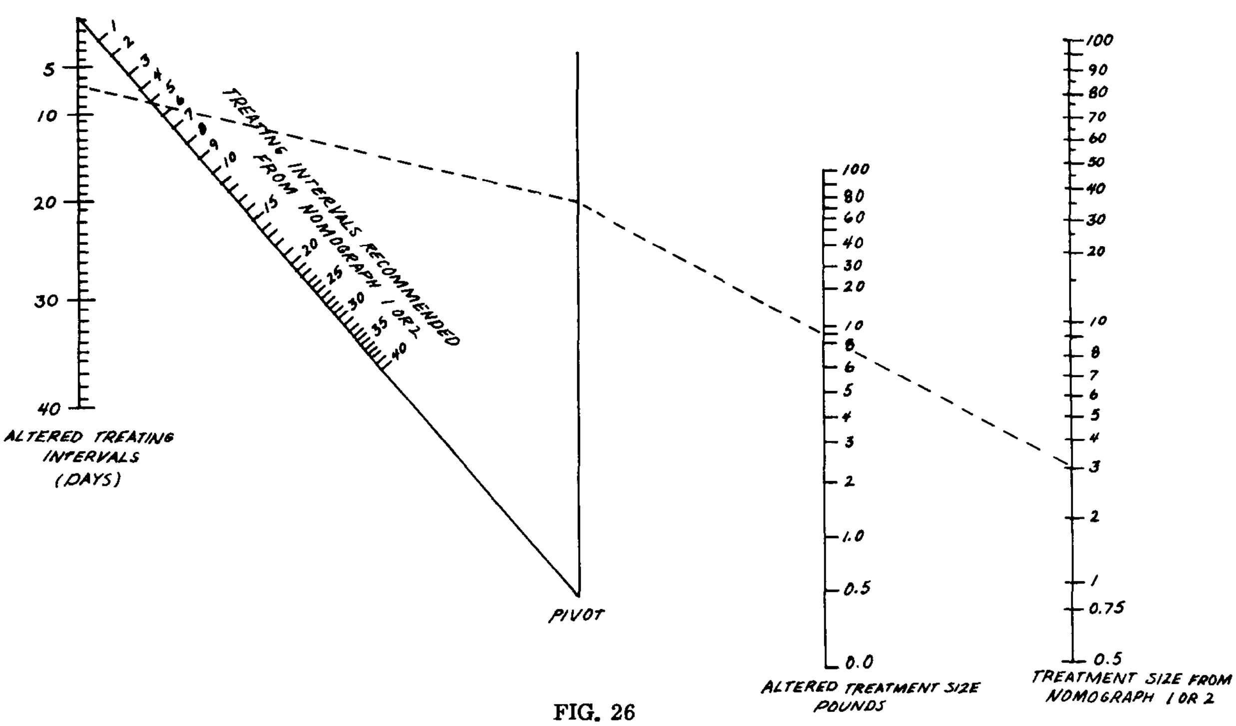


FIG. 26

Nomograph Used For Altering Treatment - Ball or Stick Dispersant

The nomograph, shown in Fig. 26, is intended for estimating slight alterations in the "treating interval" or the amount of the paraffin dispersant used as recommended by either of the other nomographs.

To use, draw a line between the value of the new or desired "treating interval" on line 1 and the value of the "treatment period" recommended from either Fig. 24 or 25 on line 2 until it intersects the pivot line. From this pivot line draw a line to the point on line 5 corresponding to the number of pounds, or sticks, of dispersant recommended from either Fig. 24 or Fig. 25. Where this line intersects line 4, read the new value of the treatment size.

The example shown by the dashed line illustrates a change in treatment schedule from that recommended in the example on Fig. 24. To alter the "treating interval" from 5 days to 7, the treatment size should be enlarged from 3 lbs. to 9 lbs. of ball dispersant.

For an alteration in the bed size or the number of sticks to be used, the above procedure should be reversed.

CONCLUSIONS

In conclusion, we have shown:

1. Production costs due to paraffin problems can now be controlled economically by the use of a new chemical dispersant.
2. The progress made thus far from the laboratory theory to successful experimental field applications using this new chemical dispersant.
3. The location of certain major paraffin problem areas and various geographical locations which this new dispersant has been and continues to be used effectively.
4. A scientific method presented in the form of nomographs, for determining the treatment requirements of the ball and stick form of this dispersant.

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