KHAZAR UNIVERSITY

MASTER THESIS

School**: Engineering and Applied Science**
Department: **Petroleum Engineering**
Major: **Petroleum Reservoir Engineering**

Title: Applying Advanced Techniques in Paraffin Control in Offshore Oil Wells

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I. ABSTRACT

APPLYING ADVANCED TECHNIQUES IN PARAFFIN CONTROL IN OFFSHORE OIL WELLS

The present thesis is devoted to the topical research problem-providing of normal operation of paraffin producing offshore oil wells.

A number of physical, chemical and thermal methods are used in the paraffin control process in oil production.

The successful application of technologies based on magnetic field generation in well-bottom-hole and well-bore allows deciding a number of problems in oil industry that increases the production rate of producers.

Furthermore the magnetic field experiments were carried out under the influence of various oersteds of magnitudes.

The best results were obtained at the magnetic field tension of 680000 A/m (8500 oersted) magnitude.

In the absence of non-magnetic field at the test pressure differentials if the oil viscosity is valued 1.54-1.65 mP.sec, after switching of magnetic field this viscosity reaches the magnitude of 1.34-1.45 mPa.sec. This fact shows the oil viscosity decrease to 12.5%.

Taking into consideration the above mentioned facts we could come to the conclusion that it is possible to adjust non-Newtonian oils' viscosity through generating magnet field in the investigated area.

Experiments provided on the laboratory device established the alternating magnetic field effect on the freezing temperature of the paraffinous oil. Experiments for this purpose were carried out to the magnetic field absent and magnetic field presence with 630000, 680000, 730000 A/m (in accordance with the 8000, 8500, 9000 oersted) magnitudes.

Furthermore, accordingly, at the magnetic field potential H = 680000 A/m, the relationship between the flow rate and the paraffinous oil freezing temperature was studied.. At experience period if the paraffin as part of oil, in the absence of magnetic field is frozen in 18 minutes, when the magnetic effect is applied the freezing period is increased for 24 minutes, in other words, extends by 33%.

The paraffin freezing period in the presence of distilled and sea water in the oil, in accordance with the influence of magnetic field is extended up to 40 and 65 minutes.

The investigation of constant magnetic field influence to the paraffin oil freezing temperature at the different amplitude, frequency and conservation time were provided.

It was established from the experiment results that at the maximum values of amplitude and minimum values of frequency magnetic field exert the greatest influence upon the paraffin oils freezing temperature.

The investigation of magnetic field influence to the paraffin oils rheological characteristics separately and together with the "compozit-2" were studied.

At present, to improve paraffin rich oils production and transportation properties is widely used methods that decline paraffin freezing temperature and consequently, prevent paraffin lattice formation.

For this purpose they used physical fields (e.g. magnetic field) and different types of polymer substances, i.e., special additives,

When paraffin rich oil if influenced by the magnetic field this hysteresis curves becomes closer to each other.

So, the magnetic field breaking the paraffin crystals lattice, forces the system to be in a flow steady state.

Consequently increasing the shear rate of oil flow leads to breaking of the paraffin crystal lattice and bringing the system into the steady state (equilibrium) flow.

As a result of investigations it was established that if the paraffin crystals were formed for example, at 60 °C, after affecting by the magnetic field, the mass crystallization is taken place at a low temperature, i.e. at 25-35 ^{0}C.

Influencing to paraffin high rich oils by the high magnetic field and chemical reagent together, impact depending upon the temperature of their constant shear rates the dynamic viscosity of oils decreases.

The magnetic field and depressors reduce the rate of non-steadiness and the best results with the magnetic field give the chemical reagent applying. The research results have shown that paraffin rich oils affected by a chemical reagent and examined to the “cold fingers “ showed 7 g paraffin, affected by a magnetic field - 6.85 g, and in case of a joint effect with the magnetic field and chemical reagent “cold fingers” paraffin deposits were 6.7 g. From here you can see that the synergetic effect occurrence.

At the end of thesis, the suitable conclusion was made and references are given.

The results of the researches carried out can be put into practice of paraffin rich oils production in offshore, and also onshore producing wells.

The thesis includes pages 67, figures 28, formula 1, tables 8 and slides on the CD.

II. ХЦЛАСЯ

ДЯНИЗ НЕФТ ГУЙУЛАРЫНЫН ИСТИСМАРЫНДА ПАРАФИНЯ ГАРШЫ МЦБАРИЗЯДЯ ГАБАГЪЫЛ ТЕХНОЛОЭИЙАНЫН ТЯТБИГИ

Щазыркы диссертасийа мцщцм бир проблемин щяллиня-дяниз гуйуларынын истисмарында парафиня гаршы мцбаризя вя онларын нормал ишинин тямин олунмасына щяср олунмушдур.

Гуйуларынын истисмарында парафиня гаршы мцбаризядя бир сыра физики, кимйяви вя истилик цсулларындан истифадя олунур.

Магнит сащясинин мцвяффягиййятля тятбигиня ясасланан технолоэийа гуйудиби вя гуйу эювдясиндя баш верян бир сыра проблемлярин щяллини асанлашдырыр вя гуйуларын щасилатынын артмасына эятириб чыхарыр.

Парафин чюкмясиня гаршы мцбаризядя мцхтялиф эярэинликлярля характеризя олунан магнит сащяляринин тясири тядгиг олунмушдур. Ян йахшы нятиъяляр магнит сащясинин эярэинлийинин 680000 А/м (8500 ерстед) гиймятиндя олмушдур.

Магнит сащясиндя тязйиг дцшэцсц шяраитиндя нефтин юзлцлцйц 1,54-1,65 MPa.c-дирся, магнит сащяси сюндцрцлдцкдян сонра ися юзлцлцйцн гиймяти 1,54-1,65 MPa.c-дяк ашаьы дцшцр. Бунунла да магнит сащясинин тясири нятиъясиндя юзлцлцйцн 12,5% ашаьы дцшмяси ялдя едилир. Гейд олунанлары нязяря алараг беля бир нятиъяйя эялмяк олур ки, магнит сащяси тятбиг етмякля гейри-Нйутон тябиятли нефтлярин юзлцлцйцнц тянзимлямяк олар.

Лабораторийа гурьусунда апарылмыш тядгигатлар эюстярди ки, дяйишян магнит сащясиндя йерляшдирилмиш парафинли нефтлярдя парафинин донма температуру ашаьы дцшцр. Бу мягсядля тяърцбяляр магнит сащяси олмайан вя магнит сащяси 630000, 680000, 730000 A/m (уйьун олараг 8000, 8500, 9000 ерстед) олан мцщитдя апарылмышдыр.

Магнит сащясинин потенсиалынын H = 680000 A/m гиймяти цчцн гуйунун мящсулдарлыьы иля парафинин донма температуру арасындакы асылылыг юйрянилмишдир.

Тяърцбя дюврцндя нефтин тяркибиндя олан парафин магнитсиз сащядя донма мцддяти 18 дягигя олмушдурса, магнит сащясиндя ися парафинин донма вахты 24 дягигяйя чатмыш, йяни 33%-дяк артмышдыр.

Нефтдя дистилля оунмуш су вя дяниз суйу олдугда магнит сащясиндя парафинин донма вахты 40 дягигядян 60 дягигяйядяк артмышдыр.

Сабит магнит сащясинин нефтдя олан парафинин донма температуруна тясири магнит сащясинин мцхтялиф амплитуду, тезлийи вя эеъикмя вахты цчцн тядгиг олунмушдур.

Магнит сащясинин парафинли нефтлярин реоложи хассяляриня тясири реаэентсиз вя "compozit-2" реаэентинин тясири олмагла юйрянилмишдир.

Щазырда парафинля зянэин нефтлярин щасилаты вя няглиййаты заманы онларын реоложи хассялярини йахшылашдырылмаг мягсядиля парафинин донма температуруну ашаьы салан вя беляликля дя, парафин шябякясинин формалашмасынын гаршысыны алмаг цсулларындан истифадя олунур.

Бу мягсядля тяърцбядя физики сащялярдян (башлыъа олараг магнит сащясиндян) вя мцхтялиф нюв ашгарлардан, башга сюзля, полимер ялавяляриндян истифадя олунур.

Магнит сащясинин тясири нятиъясиндя ахын заманы ямяля эялян щистерезис яйриляри бири-бириня йахынлашыр. Беляликля, магнит сащясинин тясири нятиъясиндя парафин кристалларынын шябякяси даьылыр вя флцидин ахыны гярарлашмыш олур.

Сцрцшмя эярэинлийинин артмасы парафинин кристалл шябякясинин даьылмасына вя ахынын гярарлашмыш мцвазинят шяклиня кечмясиня сябяб олур.

Тядгигатлар нятиъясиндя мцяййян едилмишдир ки, магнит сащяси тятбиг едилмядикдя парафинин кристаллашмасы 60^0Ъ температурда баш вердийи щалда, магнит сащясинин тясири нятиъясиндя ися парафинин кцтляви кристаллашмасы ашаьы температурларда, 25-35^{0}C температур интервалында баш верир.

Парафинля зянэин нефтляря йцксяк магнит сащяси вя кимйяви реаэентля тясир етдикдя температурдан асылы олараг сабит сцрцшмя сцрятиндя нефтин юзлцлцйц азалыр. Парафинли нефтляря магнит сащяси вя щямзаман реаэентля тясир етдикдя гярарлашмамыш ахынын сявиййяси азалыр. Тядгигат нятиъяляри эюстярмишдир ки, парафинля зянэин нефтляря кимйяви реаэентля тясир етдикдя "сойуг бармаглар" цсулу иля юлчцлмцш парафинирн мигдары 7 г, магнит сащяси иля тясир етдикдя ися 6,85 г, магнит сащяси вя кимйяви реаэентля бирликдя тясир етдикдя ися "сойуг бармаглар" цсулу иля юлчцлмцш парафинирн мигдары 6,7 г олмушдур,

Диссертасийанын сонунда мцвафиг нятиъя вя тяклифляр верилмиш вя истифадя олунмуш ядябиййатын сийащысы эюстярилмишдир.

Диссертасийанын нятиъяляри истяр дяниз, истярся дя гуру йатагларынын мящсулунда парафин олан гуйуларынын истисмарыны йахшылашдырмаг цчцн истифадя едиля биляр.

Диссертасийа 67 сящифя, 28 шякил, 1 дцстур, 8 ъядвял вя слайдлардан ибарятдир.

III. TABLE OF CONTENTS

INTRODUCTION

I. The actuality of the present master thesis is concluded in right organization of paraffin control of offshore oil wells. It is known that paraffin deposits leads to considerable loss of oil in a formation. Paraffin deposits are accumulated mainly in the well bottom, well-bore, well head, flow line and surface communications. It disturbs the normal operation of well system and surface communications. Leads to decrease of wells production rate and upsets the normal functioning of surface equipment, devices and apparatus.

Paraffin control processes to be applied in the field practice are divided into three groups:

(1) physical methods; (2) chemical methods; (3) thermal methods.

Every method has its varieties. Every paraffin control method with its varieties has their field application area and proper advantages and disadvantages.

II. The main object of a present thesis is to analyze the character of paraffin control methods and chose efficiency one. For today the most acceptable among great number of paraffin control methods and means we decided to investigate magnetic field application physical method. The latter occupies the visible place in practice from point of view simplicity, practicality and effectiveness.

III. The ways of solving of problems.

The present thesis is prepared on the base of laboratory investigations and field data analysis.

IV. Scientific novelty of the thesis. At the first time magnetic field is applied to prevent paraffin deposits originated in offshore oil producers. It gave a considerable economic effect in paraffin control of offshore producing wells.

The brief descriptions of problems considered in the thesis are given below.

Chapter 1. Paraffin control investigation problems are investigated.

The review of the literature on technological methods to control of paraffin deposits is given. The development experience of a number of producing formations was analyzed.

It was established that when bottom-hole (or well bottom or formation) pressure declines below the bubble-point pressure of oil by gas, the equilibrium state of the system is broken, thus increasing the volume of the gas phase and liquid phase becomes unstable. This leads to the release of asphalt-resin-paraffin deposits from oil. The equilibrium state is disturbed in the formation and precipitation of paraffin deposits as possible in the reservoir and in the well, starting from the bottom.

The development of the new paraffin control techniques in offshore
producing wells are considered. Many physical, chemical and thermal methods are used in the paraffin control in oil production practice. Between them we could call methods, such as physical, chemical, thermal, generation of electric, ultrasound, and magnetic fields in the appropriate environment.

There are several well-known and most actively used in the oil industry methods of controlling ARPD based on the dosing of the produced compounds that reduce or even completely prevent the formation deposits of ARPD. But variety of oil fields development and distinction of produced oil often demand individual approach and even developing new technologies.

Physical methods of paraffin control based on the process mechanically cleaning of paraffin deposits from the inside surface of flow tunings by the special scrapers (wall cleaners), run-in the bore-hole.

Mechanical methods involve removing already formed deposits of paraffin on the tubing. For this purpose developed a whole range of scrubbers (scrapers) of various designs. According to the construction and operation of scrapers are divided into:

- plate with rotation of the rod string having two inserts that can clean only the rotation of the ARPD. For this purpose, rotation of the rod string hanging from the head of the balance of pumping unit. Rotation of the rod string, and therefore, occurs only when the pigs moving down. In this way the scraper cuts the paraffin deposits from the surface of the tubing;
- spiral, reciprocating;
- «flying", equipped with knives, their wings, which are disclosed in the upward, allowing them to lift. Generally, is applied in curved wells. Using this method of control with the ARPD greatly complicated by the fact that its application often requires stopping of the well and the pipe surface pre-treatment (for some types of scrapers). Additionally, you may get

stuck pig, break their attachment and some other complications. In recent years, instead of the metal plate scraper bars to reinforce the plastic scrapers.

As a method of preventing the ARPD should be singled out the use of smooth protective coating of lacquer, glass and enamel. During transportation, round-trip transactions and tubing in the wells are at high impact, tensile, compressive, and bending and other loads. Glass coating due to its fragility, of considerable thickness and lack of adhesion to the metal pipe securely and destroyed in the process of tripping. This leads to the formation of the glass tubes in the tubing string and pump jam. In addition, the technology of glass and enamel coatings involves heating the tube to 700-800 ^{0}C, which causes irreversible processes in the metal structure and melting peaks threads. In the fields of "Orenburgneft" tubing were tested with the coating of bakelite lacquer, bakelite, epoxy, epoxy paint and vitreous [1]. Lack of heat and cold resistance of epoxy resins are a deterrent to widespread use. From these positions can be considered the best tubing lined with vitreous enamels. Strength and adhesion of the enamel are high. Chipped in the process of tripping and transportation are not observed. Great abrasion resistance, low thermal and electrical conductivity offer great prospects for implementation of tubes with glass-coated in the oil industry.

Chemical methods of ARPD control are based on dosing chemicals into the produced oil, decreasing, at other times wholly preventing well-bore and formation deposits.

At the heart of paraffin inhibitors are adsorption processes occurring at the interface between the liquid phase and the surface of the metal tube [3]. Chemicals are classified into wetting, modifiers, and dispersants deprecatory [4]: Wetting agents form a hydrophilic film on the surface of the metal that prevents adhesion of wax crystals to the tubes, thus creating conditions for the removal of fluid flow. These include polyacrylamide (PAA), IP 1, 2, 3, acidic organic phosphates, silicates of alkali metals, aqueous solutions of synthetic polymeric surfactants. Modifiers interact with the molecules of wax, hindering the process of enlargement of the crystals. This helps to maintain the crystals in suspension in the process of their movement. Such properties are possessed atactic polypropylene with a molecular weight of 2000-3000, low molecular weight polyisobutylene with a molecular weight of 8,000-12,000, aliphatic polymers, copolymers of ethylene and an ester with a double bond, triple-vinyl acetate copolymer of ethylene and vinilpirolidonom, a polymer with a molecular weight of 2500-3000. The mechanism of action is to deprecatory adsorption of molecules in crystals of paraffin, which hinders their ability to aggregate and accumulate. Well-known deprecatory include "Paraflou AzNII" alkylphenol IPX 9, "1A Dorada", VEO 504 TyumII, "Asolyat 7" [1]. Dispersants are chemicals that provide formation fine disperse systems, which are carried away by the flow of oil, which prevents the deposition of wax crystals on the walls of the tubes. These include metal salts, salts of higher fatty acids, synthetic, silicate-sulfanol solutions sulphated alkaline lignin.

Investigations provided during thermal treatment of paraffin oils have shown that due to heating the paraffin oils rheological characteristics are changed within some time period.

It was established that during thermal processing of oils paraffin crystals structure is destroyed after a certain time and then the destroyed structure is restored again. The paraffin crystals give of the system the viscous-plastic features which are lost during the thermal processing.

Currently, for heating of the oil the technology with the use of hot oil or water as a heating system, hot dry steam, electric surface and downhole performance, elektrodewaxing (induction heater), offering heating oil in the wellbore, and reactants, with the reaction of which exothermic reactions are taken place.

When paraffin oils are placed in the electric field with E=1500 V/m, under the influence of electric charges hydrocarbons' static shear stress and viscosity are decreasd.

In this case, asphalt-resin-paraffin different accumulation in tubing is prevented. As a result of heat influence hydraulic resistance to fluid flow is reduced and shift as a result of phase transformations tubing throughput flow capacity is increased. This phenomena in gas-liquid and water-oil systems is explained by a reduction of triboelektrik effect in the system.

Under ultra-sound influence of paraffin oils the movement velocity of solids inside of paraffin increases that causes the decreasing of oils' structural viscosity.

The successful application of technologies based on magnet field generation in well-bottom-hole and well-bore allows deciding a number of problems in oil industry that increases the production process.

The results of investigations carried out by a number of researches under the influence of magnetic field allowed to get formation rock permeability increasing, oil recovery factor increase, corrosion speed reduction, salt deposition control, asphalt-resin-paraffin deposits of successful control, etc.

The influence of the magnetic field to the paraffin deposition in oil (test temperature conditions were chosen 40°C, 35°C, 30°C and 25°C) has been studied at the special laboratory device.

Paraffin rich oil flow rate vs pressure differential has been studied. Magnetic field influence to the paraffin oil's flow is also investigated. In this case the experiment was carried out without and with magnetic field of 7889, 8446, 9032 oersted.

From the experiments results it was established that the relationship between paraffin oils flow rate vs pressure differential is the straight-line.

It was also established that paraffin oil in a non-magnetic field at pressure differentials ΔP = 2690, 4900, 5600, 6020, 8500 Pa and production rates (0.82, 1.46, 1.7, 1.85, 2.7) 10^{-6} m^3/sec, had the flow rate of 0.0019 - 0.02 m/sec, flow time 122-37 sec.

Furthermore the magnetic field experiments were carried out under the influence of various oersteds of magnitudes.

The best results were obtained at the magnetic field tension of 680000 A/m (8500 oersted) magnitude. So, at the pressure differentials of ΔP = 2690, 4900, 5600, 6020, 8500 Pa and paraffin oils production rates are (0,91, 1.67, 1.96, 2.20, 2,92) 10^{-6} m/sec,

At the pressure differentials magnitudes ΔP=2690, 4900, 5600, 6020, 8500 Pa, oil production in accordance with the paraffin oils rate of (0.91, 1.67, 1.96, 2.20, 2.92) 10^{-6} m^3/sec, the oils flow rate became 0.0021 - 0.022 m/sec, but flow time was 110-34 sec.

In the absence of non-magnetic field at the test pressure differentials if the oil viscosity is valued 1.54-1.65 mP.sec, after switching of magnetic field this viscosity reaches the magnitude of 1.34-1.45 mPa.sec. This fact shows the oil viscosity decrease to 12.5%.

Taking into consideration the above mentioned facts we could come to the conclusion that it is possible to adjust non-Newtonian oils' viscosity through generating magnet field in the investigated area.

Chapter 2. This chapter is devoted to the problems how the magnetic field is used against paraffin deposition. The investigation of the magnetic field influence to the paraffin oil freezing temperature in the flow time is studied.

On the laboratory device alternating magnetic field effect on the freezing temperature of the paraffinous oil was studied. Experiments for this purpose were carried out to the magnetic absent and magnetic field with 630000, 680000, 730000 A/m (in accordance with the 8000, 8500, 9000 oersted) magnitudes.

The research provided in this device shows that at the 680000 A/m (8500 oersted) the magnetic field difference of potential effect to the paraffinous oil is higher than the other magnetic field values. Furthermore, accordingly, at the magnetic field potential H = 680000 A/m, the relationship between the flow rate and the paraffinous oil freezing temperature was studied.

In addition to this, the experiments, with the oils composed of 10% of the distilled water and sea water were carried out. Such investigations can be concluded that the magnetic

field considerably affects to the freezing temperature of the paraffinous oil, in other words, magnetic field extends the
period of paraffinous oils freezing temperature.

At experience period if the paraffin as part of oil, in the absence of magnetic field is frozen in 18 minutes, when the magnetic effect is applied the freezing period is increased for 24 minutes, in other words, extends by 33%.

The paraffin freezing period in the presence of distilled and sea water in the oil, in accordance with the influence of magnetic field is extended up to 40 and 65 minutes.

In accordance with the 680000 A/m magnetic field, paraffin oils flow rate vs flow time, the influence of magnetic field to paraffin oils fluidity, magnet field's induction influence of paraffin freezing temperature curves were introduced in figure 1.3-1.5.
Furthermore, the investigation of the magnetic field influence to the paraffin oil freezing temperature at different amplitude, frequency and conservation time are examined.

To study the influence effect of different amplitude, frequency and duration time in a fixed magnetic field to the freezing temperature of the paraffin oils a special time relay was studied.

The purpose of the time relay building into the device is to study of the magnetic field, created by a constant current of different amplitudes, frequencies and periods of detention to the impact of paraffin oils temperature of freezing.
The influence of the magnetic fields, created by the fixed and variable currents, to paraffin oils flow is determined.

The magnetic current, frequency and magnetic field delay time impact to the paraffin oils freezing temperature of what period of time have been studied
within the following conditions:

1) a fixed (direct) magnetic field's difference of potential of 42400 A/m (530 oersted) impact to the paraffin oils flow, within 2 minutes delaying, how magnetic field influence to the paraffin oils freezing temperature was investigated. Paraffin oils temperature, in this case, has been assumed 25°C.

2) a fixed (direct) magnetic field's difference of potential of 42400 A/m (530 oersted) impact to the paraffin oils flow, within 60 minutes delaying, how magnetic field influence to the paraffin oils freezing temperature was investigated. In this case, paraffin oils temperature, has been assumed 25°C.

It was established from the experiment results that at the maximum values of amplitude and minimum values of frequency magnetic field exert the greatest influence upon the paraffin oils freezing temperature.

Chapter 3. The investigation of magnetic field influence to the paraffin oil rheological characteristics without and together with "compozit-2"

Master thesis investigates the development of offshore oil wells paraffin control physical methods. For this purpose, in a special laboratory facility changing magnetic field influence mechanism to the paraffin oils have practically been studied. Laboratory experiments were provided at temperatures 25^0C, 30^0C, 35^0C and 40^0C in the absence of the influence of magnetic field and also 8000, 8500, 9000 ersted voltage variable magnetic field influence again at different temperatures have been carried out.

In order to investigate paraffin oils flow parameters, the relationship between liquid flow rate and pressure differential has been studied.

In the absence of magnetic field the paraffin oils flow rate has been studied at different pressure differentials.

Later, experiments were carried out with the influence of magnetic field at different voltage. The best results were given at magnetic field voltage of 8500 oersted.

It was established that as a result of the influence of magnetic field at a different pressure differential, the paraffin oils' flow rate increases. Thus, in the absence of the influence of magnetic field at pressure differential Δ P = 8500 Pa, if the flow rate of paraffin oil was of 0.018 m/sec, then as a result of magnetic field impact the paraffin oil flow rate became 0.022 m/sec. In other words, as a result of the influence of magnetic field paraffin oils'flow rate was increased by22%.

Then the influence of magnetic field to the freezing temperature of paraffin oils in the flow time has been studied. To carry out the work, oil reached with paraffin in the magnetic field and without the magnetic field passes through refrigerator installed in the laboratory device. If the paraffin oil in the absence of magnetic field is frozen in 18 minutes, in the presence of magnetic field with stress of H=8500 oersted oil freezing temperature reaches 24 minutes., i.e. in the magnetic field paraffin oils freezing temperature increases by 33%.

In the thesis different amplitudes, frequency and periods of detention in a constant magnetic field affect to the paraffin oil freezing temperature mechanism have been studied. To implement the work variable and fixed magnet fields constant values influence to the freezing times of paraffin oils have been studied.

The largest impact of paraffin rich oils freezing times is taken place at amplitude’s maximum, and the frequency minimum values. With increasing of the paraffin oil freezing time in the magnetic field, its freezing time is decreased, as well as. Experiences show that the best results is given at the value of a fixed magnetic field H = 2815 oersted.

Then the paraffin oils magnetic field and the "composite-2" reagent’s combined impact have been studied and it was shown that the combined impact time on the reagent optimal consumption norm decreased to 10 l/t that is, 43%,
non-equilibrium factor become 40.92.

Magnetic field and the "composite-2" reagent combined influence to the paraffin oils also tested by the method of “cold fingers” . It was shown that, without any effect on cold fingers, if there was 10.41g of paraffin deposition, only the "Composite-2" reagent presence decreases paraffin deposition by 7 g (i.e. 49% is decreased); If this figure is affected by the magnetic field paraffin field deposition decreases of 6.85g (52% is reduced). So, magnetic field and the "composite-2" as a result of the impact of the collapsing paraffin deposition by amount of 6.7g, which was 55% less. From here you can see that the synergetic
effect occurrence in the production process.

At the end of thesis, the suitable conclusion and recommendations were made. References are also given at the end of the thesis. The results of the researches carried out can be put into practice of paraffin rich offshore, and also onshore producing wells.

CHAPTER 1. PARAFFIN CONTROL INVESTIGATION PROBLEMS

1.1. REVIEW OF THE LITERATURE ON TECHNOLOGICAL MEANS TO CONTROL ASPHALT-RESIN-PARAFFIN DEPOSITS

In this section we analyze the conditions and causes of asphalt-resin-paraffin deposits (ARPD) for oil production fields. Known to date chemical and physical methods for preventing and removing ARPD form producing wells are considered. We propose a method of dealing with ARPD, based on the use of downhole magnetic systems and the main results of their use.

1. Causes and conditions of asfalt-resin-paraffin (ARPD) deposits in oil production, one of the modern problems that cause complications in the wells, oil field equipment and pipeline communication (Figures 1 and 2). [1]

Figure 1. Asphalt-resin-paraffin deposits in the oil well tubings [1]

(1)

(2)

Figure 2. Asphalt-resin-paraffin deposits in the oilfield equipment (1) and pipeline communication (2) [1]

The accumulation of ARPD in a flow of oil field equipment and on the inner surface of pipes leads to a decrease in system performance, reduce the overhaul period of wells (OPW) and pumping systems efficiency.

The composition and structure of the ARPD. ARPD is a complex hydrocarbon mixture consisting of paraffin (wax) (20-70% by weight), asphalt-resin matter (ARM) (20-40% by weight, silica gel resins, oils, water and solids [1]. Paraffin hydrocarbons of methane series consist of hydrocarbons from $C_{16}H_{34}$ to $C_{64}H_{34}$. In situ oil they are dissolved. Depending on the content of paraffin these oils are classified as follows: low-paraffinicity oils- paraffin content less than 1.5% by weight; paraffin base crude oil from 1.5 to 6 % by weight; high-paraffin base oils- paraffin content of which more than 6% by weight.

Waxes are resistant to various chemicals (acids, bases, etc.) are easily oxidized in air. High-molecular paraffin's, in other words ceresin- hydrocarbons from $C_{37}H_{76}$ to $C_{53}H_{108}$ have a higher boiling point, higher molecular weight and density. The composition of ARM includes nitrogen, sulfur and oxygen. ARP have a high molecular mass, non-volatile, have substantial heterogeneity structure. The content of resinous substances in the oil increases due to evaporation of light components and its oxidation, and oil on contact with water. Sometimes a group of resinous compounds include asphaltenes. Asphaltenes powdery substance brownish black or brown in color, with density more than a unit, the mass content in crude oil reaches 5.0% by weight. In asphaltenes contained (wt) 80.0-86.0% carbon, 7.0-9.0% hydrogen, and 9.0% sulfur, 1.0-9.0% oxygen and up to1.5% nitrogen. They are the most refractory (high-melting) and slightly soluble part of the deposits of heavy oil components. Oil dispersions belong to a class of colloids, in which ARP are dispersed environment. Obviously, the physical, chemical and technological properties of the oils are largely due to intermolecular interactions in systems "asphaltene-resin" and "Malta-resin-asphaltenes".

As a rule, the structure of the resins and asphaltenes treated as a "sandwich" structures that are parallel naphthenic-aromatic layers related to each other by forming charge-transfer complexes. In this case there is some overestimation of the degree of ordering of asphaltenes, as they are considered as ideal crystals, although the quasicrystal is a small fraction of the asphaltene substances (less than 3-4% wt.). It is believed that resins and asphaltenes are paramagnetic liquids and crude oil, petroleum products thermodynamically stable paramagnetic solutions. Asphaltenes are a combination of many associates, depending on the degree of dissociation diamagnetic particles. The change in concentration of paramagnetic resins and asphaltenes in crude oil takes place due to the change in the structure of combinations of associates.

Resins and asphaltenes have the following features [2]:

1. Chemical and physico-chemical processes involving asphalt-resinous substances (ARM) is collective in nature. Asphaltenes are not individual components, and form associative combination, which are localized in the center of the stable free radicals.
2. The emergence of the solvate shell of diamagnetic is an indispensable condition for the existence of paramagnetic species in solution. The formation of the solvate shell weakens the force of attraction of paramagnetic molecules and preventing them from recombination due to thermal motion.
3. The resins are composed of diamagnetic molecules, some of which can pass into excited triplet state or undergo homologues. Therefore, the resin is a potential source of asphaltenes.
4. The properties of the ARP are determined not by elemental composition, and, above all, the degree of intermolecular interaction components. Within a single oil-producing region, and even individual field component of ARPD varies widely. Knowledge of ARPD is of practical importance to determine the optimal methods of controlling them, in particular, to select chemicals. This selection is often carried out based on the ARPD type (Table 1). To study the composition and structure of the ARPD widely uses an extraction, chromatographic, thermal, spectral, electrochemical and other methods.

On the example we consider a number of fields of crude oil and paraffin (Table 2). Oils of these deposits belong to the wax. Analysis of the ARPD allows to relate them to a group of asphaltene. An analysis of ARPD South Yagunsk field, Vyatka, Arlan, Nicholas-Bereza areas of Arlan oil field showed that the content of asphaltenes and resins is significantly higher in oil. The number of paraffin waxes in South Yagunsk field commensurate with their content in the oil and not more than 3.5%, and Vyatka, Arlan and Nicholaevo-Berezov areas of Arlan field 2-3 times higher than in produced o

Table 1.Classification of asphalt-resin-paraffin deposits [2]

ARPD Group	ARPD Subgroup	Ratio of paraffin's (P) to the amount of resin (R) and asphaltenes (A) P/(R+A)	Solids
Asphaltene (A)	A1 A2 A3	0.9 0.9 0.9	0.2 0.2-0.5 0.5
Compound (C)	C1 C2 C3	0.9-1.10.9-1.10.9- 1.1	0.2 0.2-0.5 0.5
Paraffin (P)	P1 P2 P3	1.1 1.1 1.1	0.2 0.2-0.5 0.5

Table 2

Composition of oil and asphaltene-resin-paraffin deposits

some oil fields [2]

Oil field	Resins, % wt	Asphaltenes, % wt	Paraffins, % wt	Oil viscosity at 20 ^{0}C, mPa.s	
Oil	ARPD	Oil	ARPD	Oil	ARPD
Vyatka area,					

Arlan oilfield	18.8	35.0-48.0	5.9	15.0	2.2-4.0
Arlan area, Arlan oilfield	16.2	20.0-40.0	3.8	10.0-12.0	2.9
Nicolayevo-Berezov area, Arlan oilfield	13.6	12.0-37.0	7.5	8.0-12.0	2.3
Volkov oil field	15.0-20.0	11.74-19.43	3.0-5.0	1.17-4.0	3.0-5.0
Yujno-Yagunsk oil field	26.6	18.7-49.4	6.5	10.3-21.4	3.5
Drujnoe oil field	21.1	-	8.0	-	2.2
Povkhovsk oil field	9.8	-	1.0	-	2.9

It was established that loss of aggregate stability of heavy components of oils’ of Yujno-Yagunsk, Drujnoe and Povkhovsk oil fields and deposits in gassing determined by the composition and properties of the initial oil.

Heavy viscous oil (31 mPas at reservoir conditions) of Yujno-Yagunsk oil field with high content of asphaltenes and resins (6.5 and 26.6% respectively) with degassing loses of asphaltene and resinous substances. Oil of Drujnoe field contains the close of asphaltenes and resins (8.0 and 21.1% respectively), but has much lower viscosity (5.3 mPas at reservoir conditions), while maintaining almost the heavy components in the solution after degassing. Light low-viscosity oil (0.89 mPa s at reservoir conditions) Povhovskoe field with asphaltene content of 1.0% and 2.9% wax during degassing of losing a small amount of high-paraffin with some increase in asphaltene content due to loss of light hydrocarbons and deposition of paraffins.

Causes and conditions of ARPD. There are two stages in the formation and growth of ARPD. The first stage is the nucleation of crystallization centers and the growth of wax crystals directly in contact with the oil surface. In the second phase is deposited on a surface coated with paraffin larger crystals. The formation of ARPD have a significant effect: reducing pressure on the bottom hole and the consequent violation of hydrodynamic equilibrium gas-liquid system, intensive gas emission, reduction of temperature in the reservoir and the wellbore; change the speed of the gas-liquid mixture and its components, the composition of hydrocarbons in each phase of the mixture ratio of the phases, the state of the pipe surface. Intensity of ARPD depends on the predominance of one or more factors, which may vary over time and depth, so the number and nature of the deposits are not permanent.

The effect of pressure on the bottom-hole and in the wellbore. In the case where bottom-hole pressure is less than the bubble-point pressure of oil by gas, the equilibrium state of the system is broken, thus increasing the volume of the gas phase and liquid phase becomes unstable. This leads to the release of its waxes. The equilibrium state is disturbed in the formation and precipitation of paraffin as possible in the reservoir and in the well, starting from the bottom. In the pumping conditions two zones are distinguished. The first is directly above the pump: pressure here increases rapidly and becomes larger than the saturation pressure. The probability of deposition in this area is minimal. The second zone of lower pressure to the saturation pressure and below, which begins intensive selection paraffin. In the flowing well while maintaining the pressure at the shoe equal to the saturation pressure, loss of wax should be expected in the tubing string. Practice shows [1], the main objects in which there is formation of deposits of paraffin, are down hole pumps, tubing, flow lines from wells, tanks of commercial collection points. The most intensive wax deposited on the inner surface of the lifting tube wells. Field studies have shown [1] that the distributions of paraffin deposits in pipes of different diameters are approximately the same. The thickness of the paraffin deposits gradually increases from the place of beginning their deposition at a depth of 500-900 m and reaches a maximum at a depth of 50-200 m from the wellhead, and then decreases to a thickness of 1-2 mm in the wellhead. Analysis of the ARPD selected wells at different depths, showed that at a depth of 1000m ARPD has more than paraffins. Contamination at these depths do not participate in the formation of deposits (the content does not exceed 4-5% wt.) ARPD, as well as, increasing the number of solids and solid paraffins. The closer to the wellhead, especially in the ARPD more ceresin, and, accordingly, the higher the structural strength of the deposits ARPD.

2. Methods of dealing with ARPD. ARPD control calls for efforts to prevent the formation of deposits and their removal (Fig.4). There are several well-known and most actively used in the oil industry methods of controlling ARPD based on the dosing of the produced compounds that reduce or even completely prevent the formation of deposits ARPD. But variety of oil fields development and distinction of produced oil often demand individual approach and even developing new technologies. Chemical methods of ARPD

control are based on dosing chemicals into the produced oil, decreasing, at other times wholly preventing formation deposits.

At the heart of paraffin inhibitors are adsorption processes occurring at the interface between the liquid phase and the surface of the metal tube [3].Chemicals are classified into wetting, modifiers, and dispersants deprecatory [4]: Wetting agents form a hydrophilic film on the surface of the metal that prevents adhesion of wax crystals to the tubes, thus creating conditions for the removal of fluid flow. These include polyacrylamide (PAA), IP 1, 2, 3, acidic organic phosphates, silicates of alkali metals, aqueous solutions of synthetic polymeric surfactants. Modifiers interact with the molecules of wax, hindering the process of enlargement of the crystals. This helps to maintain the crystals in suspension in the process of their movement. Such properties are possessed atactic polypropylene with a molecular weight of 2000-3000, low molecular weight polyisobutylene with a molecular weight of 8,000-12,000, aliphatic polymers, copolymers of ethylene and an ester with a double bond, triple-vinyl acetate copolymer of ethylene and vinilpirolidonom, a polymer with a molecular weight of 2500-3000. The mechanism of action is to deprecatory adsorption of molecules in crystals of paraffin, which hinders their ability to aggregate and accumulate. Well-known deprecatory include "Paraflou AzNII" alkylphenol IPX 9, "1A Dorada", VEO 504 TyumII, "Asolyat 7" [1]. Dispersants are chemicals that provide formation fine disperse systems, which are carried away by the flow of oil, which prevents the deposition of wax crystals on the walls of the tubes. These include metal salts, salts of higher fatty acids, synthetic, silicate-sulfanol solutions sulphated alkaline lignin. The use of chemicals to prevent paraffin in many cases combined with:

- the process of destruction of stable oil emulsions;
- protection of oil field equipment from corrosion;
- protection from scaling;
- the process of forming the optimal structure of gas-liquid flow. Developed a wide range of chemicals for control of AFS. Currently, the following brands of reagents:
- butilbenzol fraction (butilenbenzol, isopropylbenzene, polialkilbenzol). We propose to use SevKavNIPIneft;
- toluene fraction (toluene, isopentane, n-pentane, isoprene);
- SNPH 7p 1 - a mixture of paraffin hydrocarbons of normal and isometric structure, as well as aromatic hydrocarbons (JSC "NIIneftexim", Kazan);
- SNPH 7p 2 - hydrocarbon composition consisting of mild pyrolysis tar and hexane

fraction (JSC "NIIneftexim", Kazan)
- HSP 003, 004, 007 (JSC "Kogalym plant chemicals," Kogalym);
- MLS 72 - a mixture of synthetic surfactants;
- reagents such SNPH 7200 SNPH 7400 - complex mixtures of surfactants and oksialkilirovannyh aromatic hydrocarbons (JSC "NIIneftehim", Kazan);
- SDS reagent 4, providing a complex effect on the AFS and the corrosion of metal pipes (IPP, Ufa);
- INPAR (Pilot Plant "Neftekxim", Ufa);
- CMEA 28 - ethylene vinyl acetate (VNIINP and VNIITneft, Moscow).

Classification of methods of control with ARPD. In addition to the reagents used in oil and gas well Ural 04/88, DM 51, 513; 655; 650, DW 02; 03, SD 1, 2, G1, B1, HT48, ML80, Progalit GM20/40 and NM20/40. Along with the high cost of a significant drawback is the complexity of chemical method of selection of effective reagent associated with the constant changes in operating conditions during field development. Methods attributable to physical, based on the effects of mechanical and ultrasonic vibrations (vibration method), as well as electrical, magnetic and electromagnetic fields on oil produced and transported products. Vibratory methods can generate ultrasonic vibrations in paraffin deposits that, acting on the paraffin crystals cause them mikro-displacement that prevents paraffin deposits on the walls of the tubes [1]. The impact of magnetic fields is assumed to be the most promising physical methods. The use of magnetic devices in oil to prevent AFS began in the fifties of last century, but because of the low efficiency was not widespread. There were no magnets, long enough and stable working conditions in the well. Recently, interest in the use of a magnetic field to influence the AFS increased significantly, due to the appearance on the market a wide range of high-energy magnets based on rare-earth materials. At present about 30 different organizations offering magnetic deparafinizator [2]. It was established [2] that under the influence of the magnetic field in a moving fluid is destroyed aggregates consisting of submicron ferromagnetic microparticles of iron compounds, which are at a concentration of 10-100 g/t of oil and associated water. Each unit contains several hundred to several thousands of micro-particles, so the destruction of aggregates leads to a sharp (100-1000 times) increase in the concentration of crystallization centers paraffins and salts and the formation of ferromagnetic particles on the surface of gas bubbles of micron size. The destruction of aggregates of paraffin crystals precipitate in the form of fine, large, stable suspension, and the growth rate of deposits is reduced proportionately reduced average size dropped together with resins and asphaltenes in the solid phase wax crystals. The formation of microbubbles of gas in the centers of crystallization after magnetic treatment provides, according to some researchers, the gas lift effect, leading to some increase in well production. In the oil industry using thermal, chemical and mechanical methods for removal of AFS. Thermal methods are based on the ability of wax melt at temperatures above 50 0 C and drain away from the heated surface. To create the required temperature, a special heat source that can be placed directly into the zone of sediments, or to produce heat content agent at the wellhead.

Currently, use of technology with the use of:

- hot oil or water as a heating system;
- dry hot steam;
- electric surface and downhole performance;
- elektrodewaxing (induction heater), offering heating oil in the wellbore;
- reactants, with the reaction of which exothermic reactions are taken place.

Technology provides the heating of the coolant fluid in the heater (boiler installations of mobile type) and feed it into the hole means the direct or reverse circulation. Backwash is preferable; as this is possible the formation of wax plugs, often associated with direct leaching [1]. The disadvantages of these methods are their high energy-, electricity consuming ability and fire danger, the unreliability and poor performance of the technologies. The use of solvents for removing already formed deposits is one of the best known and most common methods of intensifying technological processes of production, transportation, storage and refining. However, here the problem of selection of the solvent under specific conditions is far from being solved.

The selection of solvents by ARPD empirically. This is due to a lack of information about their structure and properties, and little research of the mechanism of interaction of petroleum disperse systems with solvents. Mechanical methods involve removing already formed deposits of paraffin on the tubing. For this purpose developed a whole range of scrubbers of various designs. According to the construction and operation of scrapers are divided into:

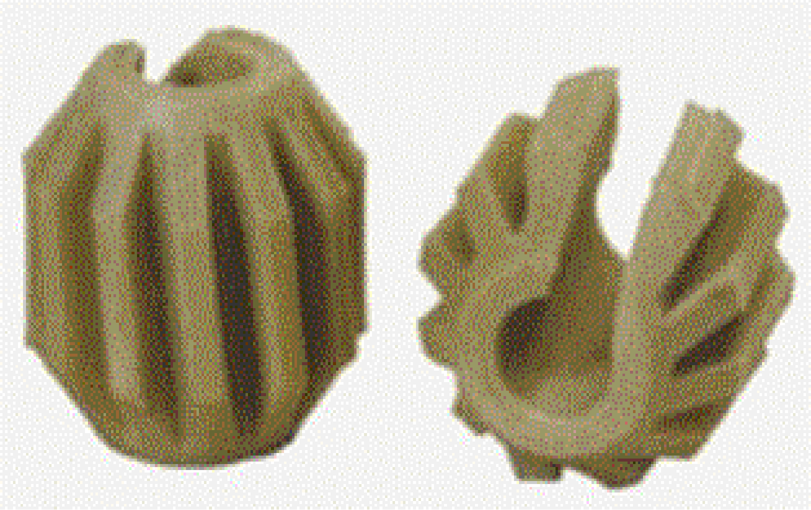
- plate with rotation of the rod string having two inserts that can clean only the rotation of the ARPD. For this purpose, rotation of the rod string hanging from the head of the balance of pumping unit. Rotation of the rod string, and therefore, occurs only when the pigs moving down. In this way the scraper cuts the paraffin from the surface of the tubing;
- spiral, reciprocating;

- «flying", equipped with knives, their wings, which are disclosed in the upward, allowing them to lift. Generally, is applied in curved wells. Using this method of control with the ARPD greatly complicated by the fact that its application often requires stopping of the well and the pipe surface pre-treatment (for some types of scrapers). Additionally, you may get stuck pig, break their attachment and some other complications. In recent years, instead of the metal plate scraper bars to reinforce the plastic scrapers (Figure 3). They both play the role of centralizers. There is information that the use of pig-centralizers wiped tubing.

As a method of preventing the AFS should be singled out the use of smooth protective coating of lacquer, glass and enamel. During transportation, round-trip transactions and tubing in the wells are at high impact, tensile, compressive, and bending and other loads. Glass coating due to its fragility, of considerable thickness and lack of adhesion to the metal pipe securely and destroyed in the process of tripping. This leads to the formation of the glass tubes in the tubing string and pump jam. In addition, the technology of glass and enamel coatings involves heating the tube to 700-800 ^{0}C, which causes irreversible processes in the metal structure and melting peaks threads. In the fields of "Orenburgneft" tubing were tested with the coating of bakelite lacquer, bakelite, epoxy, epoxy paint and vitreous [1]. Lack of heat and cold resistance of epoxy resins are a deterrent to widespread use. From these positions can be considered the best tubing lined with vitreous enamels. Strength and adhesion of the enamel are high. Chipped in the process of tripping and transportation are not observed. Great abrasion resistance, low thermal and electrical conductivity offer great prospects for implementation of tubes with glass-coated in the oil industry.

3. Downhole apparatus of magnetic treatment of liquid engineering company "Inkomp-oil" has mastered the production of deep borehole installations of УМЖ types for magnetic treatment of liquids. Magnets used in the form of cylinders with a diameter of 5-8 mm and a height of 3-4 mm.

a) fixed scrapers "Kanaross"



b) scraper-centralizers

Figure 3. Scrapers-centralizers. Almetyevsk plant "Radiopribor" [1]

To increase the effectiveness of magnetic treatment in real well, the technique of selection of the optimal characteristics of the magnetic field (frequency, amplitude and shape changes of the magnetic field) is developed. Created laboratory, and achieves the maximum effect on the problem at hand in real environments using electromagnetic laboratory setup [2]. Program on a PC based on laboratory data makes it possible to calculate and design the device the magnetic treatment of liquid.

Engineering company "Inkomp-oil" has mastered the production of deep borehole installations of magnetic treatment of liquid such as УМЖ (Magnetic Unit of Liquiq). Installation of УМЖ -73-005 is a shell (Fig. 4) of the ferromagnetic pipe thread. At one end is fixed to the threaded sleeve. On the inner surface of the body fixed point permanent magnets are encapsulated polymeric composition.

Installation using threads is mounted in the tubing at the suction of the oil-well sucker-rod or the tubing area required. With the passage of the produced fluid to the body it is processed in a pulsating or alternating magnetic field. Unit УМЖ -122 are designed for well-equipped by the sucker-road pumping unit.

The main results of the use of units' УМЖ. Engineering company "Inkomp-oil" produced more than 250 borehole installations УМЖ, which were introduced in oil companies "Bashneft", "Belkamneft", "Lukoil", "Yukos", "Gazprom" and several other organizations. The use of units УМЖ-122 and УМЖ-73-005 increased the average overhaul period of wells in the OGPD "Arlanneft", operating of which is complicated by the paraffin deposits and oil emulsion, in an average of 1.8 times.

Chemical treatment of wells was discontinued. On Sergiyevsk field of OGPD "Ufaneft" the use of units УМЖ-73-005 made it possible to increase the period cleaning of wells from paraffin deposits in 2.7 times, while the number of thermal and chemical treatments to reduce to 2 and 5 times, respectively.

The introduction of units УМЖ-73-005 in wells "Urayneftegaz" complicated paraffin deposits allowed to increase their average overhaul period of 2 times at the stopping of chemical treatment of wells.Analyzed various layouts of permanent magnets (see Figures 4-7).Based on field tests in OGPD "Arlanneft" on the units УМЖ types produced by various mechanisms that the best result is achieved as shown in Fig. 7. Point of permanent magnets stand out above the inner surface of the body with different heights, which contributes to more turbulence in the fluid, which increases the efficiency of magnetic treatment.

For accurate and reliable placement of the magnets in the body has developed a new technology for their manufacture. The technology provides:

Preparation of the inner surface of the body (sandblasting and degreasing);

Applying the first layer of corrosion of the composition;

Orientation drawing of the magnets on the frozen surface is not. Applying successively after drying has two layers of anti-corrosive composition on the inner surface with magnets.

a) b)

Figure 4. General view of the magnetic treatment of liquid systems УМЖ-122 (a) and УМЖ-73-005 (b).[1]

Magnets before they are installed in the chassis degreased, and they applied a layer of corrosion of the composition. Orientation drawing of the magnets provides the exact location at a specified location on the design of the casing. To do this, housing is fixed to the spindle lathe equipped with a dividing head. On a special holder cause the permanent magnets, which should be placed on one generator inside a cylindrical casing. After applying the composition of corrosion on the surface of the body, inserted into the holder inside the

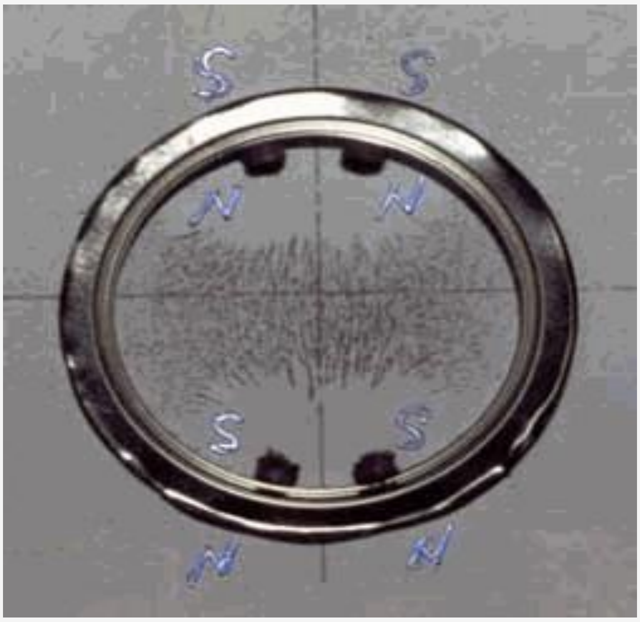


Figure 5. Arrangement of magnets installed in the УМЖ-73-005 [1]

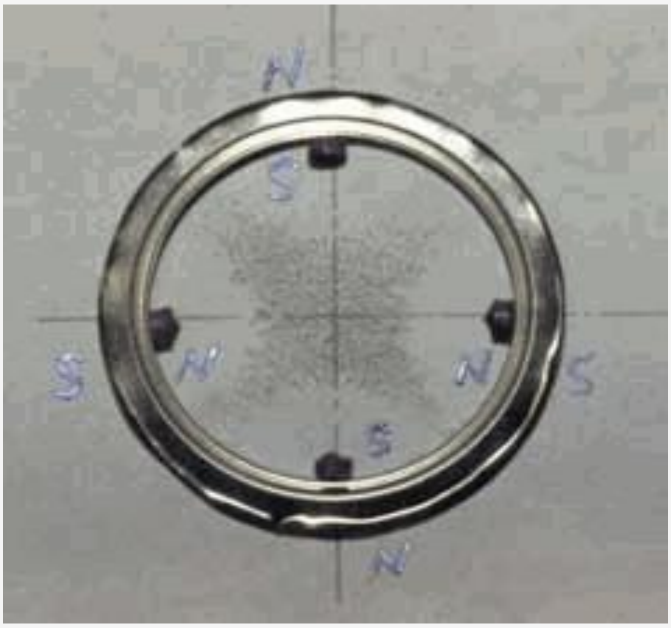


Figure 6. Arrangement of magnets installed in the УМЖ-73-005 [1]

Figure 7. Arrangement of magnets installed in the УМЖ-73-005 [1]

cavity of the body. Moving the holder along the axis body, bring it to the desired site, and the magnets are arranged on the surface of the body.

Next, assign a holder of the surface and eliminate it from the body cavity. Housing through the dividing head is turned to the desired angle and re-forming at a given set magnets. And so to complete the installation of the magnets. After the installation of magnets, applied two layers of anticorrosion composition.

After the installation of magnets, applied two layers of anticorrosion composition. Installation using threads is mounted in the tubing at the pump intake or required area of tubing. With the passage of the produced fluid to the body it is processed by a magnetic field. It was also designed and built the installation of the magnetic treatment of liquid УМЖ-122 (Fig. 4a), designed for use in wells equipped with sucker-rod pumping unit with an inner diameter of production casing from 125 to 140 mm. The system is installed at the regular place armature (the device is not used often) and is attached to the compensator 51 via GC thread. Unlike most of the existing, this setting has no outer protective housing, and create a magnetic field of permanent magnets 312 point fixed at six radial ribs. Because of this, the installation does not create significant hydraulic resistance (they are much less established compensator DG 51), and the tension created by the magnetic field of 25-30 kA/m. The main results of the use of УМЖ type devices. The engineering company "Inkomp-oil" produced more than 250 borehole installations Ukrain, which were introduced in oil companies «Bashneft", OJSC "Belkamneft", "LUKOIL", NK "YUKOS", OAO "Gazprom" and several other organizations. The use of unitsУМЖ increased the average overhaul period of wells of OGPD "Arlanneft" complicated by the paraffin deposits and oil emulsion in an average of 1.8 times. Chemical treatment of wells has been discontinued. On the field Sergeyevsk OGPD "Ufaneft use of the equipment УМЖ-73-005 provided an opportunity to increase paraffin cleaning time of wells 2.7 times, while the number of thermal and chemical treatments to reduce to 2 and 5 times, respectively. The introduction of units УМЖ-73-005 in wells of "Urayneftegaz" complicated by the paraffin deposits allowed to increase their average overhaul period of 2 times at the stopping of chemical treatment of wells..

1.2. THE DEVELOPMENT OF THE NEW PARAFFIN CONTROL TECHNIQUES IN THE OFFSHORE OIL WELLS

A more physical, chemical and thermal methods are used in the paraffin control in oil wells, i.e. against paraffin deposition preventing in producing oil fields. Between physical methods of paraffin control we could call a number of methods, such as, generation of electric, ultrasound, and magnetic fields in the corresponding environment [3,4].

Investigations provided during thermal treatment of paraffin oils have shown that the paraffin oils rheological characteristics are changed within some time period [5].

Paraffin oils producing wells periodic thermal processing is known to various scientific-research works [6].

It was established that during thermal processing of oils paraffin crystals structure is destroyed after a certain time and then the destroyed structure is restored again. The paraffin crystals give of the system the viscous-plastic features which are lost during the thermal processing [7].

When paraffin oils are placed in the electric field with E=1500 V/m, under the influence of electric charges hydrocarbons' static shear stress and viscosity are increased [8].

In this case, asphalt-resin-paraffin different accumulation in tubing is prevented. As a result of heat influence hydraulic resistance to fluid flow is reduced and shift as a result of phase transformations tubing throughput flow capacity is increased. This phenomena in gas-liquid and water-oil systems is explained by a reduction of triboelektrik effect in the system.

Under ultra-sound influence of paraffin oils the movement velocity of solids inside of paraffin increases that causes the decreasing of oils' structural viscosity [9].

The successful application of technologies based on magnet field generation in well-bottom-hole and well-bore allows deciding a number of problems in oil industry that increases the production process.

In this regard, "the results of investigations carried out by a number of researches under the influence of magnetic field: formation rock permeability increasing [7], oil recovery factor increase [10], corrosion speed reduction [11], salt deposition control [11], asphalt-resin-paraffin deposits of successful control [12], etc. are shown.

However, the small voltage magnetic field influence to the asphalt-resin-paraffin deposits have been studied by the different researchers.

Scientific researches provided only by O.L. Kuznetsov and E.M. Simkin have shown that asphalt-resin-paraffin deposits with the use of very high intensity ultrasound, it is possible to obtain satisfactory results.

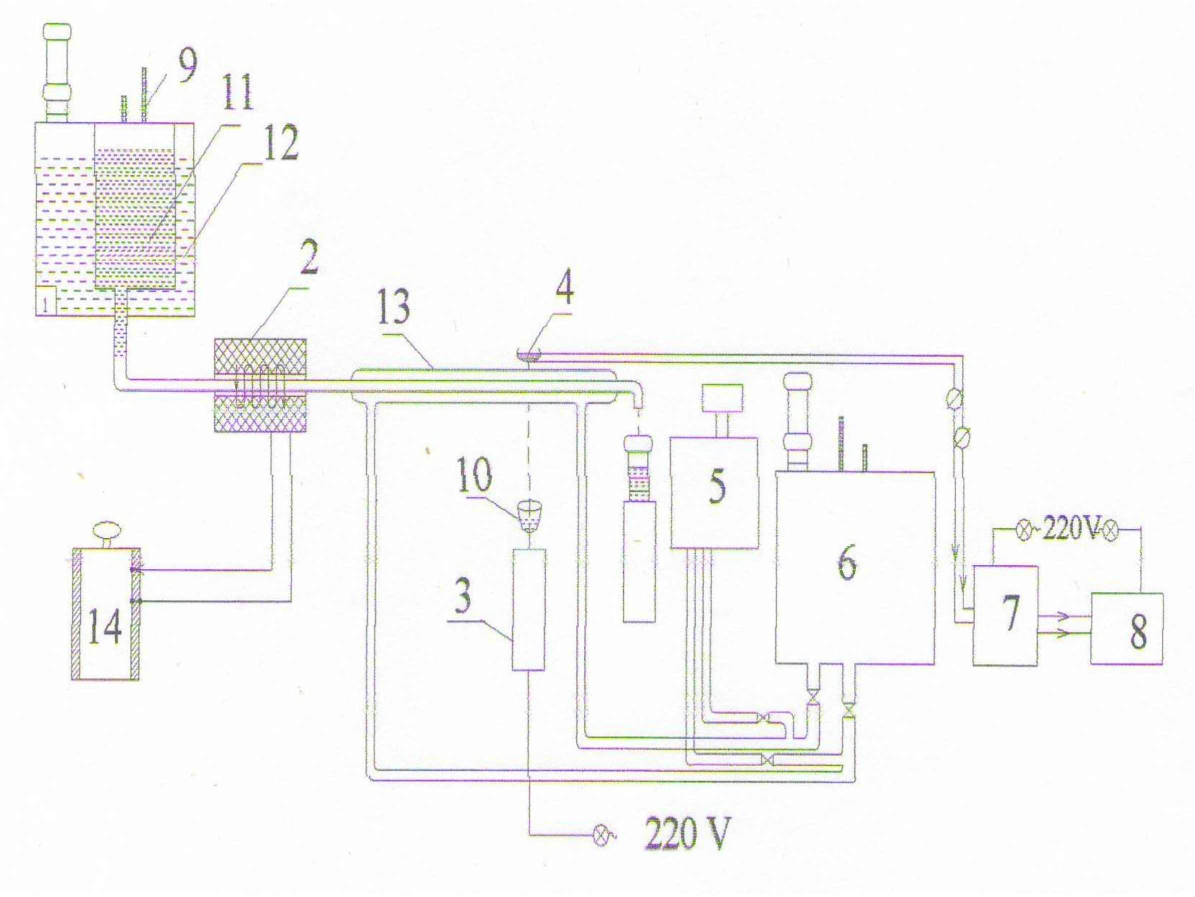
Thus, the authors in the field of acoustics with the intensity of 40-80 kVt/m2 the paraffin viscosity reduction as well as 1.5-2 times and weakening of adhesion forces can be achieved.

However, control of different sediments in the high-magnetic-voltage fields| caused the scientific and practical interest; these issues were not investigated in the work considered. In this connection a special laboratory facility was established to study the impact of magnetic field and its other parameters influence to the paraffin deposits in oil wells.

1.3. THE STUDY OF FLOW PARAMETERS DEPENDING ON THE INDICATORS OF MAGNETIC FIELD

To study the movement of fluid in the tube under the influence of magnetic field, the electromagnetic unit fed by a variable and constant of electric current is assembled (Figure 13.1). The maximum magnetic field in the electromagnetic unit created by the alternative electric current makes 993000 A/m (12500 oersted), but the magnetic field created by the direct electric constant - 160 000 A/m (2000 oersted).

Principal scheme of the device is shown in Figure 1.3.1.



Source image from:worldoil.com

Figure 1.1. The study of the effects of magnetic field to the paraffin reach oils in the laboratory unit: 1,5,6-thermostats, 2-alternative magnetic field generating device; 3-unit that transforms alternative current into a direct current; 4-fotoelektron accelerator; 7- I-37 type direct current amplifier; 8-H37-type direct current in small-size portable self-recording milliampermeter; 9-contact thermometer; 10-magnification lens with a direct current lamp; 11-the vessel used for paraffin rich oil heating; 12 thermostat; 13- refrigerator; 14-adjusting

laboratory transformer; 15-electronic time relay.

Electromagnetic fields generating unit's nominal tension, nominal electric current, the nominal power, the individual resistance of coil are shown in the table 1.3.1.

Table 1.3.1

Parameters of the electromagnetic field generating device

Unit's OS-1,0/0,22	Alternative current	Direct current
Class of resistance due to heating	F	-
Nominal power	1,0 kw	-
Nominal frecuency of the circuit	50 hertz	-
Nominal tension	220 v	3,26 v
Nominal electric current	5,0 A	6,2 A
Losses created in short circuit at 115°C	25 v	-
Short circuit voltage at 115°C	3,3%	-
Coil's individual resistance at 115°C	1,30 m	-
Magnetic field tension in the air sheet	993000 A/m	160000 A/m

Source table from: www.allaboutcircuits.com

The influence of the magnetic field to the paraffin deposition in oil (test temperature conditions were chosen 40°C, 35°C, 30°C and 25°C) has been studied at the above-mentioned device. The working principle of the device is as follows. The paraffin-rich oil to be heated is filled into the vessel (11), the vessel (11) is placed into thermostat (12). The oil is being heated in the thermostat (12) at the temperatures up to 40°C, 35°C, 30°C and 25°C, and passing an alternative and constant magnetic fields comes to the refrigerator (13). Paraffin-rich oil is supplied into the device through the glass tubes. The temperature inside the refrigerator is regulated by means of the thermostats (5.6). Paraffin-rich oil temperature is supported by means of contact thermometer (9).

In the magnetic field generating device (2) the magnetic field induction changes is provided with the help of regulatory laboratory transformer (14). In the lower part of the refrigerator equipped a lamp (10) working with direct current and magnifying lens was placed. To the other side of the refrigerator photoelectron amplifier (4) is placed. Fluid flow when passing through the refrigerator as a result of the paraffin deposits the light of the lamp (10) is blocked. In this case, what is happening in the device (4) is amplified in the amplifier of I-37 type (7). The strengthened impulses are yield to the H-37 type, small size, operating in direct current self-recorder milliampermeter (8).

In the device (8) paraffin deposits time is recorded in the form of peak-time with self-recorder ampermeter on the special sheets. In any case of the absence of the influence of magnetic field the laboratory experiments have been carried out for the different temperatures.

Liquid rate vs pressure differential in paraffin oils in given in the table 1.3.2.

Table 1.3.2

Liquid rate vs pressure differential in paraffin oils

Volume, ml	Pressure differential ΔP, Pa	Flow time t, sec		Flow rate Q, cm^3/sec		Flow velocity, m/sec	
		without maqnet field	with maqnet field	without maqnet field	with maqnet field	without magnet field	with maqnet field
100	2690	122	110	0,82	0,91	0,0019	0,0021
100	4900	68	60	1,46	1,67	0,0063	0,0072
100	5600	59	57	1,7	1,96	0,0083	0,0096
100	6020	54	46	1,85	2,20	0,0098	0,012
100	8500	37	34	2,7	2,92	0,020	0,022

Source table from:wikipedia.org

Paraffin rich oil flow rate vs pressure differential has been studied. Magnetic field influence to the paraffin oil’s flow is also investigated. In this case the experiment was carried out without and with magnetic field of 7889, 8446, 9032 oersted.

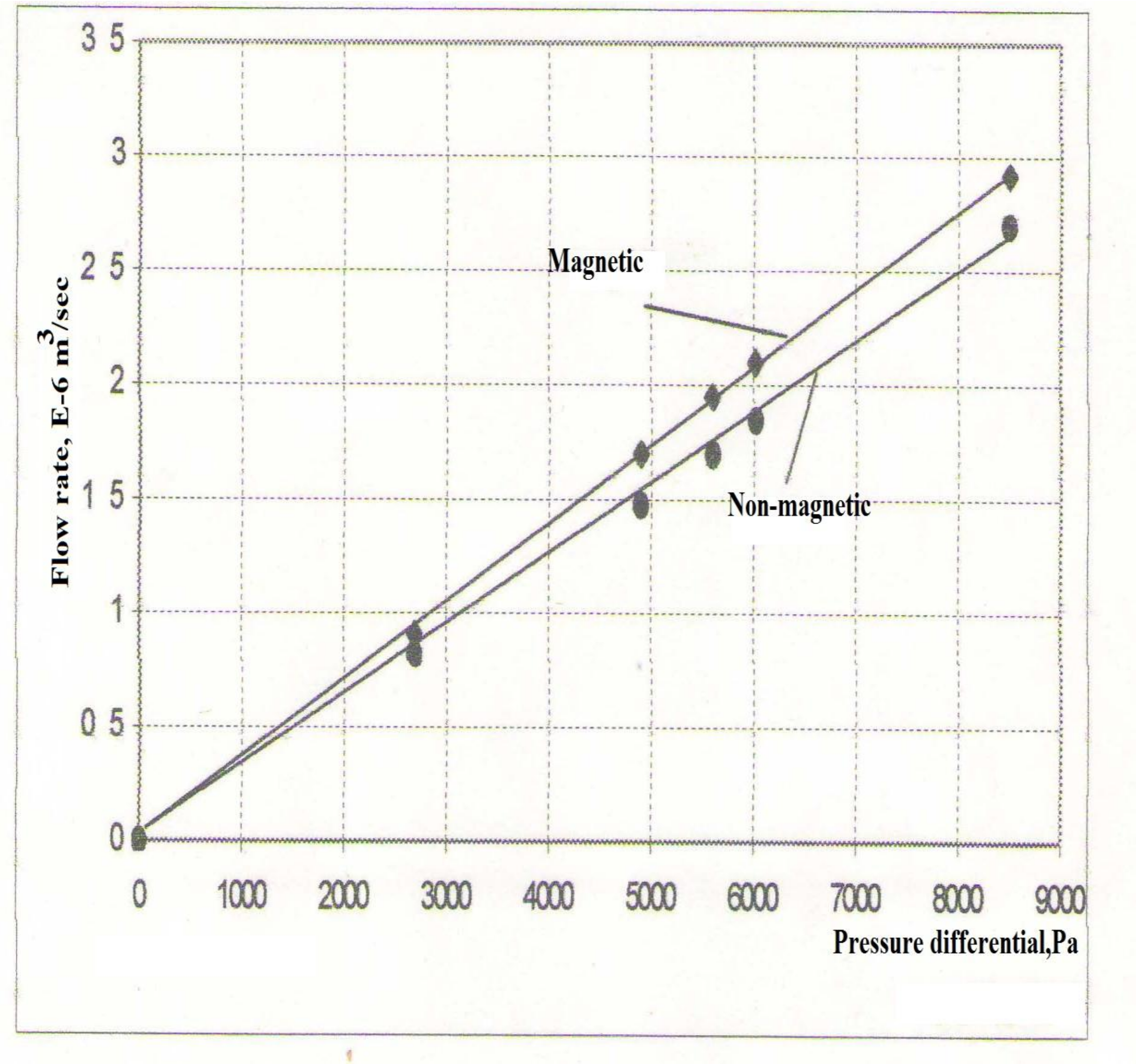
Paraffin oils flow rate vs pressure differential is shown in the Figure 1.3.2.

It is shown from figure 1.3.2 that the relationship between paraffin oils flow rate vs pressure differential is the straight-line.

It was established that paraffin oil in a non-magnetic field at pressure differentials Δ P = 2690, 4900, 5600, 6020, 8500 Pa and production rates (0.82, 1.46, 1.7, 1.85, 2.7) 10^{-6} m^3/sec, had the flow rate of 0.0019 - 0.02 m/sec, flow time 122-37 sec.

Furthermore the magnetic field experiments were carried out under the influence of various oersteds of magnitudes.

The best results were obtained at the magnetic field tension of 680000 A/m (8500 oersted) magnitude. So, at the pressure differentials of ∆ P = 2690, 4900, 5600, 6020, 8500 Pa and paraffin oils production rates are (0,91, 1.67, 1.96, 2.20, 2,92) 10^{-6} m/sec,



Source image from: www.auburn.edu

Figure 1.3.2. Paraffin oils flow rate vs pressure differential curves

At the pressure differentials magnitudes ∆ P=2690, 4900, 5600, 6020, 8500 Pa, oil production in accordance with the paraffin oils rate of (0.91, 1.67, 1.96, 2.20, 2.92) 10^{-6}

m^3/sec, the oils flow rate became 0.0021 - 0.022 m/sec, but flow time was 110-34 sec. Up to the impact of the physical field and after the switching of magnetic field to determine the oil viscosity (μ) the classical Poiseuille formula is used:

$$\mu = \frac{\pi d^4 \Delta P}{128\, Ql},$$

where d -diameter of capillary tube, mm;
ΔP - pressure differential, Pa;
Q - flow rate, m^3/sec;
l - length of capillary tube, m.

In the absence of non-magnetic field at the test pressure differentials if the oil viscosity is valued 1.54-1.65 mP.sec, after switching of magnetic field this viscosity reaches the magnitude of 1.34-1.45 mPa.sec. This fact shows the oil viscosity decrease to 12.5%.

Taking into consideration the above mentioned facts we could come to the conclusion that it is possible to adjust non-Newtonian oils’ viscosity through generating magnet field in the investigated area.

When there is magnetic field with influence to the paraffin oils and the situation where there is no magnetic field, the diagram of pressure differential vs oils production rate has been plotted. It was introduced in the figure 1.2.

CHAPTER 2. MAGNETIC FIELD AGAINST PARAFFIN DEPOSITION

2.1. THE INVESTIGATION OF THE MAGNETIC FIELD INFLUENCE TO THE PARAFFIN OIL FREEZING TEMPERATURE IN THE FLOW PROCESS

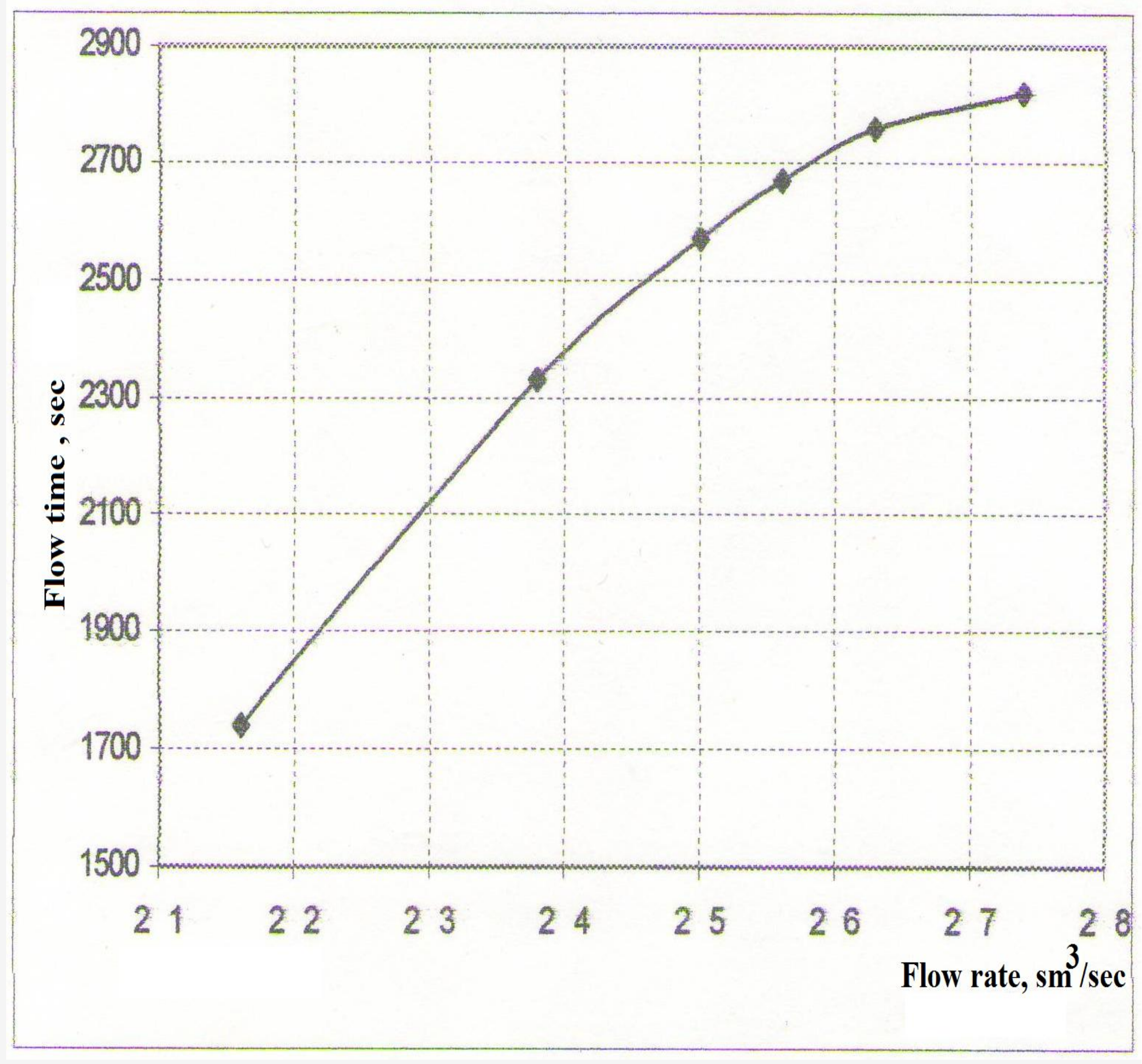
On the device established according to the scheme shown in Figure 1.1 alternating magnetic field effect on the freezing temperature of the paraffinous oil was studied. Experiments for this purpose were carried out to the magnetic absent and magnetic field with 630000, 680000, 730000 A/m (in accordance with the 8000, 8500, 9000 oersted) magnitudes.

The research provided in this device shows that at the 680000 A/m (8500 oersted) the magnetic field difference of potential effect to the paraffinous oil is higher than the other magnetic field values. Furthermore, accordingly, at the magnetic field potential H = 680000 A/m, the relationship between the flow rate and the paraffinous oil freezing temperature was studied.

In addition to this, the experiments, with the oils composed of 10% of the distilled water and sea water were carried out. Such investigations can be concluded that the magnetic field considerably affects to the freezing temperature of the paraffinous oil, in other words, magnetic field extends the period of paraffinous oils freezing temperature. At experience period if the paraffin as part of oil, in the absence of magnetic field is frozen in 18 minutes, when the magnetic effect is applied the freezing period is increased for 24 minutes, in other words, extends by 33%.

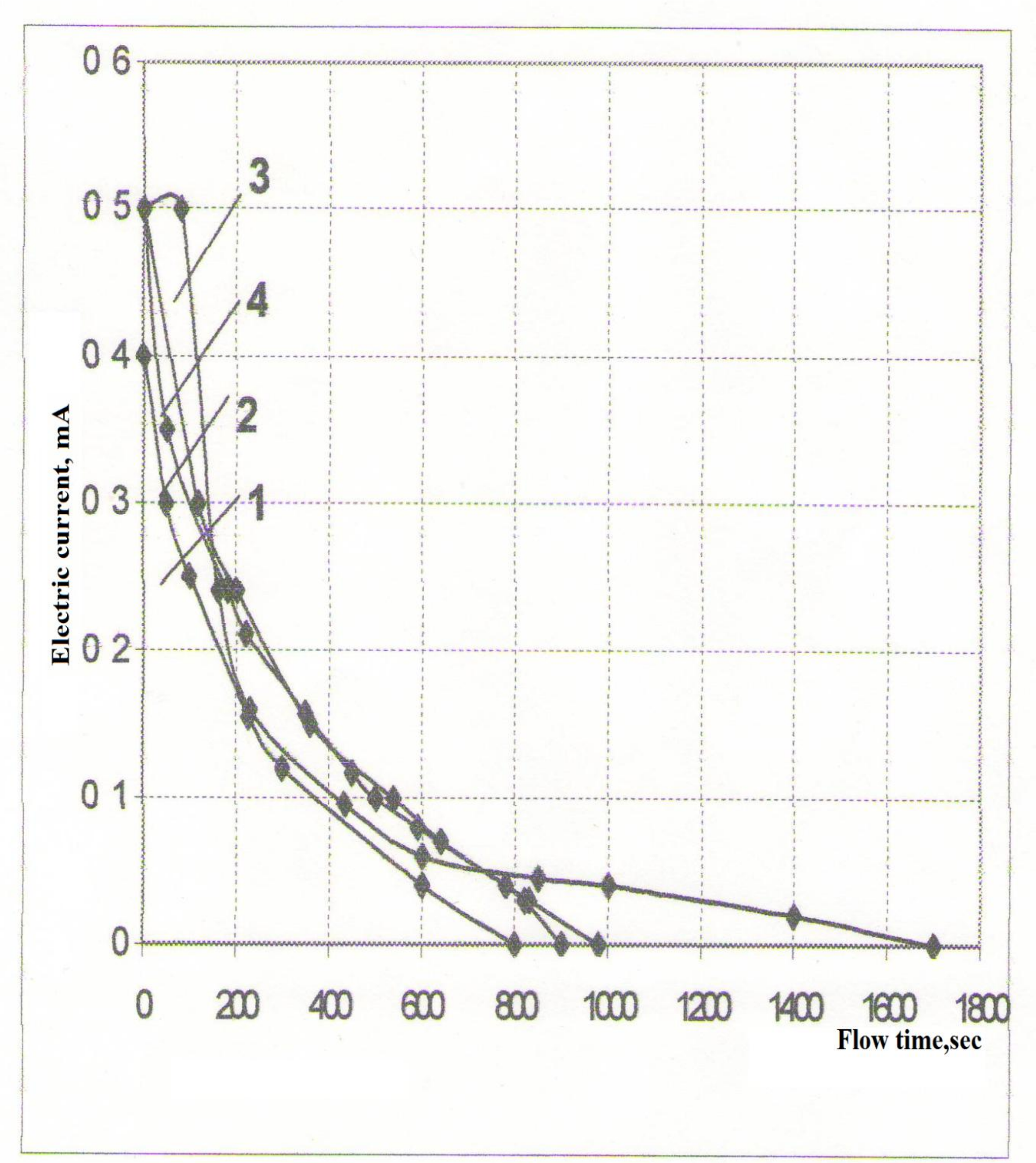
The paraffin freezing period in the presence of distilled and sea water in the oil, in accordance with the influence of magnetic field is extended up to 40 and 65 minutes.

In accordance with the 680000 A/m magnetic field, paraffin oils flow rate vs flow time, the influence of magnetic field to paraffin oils fluidity, magnet field’s induction influence of paraffin freezing temperature curves were introduced in figures 2.1.1-2.1.3.



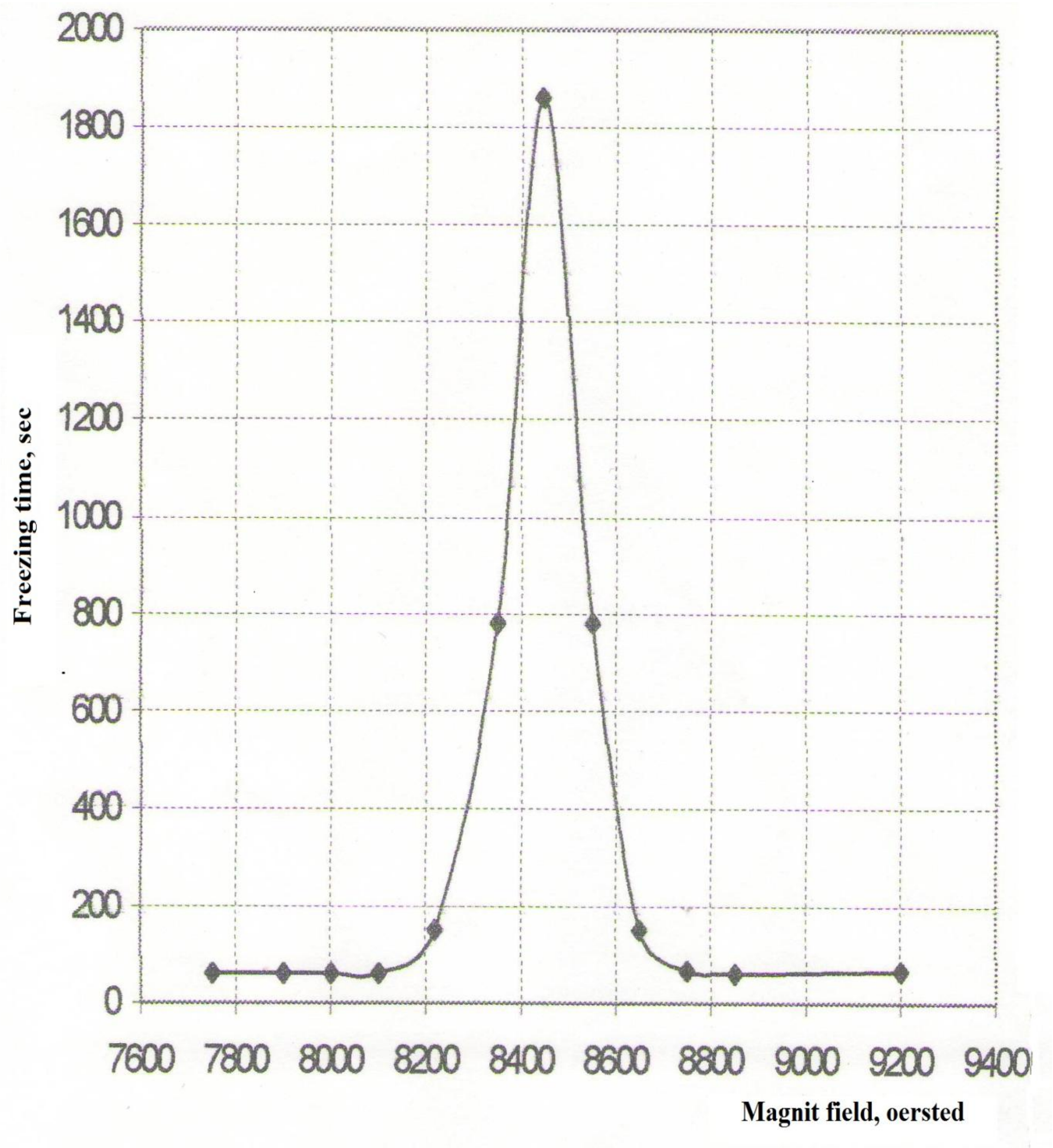
Source for this image: http://www.ntnu.no/kjempros

Figure 2.1.1. Paraffin oils flow rate vs flow time in accordance with the 680000 A/m magnetic field.



Sources for this image http://www.springerlink.com/content/p72w6445t6084743/

Figure 2.1.2. The influence of magnetic field paraffin oils fluidity chart: 1-with non-magnetic field; 2- in magnetic field with 730000 A/m; 3- in magnetic field with 680000 A/m; 4- in magnetic field with 630000 A/m.



Source for this image en.wikipedia.org/wiki/Kerosene

Figure 2.1.3. Paraffin oils freezing time vs different values of the magnet field’s induction.

2.2. THE INVESTIGATION OF CONSTANT MAGNETIC FIELD INFLUENCE TO THE PARAFFIN OIL FREEZING TEMPERATURE AT THE DIFFERENT AMPLITUDE, FREQUENCY AND CONSERVATION TIME

To study the influence effect of different amplitude, frequency and duration time of the during a fixed magnetic field to the freezing temperature of the paraffin oils a special time relay built into the device represented in the figure 1.3.1.

The purpose of the time relay building into the device is to study of the magnetic field, created by a constant current of different amplitudes, frequencies and periods of detention to the impact of paraffin oils temperature of freezing. The results of experiments showing the influence of the magnetic fields, created by the fixed and variable currents, to paraffin oils flow is shown in the figures of 2.2.1-2.2.7 and is given in the table 2.2.1.

The magnetic current, frequency and magnetic field delay time impact to the paraffin oils freezing temperature of what period of time have been studied within the following conditions:

1) a fixed (direct) magnetic field’s difference of potential of 42400 A/m (530 oersted) impact to the paraffin oils flow, within 2 minutes delaying, how magnetic field influence to the paraffin oils freezing temperature was investigated.

Paraffin oils temperature, in this case, has been assumed 25°C (Figure 2.2.1).

2) a fixed (direct) magnetic field’s difference of potential of 42400 A/m (530 oersted) impact to the paraffin oils flow, within 60 minutes delaying, how magnetic field influence to the paraffin oils freezing temperature was investigated.

In this case, paraffin oils temperature, has been assumed 25°C (Figure 2.2.2).

3) a fixed (direct) magnetic field’s difference of potential of 205000 A/m (2560 oersted) impact to the paraffin oils flow, within 2 minutes delaying, how magnetic field influence to the paraffin oils freezing temperature has been investigated.

In this case, paraffin oils temperature, has been assumed 25°C (Figure 2.2.3).

4) a fixed (direct) magnetic field’s difference of potential of 205000 A/m (2560 oersted) impact to the paraffin oils flow, within 60 minutes delaying, how magnetic field influence to the paraffin oils freezing temperature has been investigated.

In this case, paraffin oils temperature, has been assumed 25°C (Figure 2.2.4).

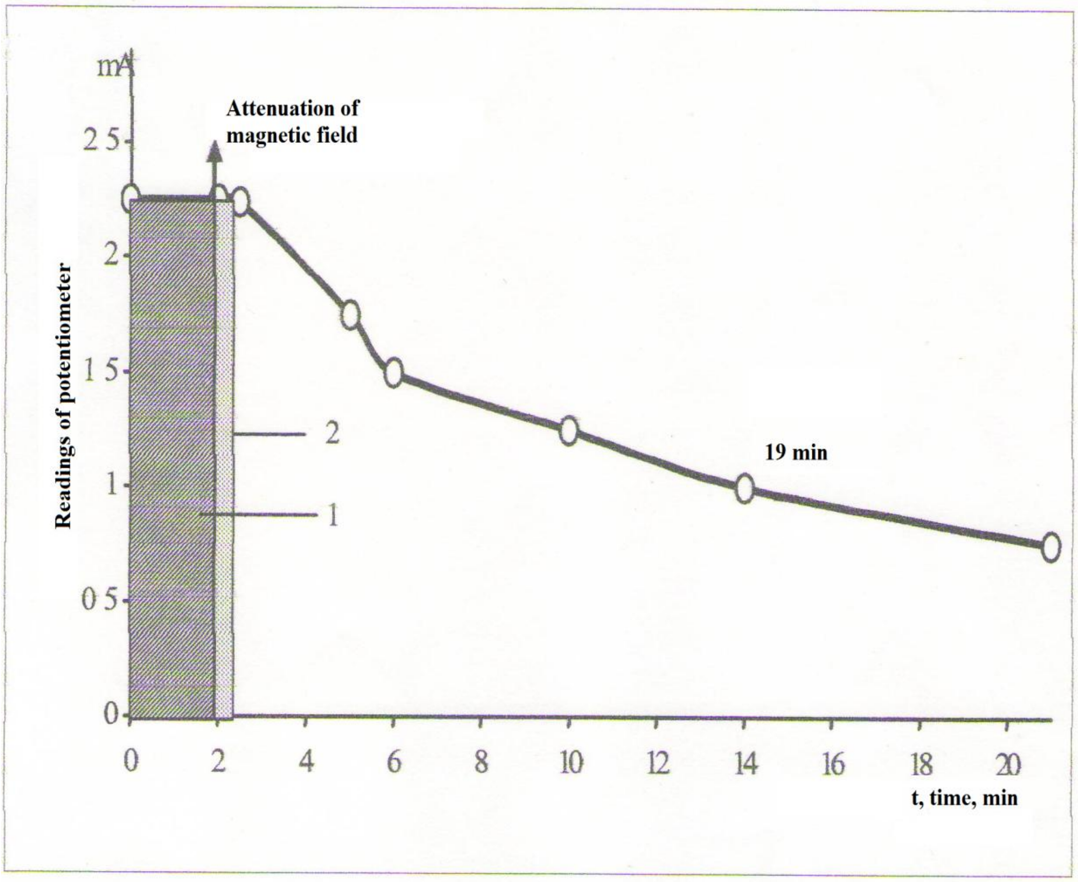


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Figure 2.2.1. Paraffin oils flow curve influenced by the magnetic field created by the fixed currents with 1A within 2 minutes delaying of magnetic field: 1-maqnet field delaying time; 2-influence time after switching off magnetic field.

5) variable (alternating) magnetic field's difference of potential of 45000 A/m (557 oersted) impact to the paraffin oils flow, within 60 minutes delaying, how magnetic field influence to the paraffin oils freezing temperature has been investigated.

In this case, paraffin oils temperature, has been assumed 25°C (Figure 2.2.5).

6) variable (alternating) magnetic field's difference of potential of 225000 A/m (2815 oersted) impact to the paraffin oils flow, within 2 minutes delaying, how magnetic field influence to the paraffin oils freezing temperature has been investigated.

In this case, paraffin oils temperature, has been assumed 25°C (Figure 2.2.6).

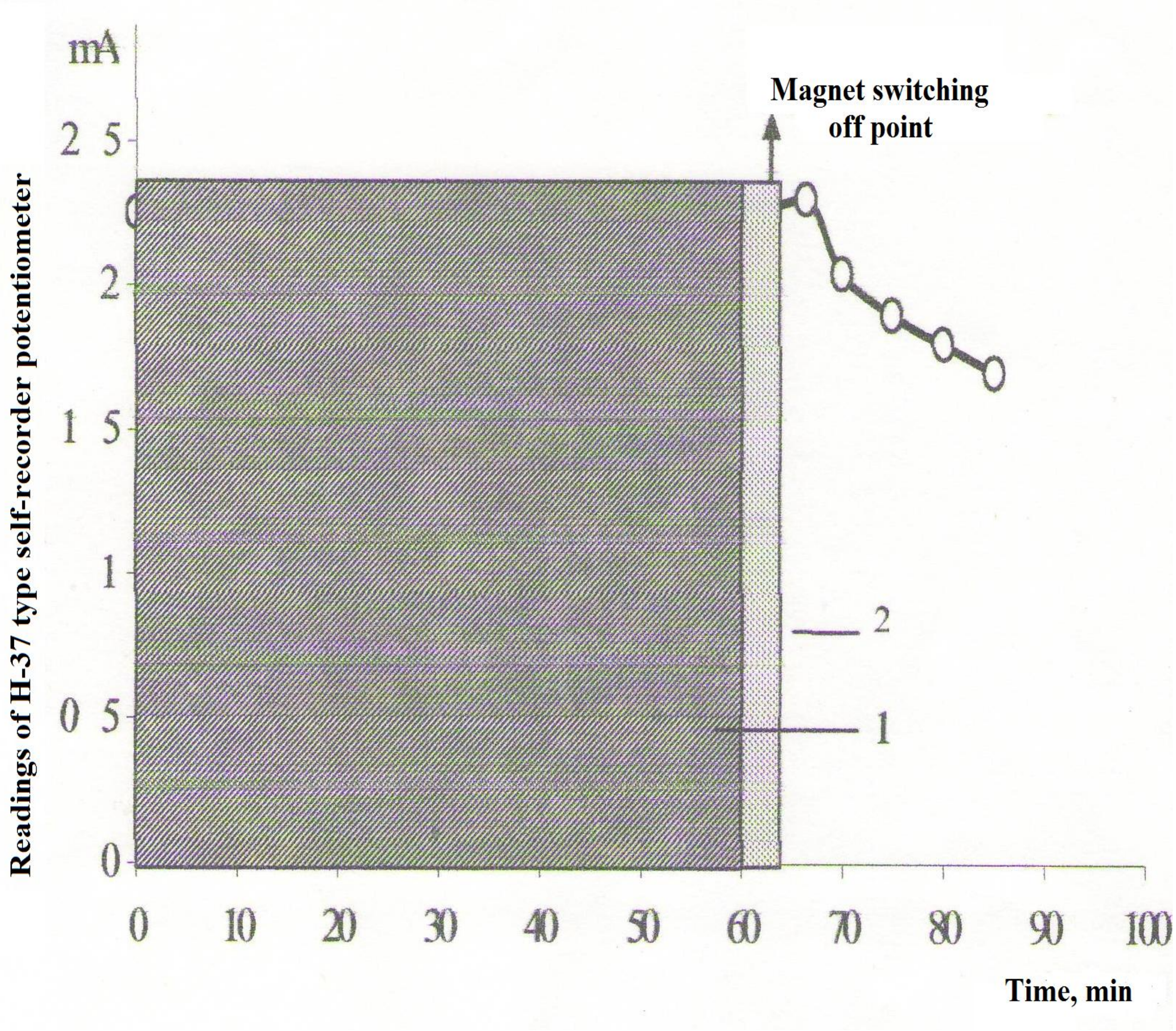

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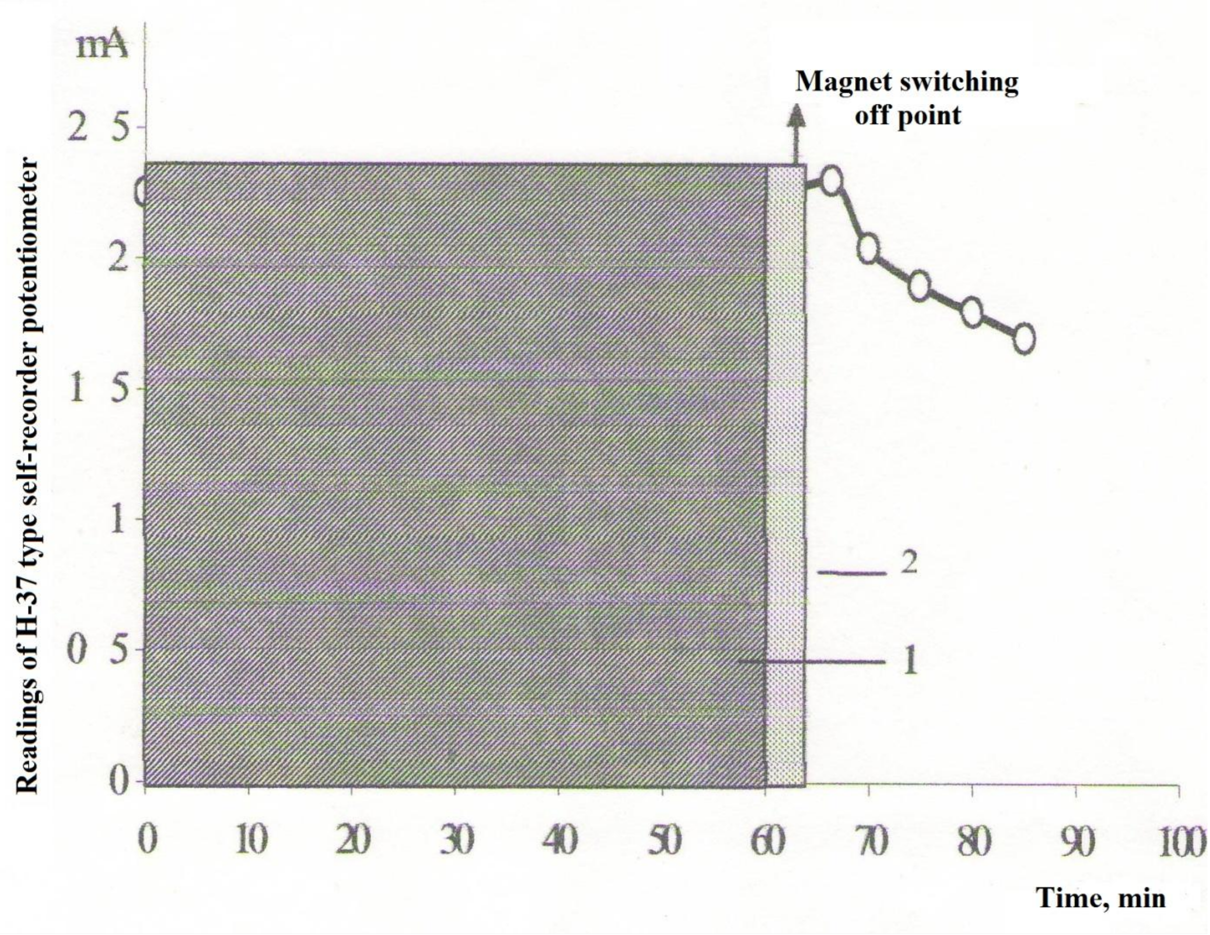
Figure 2.2.2. Paraffin oils flow curve influenced by the magnetic field created by the fixed currents with 1A within 60 minutes delaying of magnetic field: 1-maqnet field delaying time; 2-influence time after switching off magnetic field.

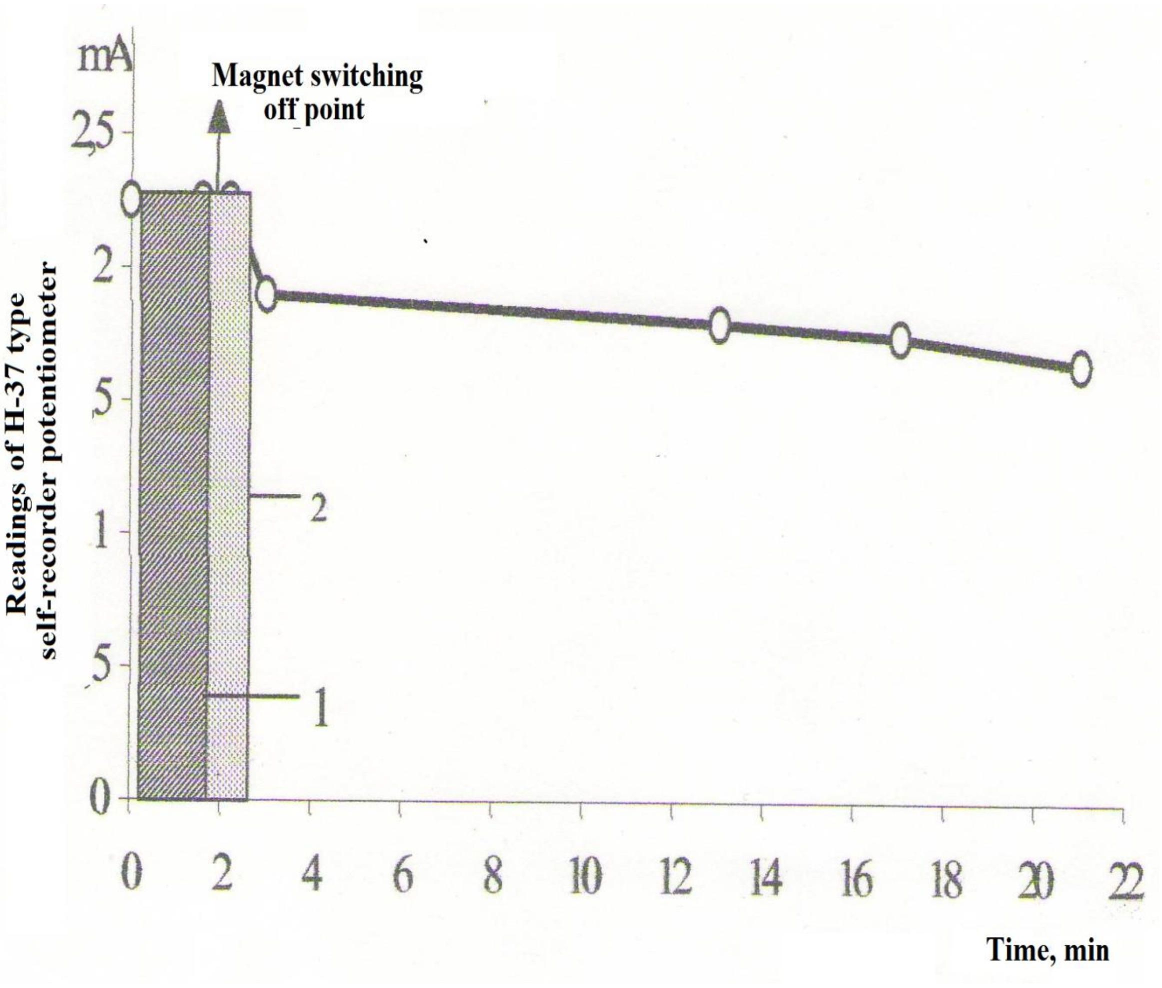
7) variable (alternating) magnetic field's difference of potential of 225000 A/m (2815 oersted) impact to the paraffin oils flow, within 60 minutes delaying, how magnetic field influence to the paraffin oils freezing temperature has been investigated.

In this case, paraffin oils temperature, has been assumed 25°C (Figure 2.2.7).



Source for this image:www.gasproductssales.com

Figure 2.2.3. Paraffin oils flow curve influenced by the magnetic field created by the fixed currents with 5A within 60 minutes delaying of magnetic field: 1-maqnet field delaying time; 2-influence time after switching off magnetic field.



Source for this image:www.gasproductssales.com

Figure 2.2.4. Paraffin oils flow curve influenced by the magnetic field created by 10 V variable currents within 2 minutes delaying of magnetic field: 1-maqnet field delaying time; 2-influence time after switching off magnetic field.

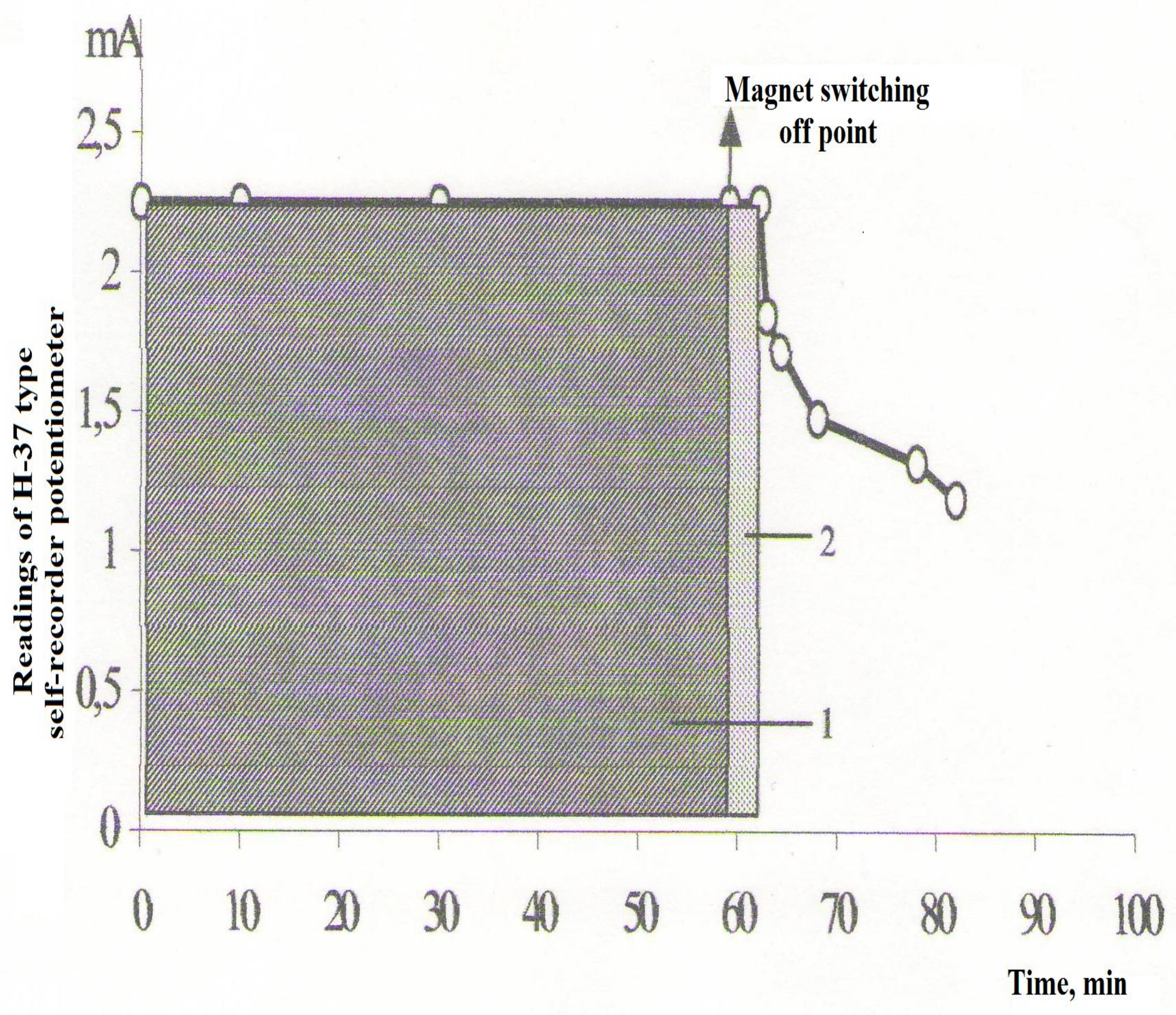


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Figure 2.2.5. Paraffin oils flow curve influenced by the magnetic field created by 10 V variable currents within 60 minutes delaying of magnetic field: 1-maqnet field delaying time; 2-influence time after switching off magnetic field.

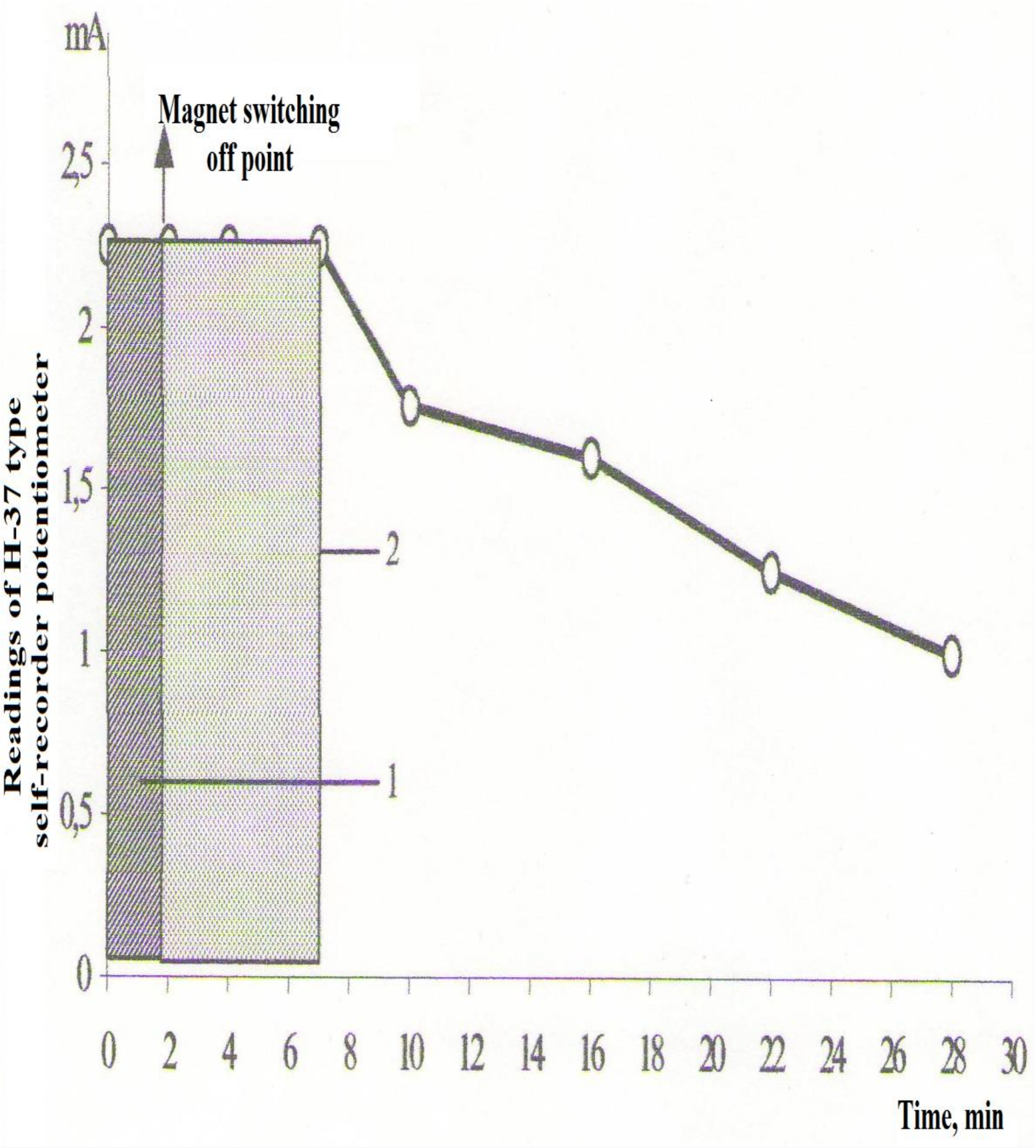

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Figure 2.2.6. Paraffin oils flow curve influenced by the magnetic field created by the variable currents with 50 V within 2 minutes delaying of magnetic field: 1-maqnet field delaying time; 2-influence time after switching off magnetic field.

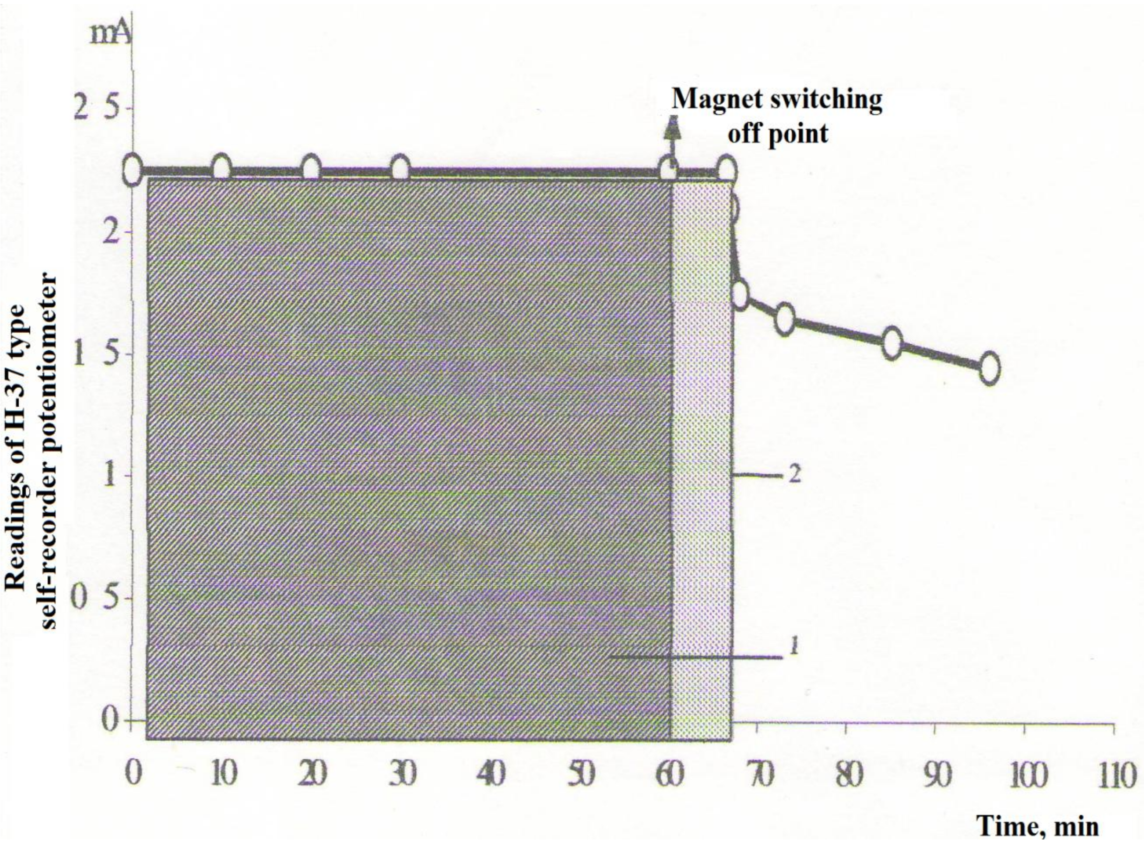

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Figure 2.2.7. Paraffin oils flow curve influenced by the magnetic field created by the variable currents with 50 V within 60 minutes delaying of magnetic field: 1-maqnet field delaying time; 2-influence time after switching off magnetic field.

Table 2.2.1

The results of experiments

№	Electric current and voltage, A, V	Frequency, ω	Magnetic field delaying time t, sec	Paraffin freezing time after magnetic field switched off, minutes
1	5	1	3600	27
2	5	1	120	21
3	10	50	120	19
4	1	1	3600	21
5	10	50	3600	22
6	50	50	120	26
7	50	50	3600	34
8	1	1	120	19

Source for this table: http://www.springerlink.com/content/w3mtr7t201578q38/

Taken into consideration the aforesaid information and based on the data introduced in the table 2.2.1 we can come to the conclusion that at the maximum values of amplitude and minimum values of frequency magnetic field exert the greatest influence upon the paraffin oils freezing temperature.

CHAPTER 3. THE INVESTIGATION OF MAGNETIC FIELD INFLUENCE TO THE PARAFFIN OILS RHEOLOGICAL CHARACTERISTICS SEPARATELY AND TOGETHER WITH "COMPOZIT-2"

Paraffin rich oils with non-homogeneous composition have non-homogeneous complicated rheological substances that under the temperature reduction subjected to structural changes, i.e. to get thixotropic characteristics.

At present, to improve paraffin rich oils production and transportation properties is widely used methods that decline paraffin freezing temperature and consequently, prevent paraffin lattice formation.

For this purpose they used physical fields (e.g. magnetic field) and different types of polymer substances, i.e., additives,

At present, there are no techniques to choose some oil additives to improve the properties of some non-Newtonian systems [13]. But, oil additives and also their concentration choosing technique are existed.

Additive and its concentration choosing are carried out by the practical way**.** Some of the oil additives (depressors or depressing agent) decline the oils’ freezing temperature, some of them oils’ shearing stress, and the others the dynamic shearing stress and dynamic viscosity of oils; therefore, it is difficult to determine the best of all additives.

This problem appears to set the selection of a reliable parameter. On the other hand, the different data, different curves and different graphs at different temperatures, makes more difficult the selection of this parameter.

At laboratory conditions oils’ structure forming rheological parameters, as a rule, is investigated with the rotational viscosimeter. the rotational viscosimeter allows to determine oils’ shearing stresses at certain temperature and shear rates.

As a result of these studies we construct diagrams that show the dependence of shearing stress vs shearing rate that introduces the flow curves characterizing the liquids rheological parameters.

It should be noted that in the rich paraffin content oils’ at low temperatures the shear rate’s consequently increase and consequently decrease, show us the curves that don’t coincide each other.

The hysteresis curves of the paraffin rich oil from well № 14 (the N. Narimanov's Oil and Gas Production Department) is shown in the figure 3.1.

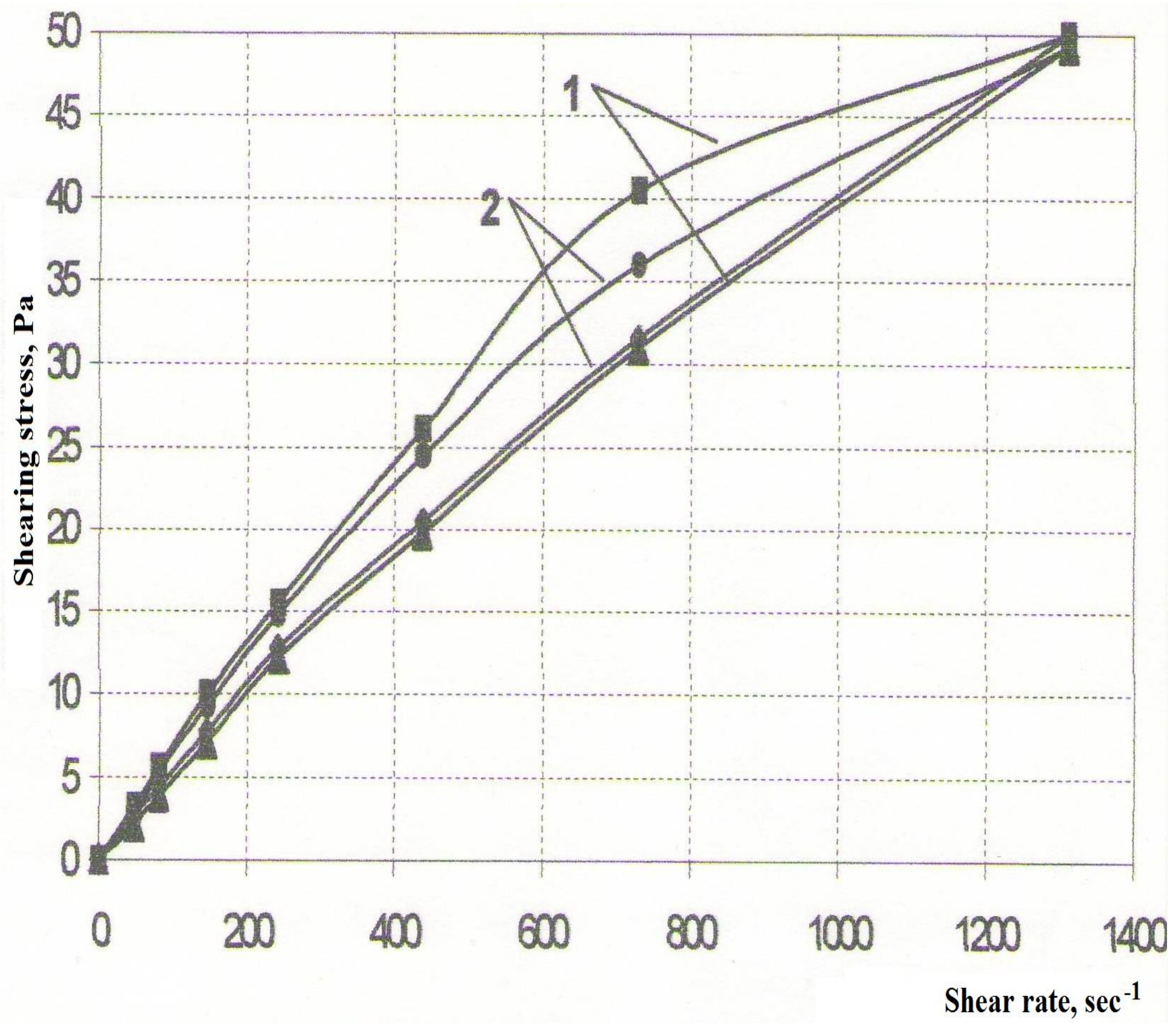

Figure 3.1. The hysteresis curves of the influence of high magnetic field to paraffin oil obtained from the well № 411 (N. Narimanov OGPD). 1-crude oil; 2-after influence of magnetic field.

When paraffin rich oil is influenced by the magnetic field, this hysteresis curves becomes closer to each other.

So, the magnetic field breaking the paraffin crystals lattice, forces the system to be in a flow steady state.

Consequently increasing the shear rate of oil flow leads to breaking of the paraffin crystal lattice and bringing the system into the steady state (equilibrium) flow.

Decreasing of the shear rate back towards to full-destroyed structure characterizing the steady flow curves of declining flows of fluid in the pipelines. In high values of shear rate the difference between the two curves is decreased, i.e. the distance between hysteresis curves is narrowed.

Increasing the temperature to perform the function of this system depressant, chemical reagent, affected together with the chemical reagent and by magnetic fields, hysteresis curves get smaller, the system's non-equilibrity decreases, the oil receiving Newtonian properties passes to the equilibrium state (Figure 3.2).

In studying the temperature influence to the flow shearing stress the investigations were provided at the shear rate constant values, i.e. ($\gamma = const$).

If we construct the dependence between the magnetic field and the temperature we get the hysteresis curves to paraffin oils that are shown in Figure 3.3. In adding in the amount of high paraffin oil 6, 10, 12 L/t of chemical reagent and providing it is passing through the magnetic field influence, in a constant shear rate the temperature influence of more clearly noticeable on the shearing stress and the shear stress makes hysteresis curves more narrative (Figure 3.4).

As a result of investigations it was established that if the paraffin crystals were formed at a low temperature, for example, at 60 °C, after affecting by the magnetic field, the mass crystallization is taken place at 25-35 ^{0}C.

If we draw the function of dynamic effective viscosity vs the temperature for the paraffin rich we could observe at the constant shear rate with increasing the amount of the temperature the dynamic viscosity decreases and this decreasing is caused by the significant effect of the magnetic field (Figure 3.5).

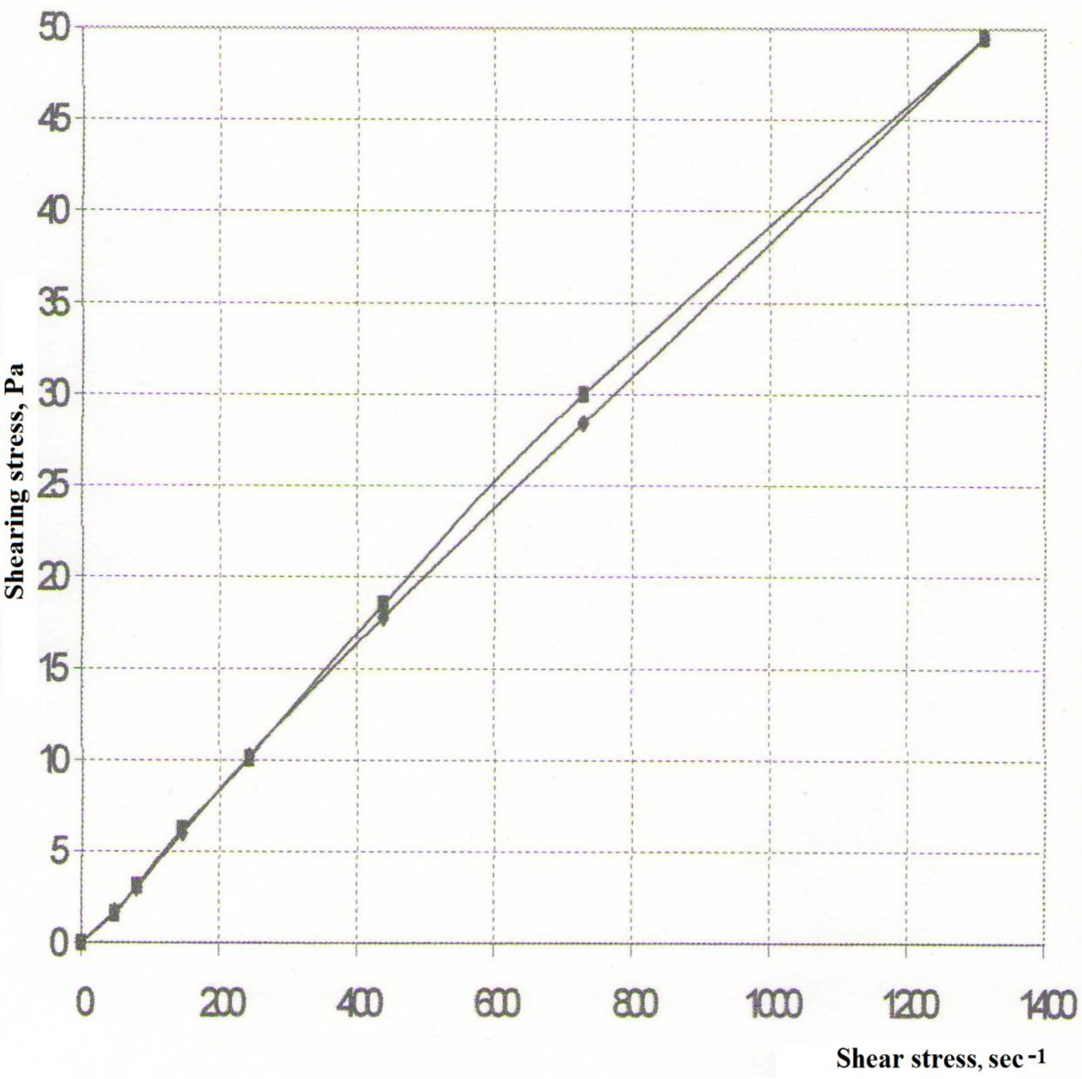

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Figure 3.2. The hysteresis curves obtained by influencing to high paraffin oil by chemical and magnetic field together at different temperatures

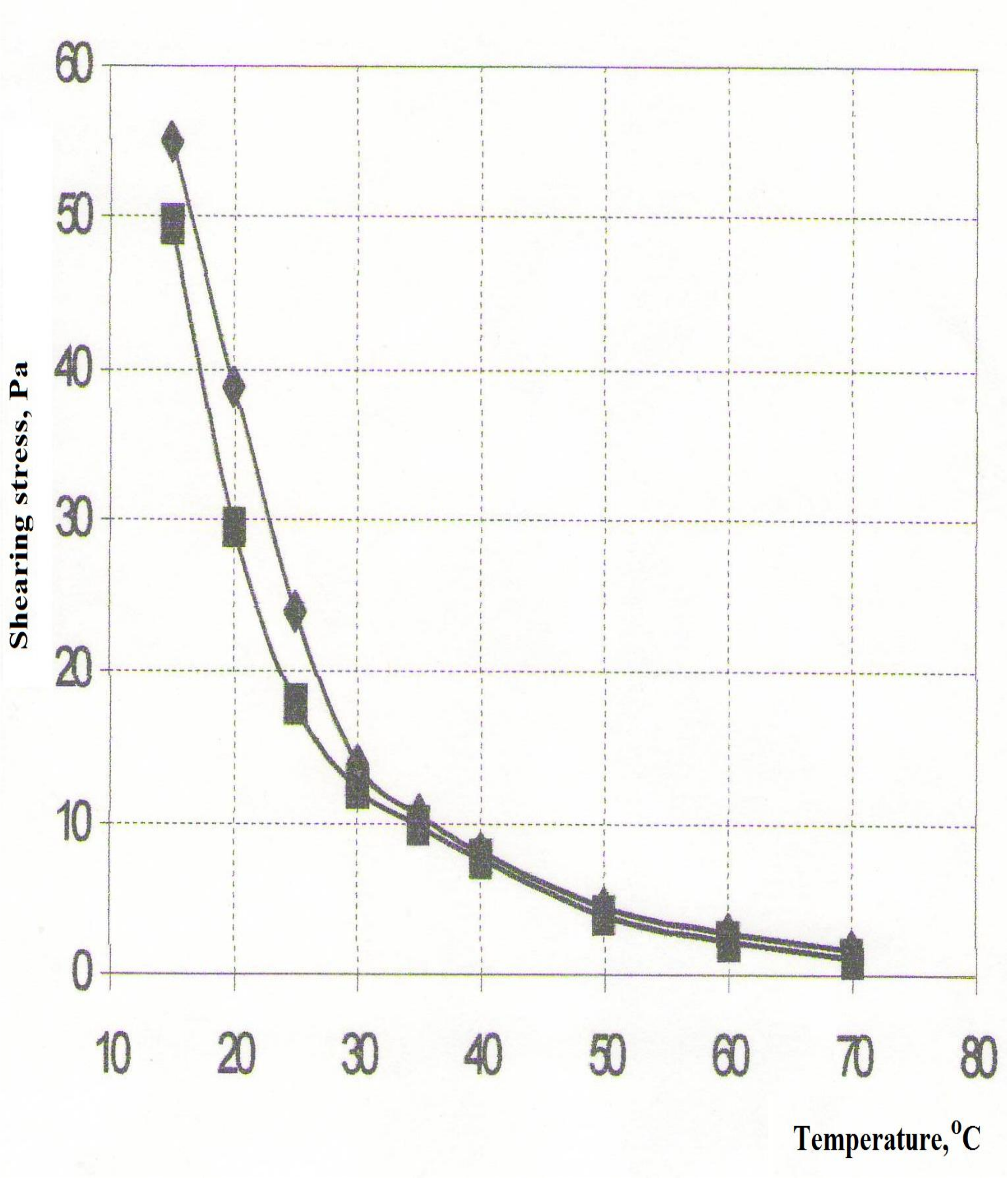

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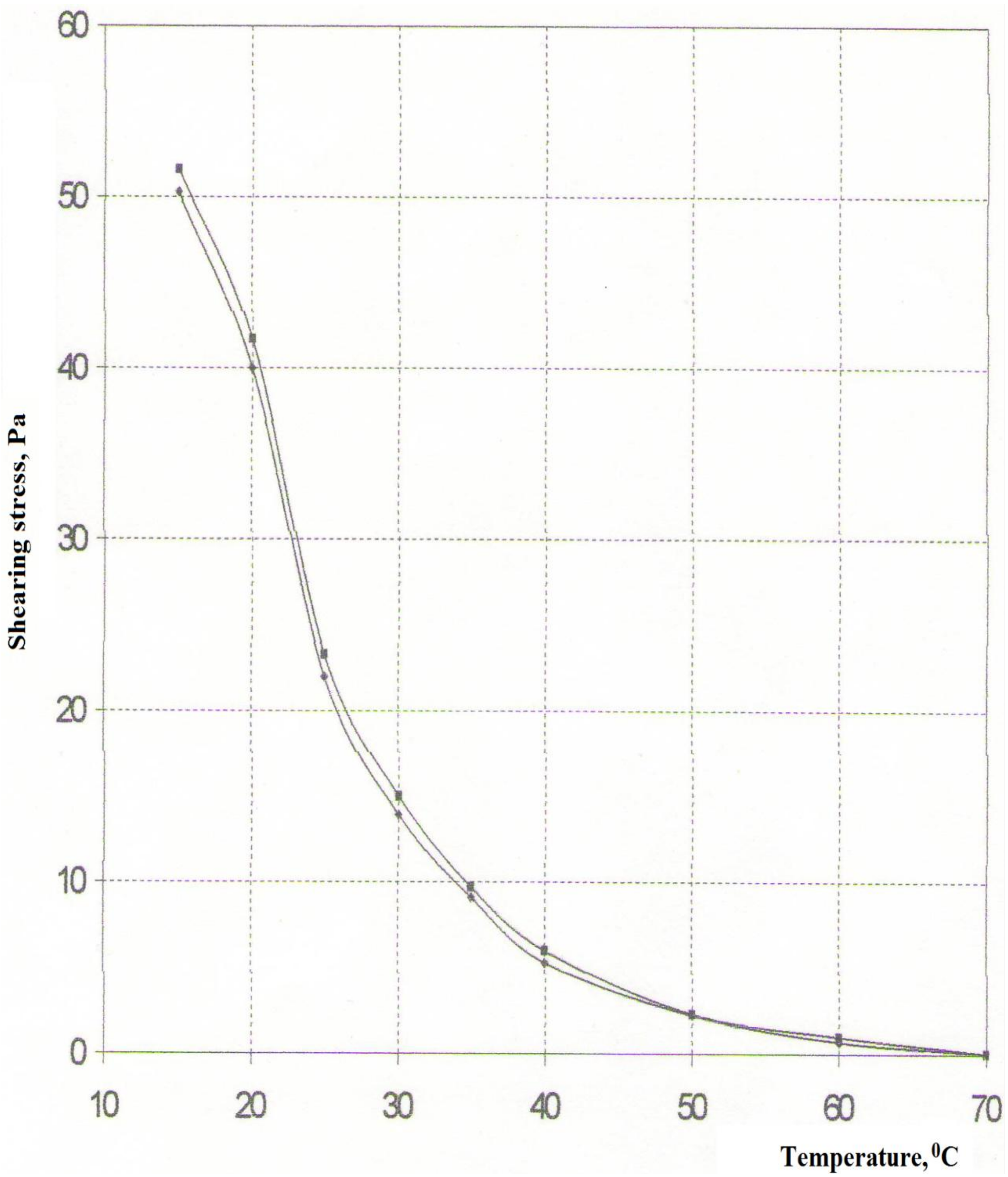
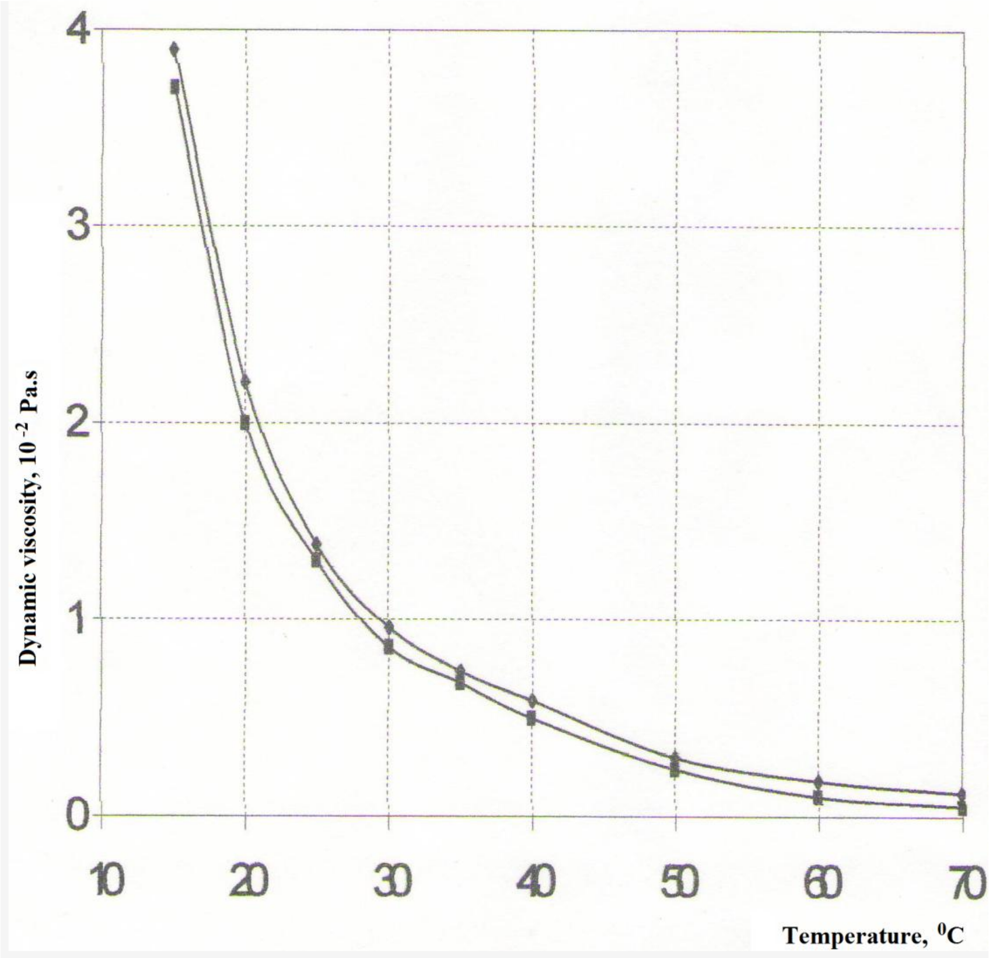
Figure 3.3. Hysteresis curves of shearing stress vs temperature obtained by influence of the magnetic field to high paraffin content oil



Source image from:www.chem.wise.edu

Figure 3.4. The hysteresis curves of high paraffin content oil influenced by magnetic field and chemical reagent together at different temperatures ($\gamma = const$)



Source image from:pubs.acs.org/doi/abs/10.1021/ef901302y

Figure 3.5. Dynamic viscosity vs temperature curves obtained by influence of the magnetic field to high paraffin content oil ($\gamma = const$)

Influencing to paraffin high rich oils by the high magnetic field and chemical reagent together, impact depending upon the temperature of their constant shear rates the dynamic viscosities decreases (Figure 3.6).

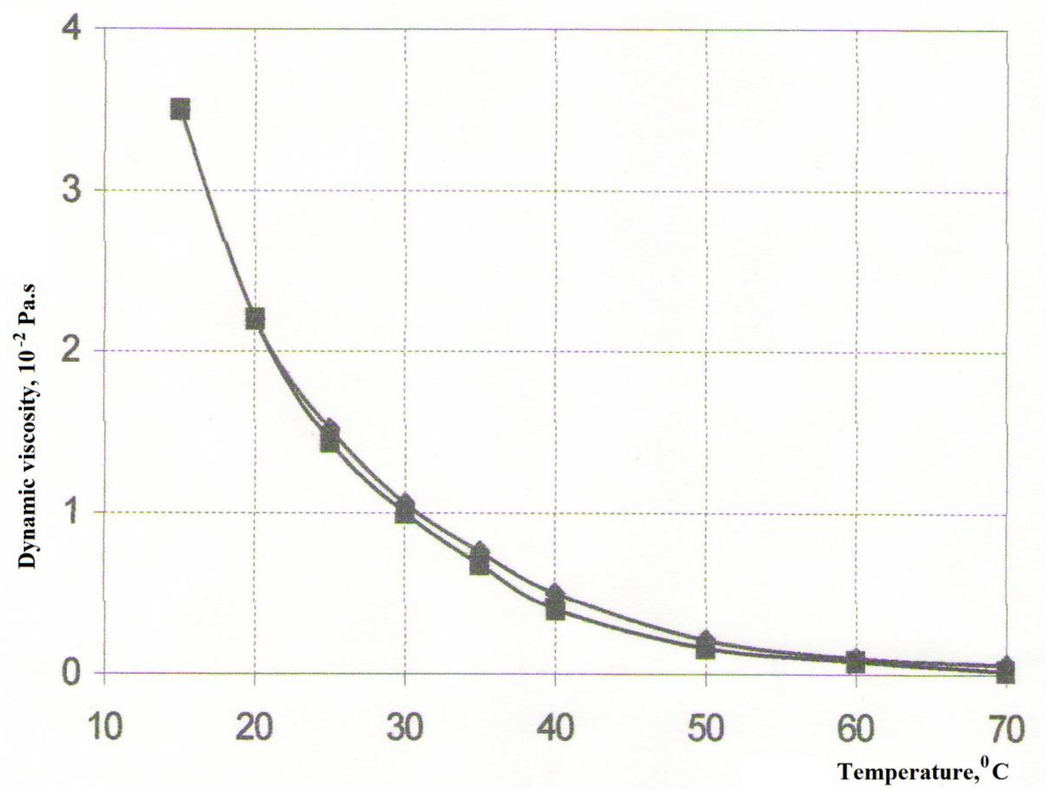


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Figure 3.6. Dynamic viscosity vs temperature curves obtained by influence of the magnetic field and chemical reagent to high paraffin content oil ($\gamma = const$)

As it is seen from the dependence between inverse value’s square of the dynamic effective viscosity of the paraffin rich oils and the square value of the shearing stress with increasing the shearing stress the inverse value of the dynamic viscosity also increases (Figure 3.7).

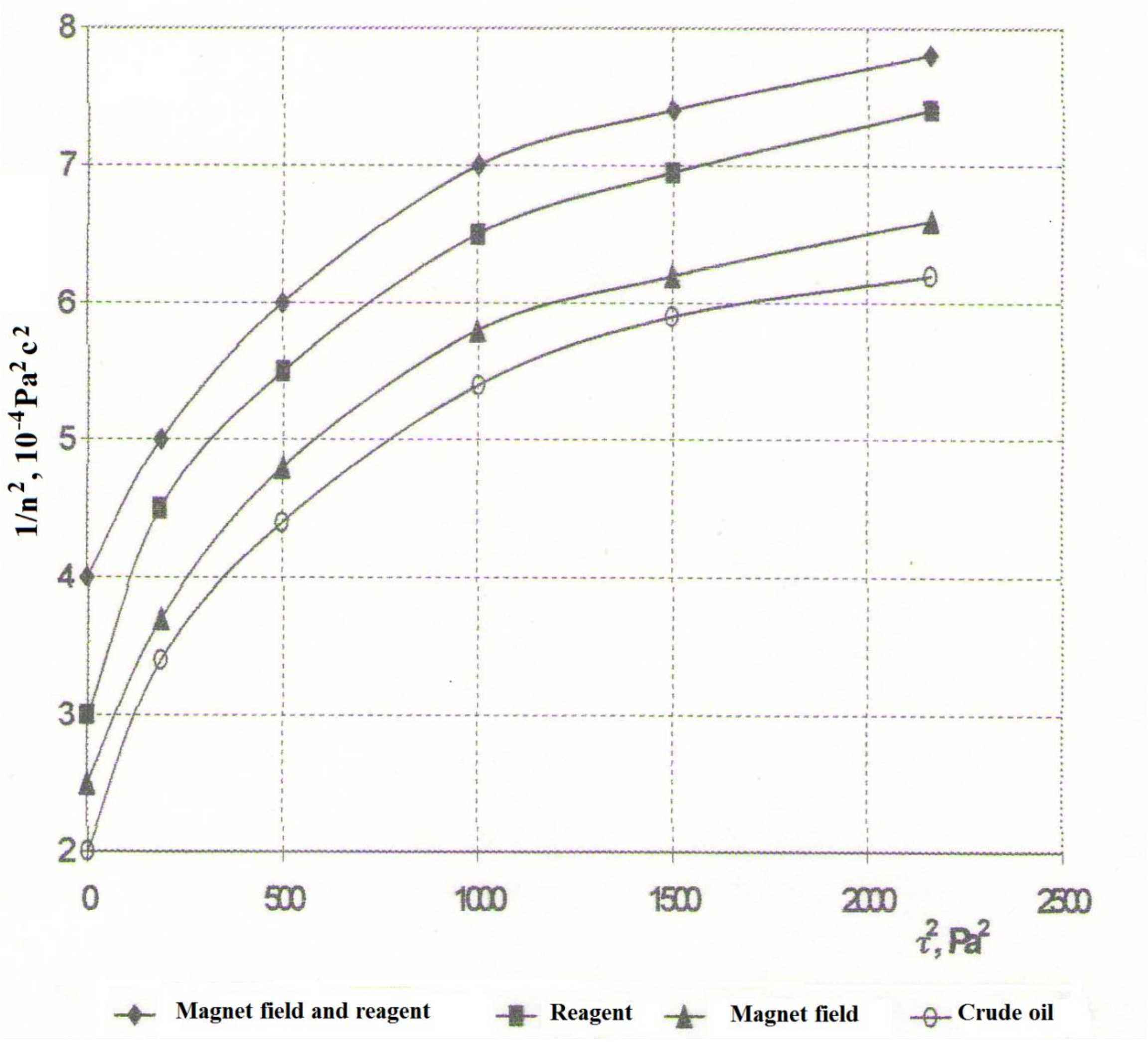

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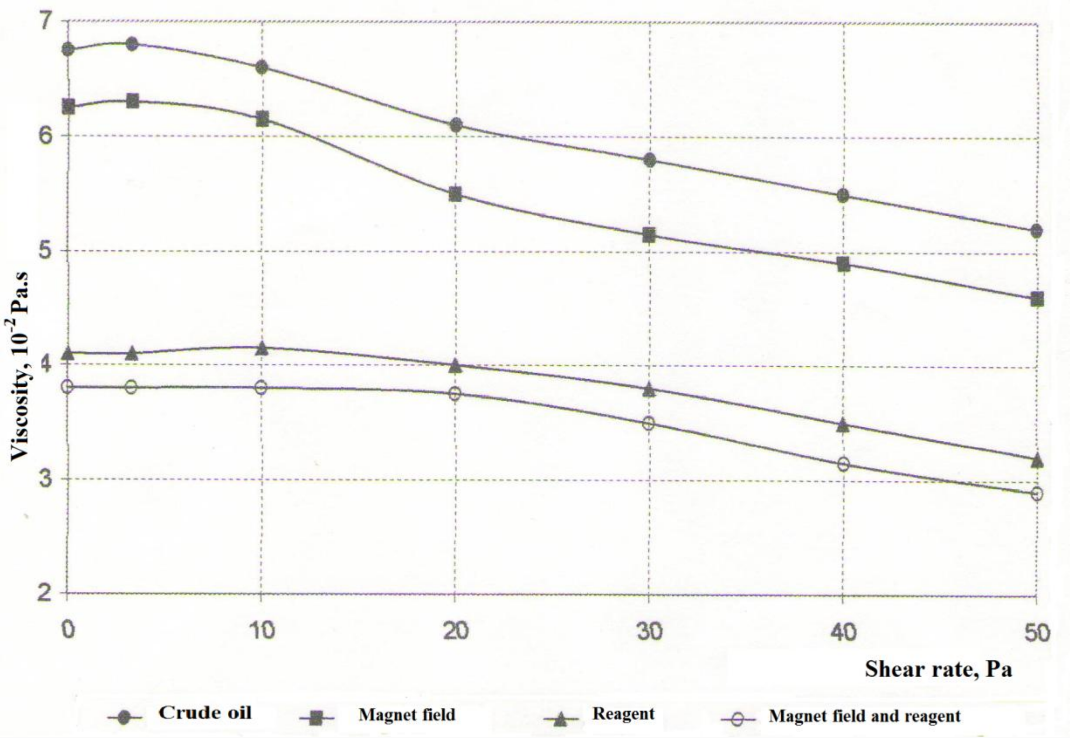
Figure 3.7. The curves of paraffin rich oils' dynamic effective viscosity's inverse value's square vs square value of shearing stress

Dynamic viscosity's inverse value for reagentless crude oils less than those if oil is influenced by magnetic field and chemical reagent.

As it has been seen from the curves showing dependences of dynamic viscosities of high paraffin content oils vs shearing stress, constructed for oil well № 411 (N. Narimanov Oil and Gas Production Department) with increasing of shear stress effective viscosity decreases.

Dynamic effective viscosity of reagentless crude oils without affecting of magnetic field and chemical reagent together is still considerably higher in comparison of processed oil (see Figure 3.8).



Source image from:pubs.acs.org/doi/abs/10.1021/ef901302y

Figure 3.8. Dynamic viscosity vs shearing stress curves obtainedby influence of the magnetic field and chemical reagent together to high paraffin content oils

It should be noted that the influence of magnetic fields and chemical reagent, together with the non-steadiness of the coefficients are determined by the formula 2.5. This calculation method is applied for oil sample with high paraffin content obtained from the well № 411 (N. Narimanov Oil and Gas Production Department (Table 3.1).

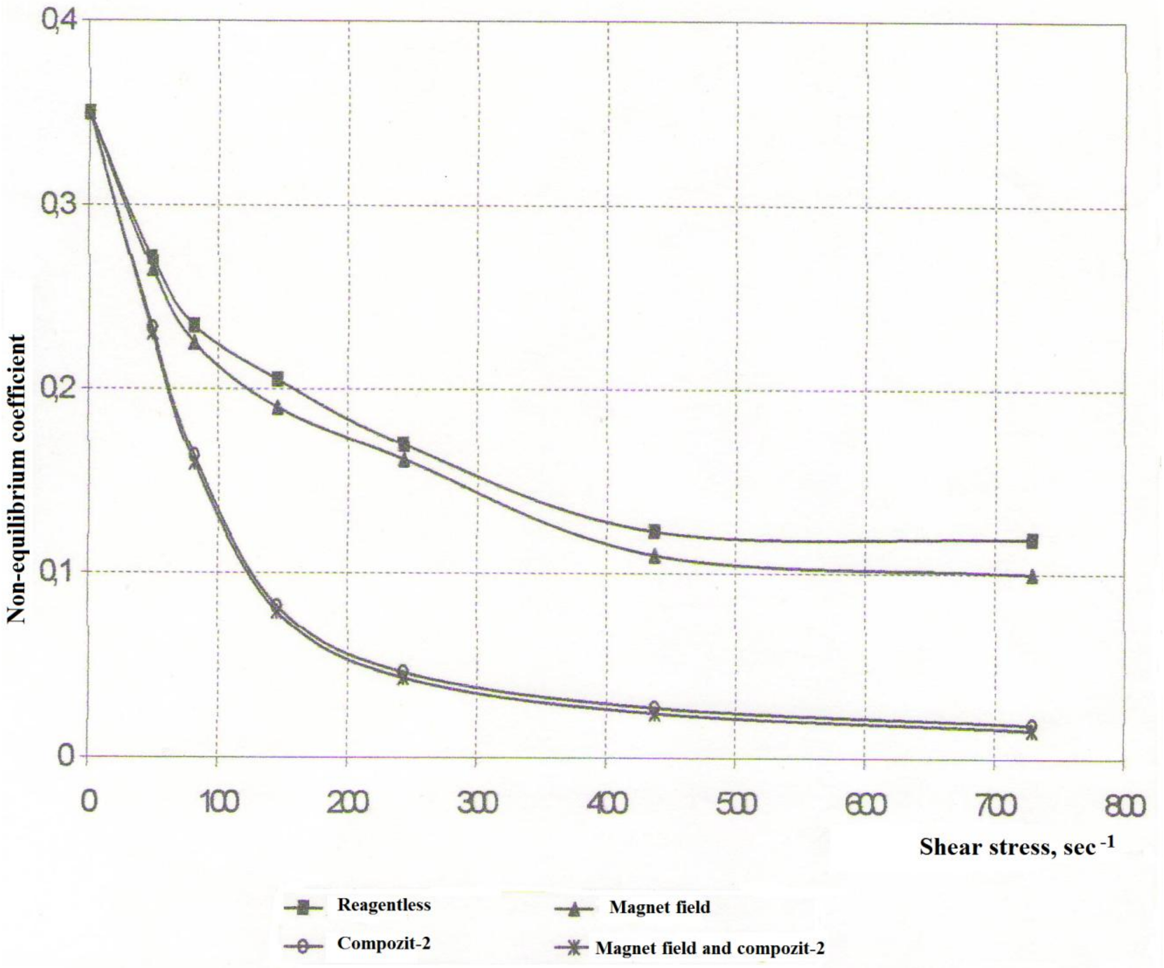
The diagram showing the dependence between shear rate and non-steadiness coefficient is shown in the figure 3.9.

Table 3.1

Magnetic fields influence to the paraffin rich oil processed by different concentration chemical reagents (t=14-16 ^{0}C)

Type of deprecator and non-steadiness coefficient α in the magnetic field	Shear rate, sec^{-1}						Cumulative non-steadiness coefficient, i
	48.6	81.0	145.8	243	437.4	729	
Reagentless	0.271	0.224	0.222	0.179	0.123	0.119	116.18
Magnetic field	0.205	0.225	0.216	0.176	0.120	0.110	112.78
Composite-2	0.233	0.164	0.082	0.049	0.027	0.018	42.96
Reagent	0.230	0.160	0.079	0.043	0.024	0.015	40.92

Table 3.1 and figure 3.9 shows that the magnetic field and depressators reduce the rate of non-steadiness and the best results with the magnetic field gives the chemical reagent is applied. In adding to a ton of oil, 6, 7, and 12 liters chemical reagent of non-steadiness ratio was appointed and results of experiments were introduced in the table 3.2.



Source image from: www.pjoes.com

Figure 3.9. Shearing stress vs non-equilibrity coefficient curves obtained by influence of the magnetic field and chemical reagent together to high paraffin content oils

It is necessary to choose of a chemical reagent optimum concentration in the magnetic field applied.

Table 3.2

Non-steadiness coefficient's value of the paraffin rich oil processed by different concentration of chemical reagents and placed by the magnetic field (t=14-16 ^{0}C)

Indices of oils processed by chemical reagents and placed in the magnetic field	Shear rate, sec-1					
	48.6	81.0	145.8	243	437.4	729
	Non-steadiness coefficient α					
6 L/t	0.240	0.199	0.086	0.075	0.069	0.064
7 L/t	0.230	0.161	0.079	0.043	0.024	0.015
12 L/t	0.245	0.208	0.108	0.100	0.094	0.092

Source table from:adsabs.harvard.edu

From table 3.2 it is seen that with increasing of the value of the shear rate the non-steadiness coefficient decreases, i.e., the crystal lattice (structure) of the paraffin is break down and oil starts to get steady state now. After you have added to the paraffin oil depressing agent and placed it in high magnetic field, the crystal structure of paraffin is brought to the poor links that would interfere with each other in the local crystal center.

Chemical reagent added into the high paraffin content oil obtained from the well № 411 (N. Narimanov Oil and Gas Production Department) and the sample was placed into the magnetic field, and the non-steady coefficient was studied. The experiment results were placed in the table 3.2.

In the figure 3.9 at constant shear rate high paraffin content oil's with chemical reagent mixture processed in the magnetic field non-steady coefficient's cumulative values were given (Table 3.3).

Table 3.3

Different concentration of chemical reagents and the magnetic field’s influence to the cumulative value of the non-steadiness coefficient

The cumulative value of the non-steadiness coefficient α	Reagentless	With reagent and magnetic field		
		6 l/t	7 l/t	12 l/t
	116.18	63.73	40.92	78.76

Source table from:www.aslo.org

From Table 1.6 it is seen that the value of the crude oil’s non-steadiness ratio is 116.18, but for the case, in the magnetic field and chemical reagent adding by 6 l/t in the amount of 63.73, by 7 lt in the amount of 40.92; by 12 l/t is made 78.76. These results have been proved in the laboratory studies and also by the hydraulic calculations.

So, after the processing of paraffin rich oils by the chemical reagent and in the magnetic fields, allows us to get steadiness and non-steadiness curves, based on which we find non-steadiness coefficient and could predict optimum concentration of depressors.

Low values of the non-steadiness coefficient fit the optimum concentration of depressors and provided its optimum (efficiency) consumption.

The joint effect of magnetic field and chemical reagent to the paraffin oils is tested by the "cold fingers" method.

The research results have shown that paraffin rich oils affected by a chemical reagent and examined to the cold fingers showed 7 g paraffin, affected by a magnetic field - 6.85 g, and in case of a joint effect with the magnetic field and chemical reagent cold fingers paraffin deposits were 6.7 g.

In the absence of any effect to the paraffin oil, paraffin deposits was 10.41 g. i.e., in comparison with the aforesaid amount paraffin collapsing, according to 50%, 52%, 55% higher. Interacting with the occurrence of synergetic effect here is clear.

CONCLUSIONS AND RECOMMENDATIONS

The thesis includes introduction, section technological means to control asphalt-resin-paraffin deposits, three chapters, conclusion and recommendations, and references.

In the Introduction urgency of a theme, the object of the thesis, ways of solving of problems and scientific novelty of the thesis were considered.

Section to control paraffin deposits describes modern technological means that prevent paraffin deposits in the oil wells. Between all paraffin control methods applying magnetic field in oil production as the dewaxing method is widely used.

The use of units УМЖ-122 and УМЖ-73-005 increased the average overhaul period of wells in the OGPD "Arlanneft", operating of which is complicated by the paraffin deposits and oil emulsion, in an average of 1.8 times. Chemical treatment of wells was discontinued. On Sergiyevsk field OGPD "Ufaneft" the use of units УМЖ-73-005 made it possible to increase the period cleaning of wells from paraffin deposits in 2.7 times, while the number of thermal and chemical treatments to reduce to 2 and 5 times, respectively. The introduction of units УМЖ—73-005 in wells "Urayneftegaz" complicated paraffin deposits allowed to increase their average overhaul period of 2 times at the stopping of chemical treatment of wells.

Magnetic field and the "composite-2" reagent combined influence to the paraffin oils also tested by the method of “cold fingers”. It was shown that, without any effect on “cold fingers”, if there was 10.41 g of paraffin deposition, only the "Composite-2" reagent presence decreases paraffin deposition by 7 g (i.e. 49% is decreased); If this figure is affected by the magnetic field paraffin field deposition decreases of 6.85 g (52% is reduced). So, magnetic field and the "composite-2" as a result of the impact of the collapsing paraffin deposition by amount of 6.7 g, which was 55% less. From here you can see that the synergetic effect occurrence.

It should be noted that in the rich paraffin content oils’ at low temperatures the shear rate’s consequently increase and consequently decrease show us the curves that don’t coincide each other.

When paraffin rich oil influenced by the magnetic field this hysteresis curves becomes closer to each other.

So, the magnetic field breaking the paraffin crystals lattice, forces the system to be in a flow steady state.

In studying the temperature influence to the flow shearing stress the investigations were provided at the shear rate constant values, i.e. ($\gamma = const$).

If we construct the dependence between the magnetic field and the temperature we get the hysteresis curves to paraffin oils. In adding in the amount of high paraffin oil 6, 10, 12 lt of chemical reagent and providing it is passing through the magnetic field influence, in a constant shear rate the temperature influence of more clearly noticeable on the shearing stress and the shear stress makes hysteresis curves more narrative).

As a result of investigations it was established that if the paraffin crystals were formed at a low temperature, for example, at 60 °C, after affecting by the magnetic field, the mass taken place at 25-35^{0}C.

So, after the processing of paraffin rich oils by the chemical reagent and in the magnetic fields allows us to get steadiness and non-steadiness curves, based on which we find non-steadiness coefficient and could predict optimum concentration of depresators.

Low values of the non-steadiness coefficient fit the optimum concentration of depresators and provided its optimum (efficiency) consumption.

The joint effect of magnetic field and chemical reagent to the paraffin oils is tested by the "cold fingers" method.

The research results have shown that paraffin rich oils affected by a chemical reagent and examined to the “cold fingers” showed 7 g paraffin, affected by a magnetic field - 6.85 g, and in case of a joint effect with the magnetic field and chemical reagent “cold fingers” paraffin deposits were 6.7 g.

In the absence of any effect to the paraffin oil, paraffin deposits was 10.41 g. i.e., in comparison with the aforesaid amount paraffin collapsing, according to 50%, 52%, 55% higher. Interacting with the occurrence of synergetic effect here is clear.

REFERENCES

1. Ibragimov G.Z., Sorokin V.A, NI Khisamutdinov Chemicals for Oil: A Handbook of the worker. Moscow: Nedra, 1986. 240. (in Russian)

2. Inyushin N.V., Kashtanova L. Equipment for magnetic processing of liquids. Moscow, Nedra Publisher, 2001. P. 144. (in Russian)

3. ErginY.V., Yaruzin K.S. Magnetic properties of oils. Moscow, “Nedra”, 1979, pp. 198.

4. Kagan Y.M. Alternative Magnetic field influence on crystallization and formation of paraffin deposits. Journal Oilfield Economy. 1965, №10. P. 16-19. (in Russian)

5. Mirzajanzade A.X. Variation of rheological properties of non-Newtonian systems at processing under pressure. Novosibirsk, Journal Rheology, 1977. pp. 211. (in Russian)

6. Bagirov O.T. Investigation of electrization of gas-liquid flows and methods of their regulation for increasing of gaslift wells productivity. PhD thesis, Azerbaijan State Oil Academy. Baki, 1985. pp.165. (in Russian)

7. Baybakov N.K., Grushev A.R. Oil fields development by heating methods. Moscow, “Nedra”, 1977, pp. 238. (in Russian)

8. Bagirov O.T. Ekcperimental isnvestigation of electric fields effect on liquids electrode potential. Post-graduate students’ conference. Baki, 1983. pp.278-279. (in Russian)

9. KonovalovE.G., Germanovich I.N. Ultrasound capillary effect. Scientific papers Belorussian Academy of Science. 1962, Volume 6, №8. pp. 54. (in Russian)

10. Bayramov A.M. Water magnetic processing effect on hydrocarbon liquids displacement processes on porous medium with residual water. Baki Journal “Oil and Gas” №2, 1978. pp.27-30. (in Russian)

11. Borsutski Z.P. and others. Equipment for magnetic processing of liquids. Patent 12409, Russian Federation. (in Russian)

12. Richardson John. Beginning of fluidization and homogeneous fluidization. Proceedings. Edited by Davidson I.F. Moscow, Journal Chemistry, 1974. pp. 37-73.

REFERENCES sources for images in chapter

1.Persiantcev M.N. Oil Production in complication conditions. Moscow: Nedra Publishers, Business Center, 2000, pages 653. (in Russian)

2.Dolomatov M.Y. & others. Physico-chemical basis of directional selection asphaltene-resinous substances solvent. Report of the Central Research Institute CSRITEneftexim, 1990, p. 35. (in Russian)

3. Ibrahimov G.Z. & others. Chemicals for oil. A handbook of the worker. Moscow: Nedra Publisher,s1986. Pages 240. (in Russian).

4. Golonckiy P.P. Paraffin control in oil production. Moscow: Gostoptexizdat, 1960, pages 88. (in Russian)