

ARTIFICIAL LIFT EQUIPMENTS REPAIRING TECHNIQUES IN DAQING OILFIELD

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Abstract

Daqing Oilfield has oil/water 60,000 wells, it needs production investment 1.07 billion yuan to change wasted mechanical production equipment. Through overcoming technolgis for several years, it has formed a series of associated techniques of rapairing mechanical production equipment, that would save costs 0.5 billion yuan, creating great social benefits and economical benefits.

The study generally introduces the study background of technologies of repairing mechanical production in Daqing Oilfield. It makes a detailed introduction about development history and present technology of crucial technologies of repairing mechanical production equipment, including oil tube, rod string and suck-rod pump. Meanwhile, with the research results and successful experience of remanufacturing technology received in automobile territory and military territory, to evaluate and estimate the development direction of repairing technologies of mechanincal production equipment later.

Keywords: mechanical production equipment; repair; remanufacturing

1 Introduction

Daqing Oilfield is a multioillayer-layer form-structure reservoirs with large-area, multi-layer and abundant-reserves, after 40 years' exploration and development ,it has been built the biggest company and petroleum base in China, it has produced crude oil 1.95 billion tons until now.

From 60 chronicle development beginning period's flowing production to 80 chronicle's artificiaial lift ,from waterflood development to polymer waterflooding development, terpolymer development and microbial development, we goes by an uncommonplace way which depends on technology to develop oilfield, depends on technology to enhanced recovery efficiency.With the increasing number of the wells, with the difficulty of exploitation getting harder and harder, the quantity of using and abandoned of mechanical equipment are increasing day by day. It has an significant sense for realizing environment-friendly oilfield and improving oilfield economical benefits to repair the mechanical production equipments.

2 Applied situation of Daqing Oilfield mechanical production equipment

At present, Daqing Oilfield has 68253 oil-water wells, there are 43508 production wells and 24745 injection wells. Production well has three mechanical production forms, is separately 37690 pumping unit lifting, 3544 progressive cavity pump lifting, 2274 submersible pump lifting.Injection well mainly includes waterflood 19649 wells, polymer waterflooding 5096 wells.The average depth of wells in Daqing Oilfield is 1200m, the average depth of pumps is 1000m.The pumping unit lifting and progressive cavity pump lifting is sucker-rod pump lifting in production well, working tube is 68.25 million meters, working rod string is 41.23 million meters. Meanwhile, in order to remedy production decline about the impact on crude oil production, finishing 6000drilling every year, there are 4000 production wells and 2000 injection wells.

The part of mechanical production equipment on ground , such as pumping unit, driving part of progressive cavity pump, always works outside and to be corroded by wind, rain, snow and dust, the working environment is fairly abominable; non-intermittent running for several years(except downhole remedial operation) , the working conditions is hostile.The part under ground such as tubing, sucker rod, sucker rod pump etc., they always contact with water, gas, oil, mineral substance and wax, being seriously corroded, meanwhile, the sucker rod, tubing in the wells also has eccentric wear problems. Therefore, Daqing Oilfield is not only a deliverability producer, but also is a huge consumer of the productions and equipments. With the Oilfield stepping into the high water exploration stage, the difficulty is getting harder and harder, the producibility per well is decling step by step, the input costs is increasing every year, consequently we need adopt each advisable technology , following with low-cost strategy, to realize the sustainable development of Daqing Oilfield. From these more than 60 thousands wells Daqing Oilfield replace 5,000,000m wasted tubing, 3,000,000m sucker rod, 15,000 sucker rod pump, 2,000 pumping unit, 1,000 progressing cavity pump, 500 electric submersible pump.Each year it will not only increase 1,070,000,000 yuan production investment to replace these equipment, but also need larger stock site and more staff management.Meanwhile ,there are 6,000 wells increased in Daqing Oilfield, the wasted mechanical production equipment and production investment is

also increasing every year.To develop repairing of mechanical production equipment, it is an important treatment to implement scientific-development concept, to develop cycle economy that continuously enhancing

the repairing technology, repairing quality and amplify the repairing range, it also provide a good idea and method for Daqing Oilfield to reduce the production cost, to increase the economic benefit.

3 Technologies of repairing mechanical equipment

3.1 The technologies of repairing tubing

The damage forms of tubing include corrosion, abrasion and screw thread damage, the amount of tubing is the most in mechanical production equipment, the amount of damage is the most, either, and the standard of repairing technology also has strict requirement.

3.1.1 Zn-Al rare earth alloying tubing

Technological process of Zn-Al rare earth alloying tubing is shown in figure 1.

Figure 1 technological flow chart of Zn-Al rare earth alloying tubing during the process, the purpose of alkaline washing and acid pickling is to clean the greasy dirt, iron oxide on the tubing surface its formula and operation method has moulded approach. Hot dipping is the approach that to dip the tubing into the compound liquor with aluminium and rare earth, with the temperature between 450 to 460 centigrade degree, that forms a new type of Zn-Al rare earth alloying covering on the surface of the tubing.

During the pretreatment of the hot dipping of the tubing, the most critical element which influences the quality of the covering. The dip solvent plating liquor is the water solution which adopts concentration of 200 g/L tin chloride, 50 g/L ammonium chloride. Putting the tubing into the water solution to be processed, it needs about 5 minutes, with the temperature between 70 to 80 centigrade degree. The process of plating aid of the tubing needs to drying in order to eliminate the water solution or other water content, so that it could prevent scalding human body and generate zinc ash during heat dip plating process, the drying process with the temperature keeping between 100-200 centigrade degree. Fluxing has the following functions:

- 1) clean the slight iron oxide which is oxidated again in the air after acid pickling;
- 2) remove the molysite on the surface of tubing which is not completely cleaned by acid pickling;
- 3) remove the oxide on the surface of the molten Zn solution;
- 4) decrease the surface tension of the molten Zn solution in order to wetting the surface of the tubing by the molten metal.

Adding aluminium into the Zn solution has the following functions: compare with galvanizing coating, aluminizing coating has better corrosion resisting, lightness, but cause of the melting point of aluminium is 660.5℃, the production technology of the aluminizing coating is complicated. Zn-Al alloy coating combine the corrosion resistance of aluminium and electrochemical conservation of zinc. Adding slight aluminium into the Zn solution, that make the alloy coating has no brittleness of rhenium, therefore it

significantly improves the plastic property, making the lightness and corrosion resisting of the coating better.

Because of the melting point of rare earth (La and Ce) is about 815℃, and with galvanizing at about 460℃, rare earth is easily oxidated and exists as the form of rare earth oxide, lost the function of rare earth in Zn solution, so it doesn't adopt the way to add rare earth directly into it, but adding rare earth into Zn solution usually adopts adding intermediated rare earth alloy into it. The concrete adding method is: melting 0# Zn (including Zn 99.99%) in the Zn pot at about 460℃, insulating for 2 hours, using the iron coop which is welded by reinforcing steel to put Zn-Al intermediated alloy and Zn-Rare earth intermediated alloy into it. remove the iron coop which is filled with alloy waggling along the length direction. It is better that the dipped alloy is all below the Zn solution, until the alloy is all melt.

The temperature of hot galvanizing is 450-460℃, the galvanizing time is 1-2min, the collecting velocity is 1.5m/min.

3.1.2 The technologies of alloying nanometer three proofing plating

The alloying metalization is the technological process and method that immersing steel or cast-iron finished piece into zinc solution after the pre-editing, then forming Zn and (or) Zn-Fe alloying layer. The alloy layers include Zn and (or) Zn-Fe alloying layer is obtained on the surface of steel workpiece by adopting the hot dipping.

Technological process of hot dipping is shown in figure 2.

Forming the dipping layer is divided into three steps, the tubing surface is dissolved by zinc solution and forms the alloy phase layer, The atoms such as zinc in the alloy layer diffusing toward the base; The superficial of alloy layer is covered with a thin piece of the pure Zn-Al, that is the surface interval of the layer, therefore, it forms the metallographic combining relationship of superficial layer, middle alloy layer and base three in one, from the tubing base to the exterior surface is separately iron base, Zn-Al alloy layer and pure Zn-Al layer.

Since it is serious that the superficial corruption of some wasted tubing, the coarseness is also great. In order to decrease the deposit rate of the filth, rate of paraffin deposition, rate of scaling and coarseness, based on the alloy layer, then coating epoxy nanometer dope inside the tubing, to create the chemical bond between coating layer and alloy layer. Moreover, by using homogen handling installation which is well-developed domestic to rotate the coated tubing, to prevent berm appearance when it is motionless, to avoid sag appearance, allow the coating of the entire tubing inside incline ideal plane, thereby fills the corruption pit, declines the superficial coarseness, declines the friction coefficient, make the coating finer and closer, so as to improve the film forming quality, achieving the face smoothly like the mirror. After composite dipping, the operating performance of alloying composite dipping antiseptic tubing come to the optimum condition, it doesn't only significantly improve the antiseptic property, mechanical strength, but also significantly improve paraffin control

property, scale control property, improve the glossy quality of hydraulic power, to exploit the reuse property of wasted tubing better, thereby.

Technologies process of composite coating is shown in figure 3:

Alloyed composite coating tubing has the following significant feature:

1) Adhesion is powerful. Alloy coating combine with iron base is in the interest of metallurgy., in the corrosion environment, it won't happen blistering and denudation. Based on the test by machine building

surperfacial overburden quality supervision testing center, the adhesion of alloy layer is 0 level (reference *GB/T1720-89*), based on the stipulation in *GB/T13912-2002*, the adhesion of alloy layer is anti-detection. Meanwhile, according to the test of ChangZhou paint chemical engineering institute, adhesion of the superficial nanometer coating is 0 level. (*GB/T9286-1998*).

2) Hardness of Zn-Fe alloy layer is high, the unmixed Zn-Al alloy is pliable. The outward of alloy coating is unmixed Zn coating, so it is pliable, it could buffer the collision to the tubing during transportation and building process, decreasing the deformation rate of tubing; however, the inward hardness of Zn-Fe alloy layer is high, depend on the measurement result from Liaoning Province analysis testing research center, the average hardness of Zn-Fe alloy layer is more than $240HV$ (*GB/T9790-0998*), the crashworthy and wear resistance are both powerful. The hardness of tubing base is $130HV$, after experiment testing by Daqing General Mechanical Company, the alloyed wasted tubing may endure at least $20MPa$ pressure (when add pressure to $20MPa$, only the circumscribed tool set-up split).

3) The electrochemistry defends itself. Not only the alloy coating may act as segregation and protection, but also due to the attribute of Zn, Al atom, it has the electrochemistry protection. The polarization potential of the alloyed wasted tubing has attained $-0.90V$, overtaking the country negative pole protection standard $-0.85V$, it could slow down the corrosion to the coating's breakage part, it makes a breakthrough to the category of negative pole protection blind area in narrow and small room along with superficial buttering of routine antiseptic layer, with powerful corrosion resistance.

4) The superficial fault of alloyed tubing is restored by the growth of phase, it offers some of decided wasted tubing with utilize value once more, it doesn't only save the task for oil production, but also find a better outlet to the abundant wasted tubing of oilfield.

5) Composite coating has the more outstanding chemistry stability than the common coating, the superficial hydrophobicity is exceedingly high, the surface tension is low, it could keep a long time not to scale, it also has great detergency. The filth factor is 1/35 of blank stainless steel, the filth deposit rate is 1/72 of blank stainless steel, being lower than the national standard value far away, therefore, the paraffin control property, scale control property of composite coating tubing is better.

6) Service life is longer. Due to the peculiarity of alloy coating, its corrosion products membrane are evenly fine and close, with protection property, hence, at the beginning with products membrane covered on the superficial of the alloy layer, it won't be corroded any longer.

3.1.3 Process the tubing screw and tubing nipple

To the tubing with broken screw, slicing the screw section and processes once more, to the middle part broken but the end part is all right, it need to see the injured situation to process the nipple.

3.2 Sucker rod repairing techniques

The failure of sucker rod is mainly due to accepted alternate load for a long time until occur fatigue fracture, for most of the sucker rod have worked more than 5 years, hence the dependability of downhole operation becomes lower and lower, the amounts of the broken become more and more, so on the technologies of repairing, we need to resolve the following problems: □classify the default rod scientifically; □scientifically gurrantee the reliability of the downhole sucker rod string; □improve the repairing technology of repairable sucker rod; □improve the antifatigue (corrosion resistance) capability of wasted sucker rod; □to analyze the economic benefit with the testing and repairing of the wasted sucker rod. Through the effort for several years, we have preliminary resolved the following process technologies such as cleaning, drying, surface strengthening, nondestructive testing, classifying, marking, creating file, packing and corrosion resistance etc. To take shape a whole set of technology of industrialize repairing, it brings well economic benefit.

Sucker rod repairing technologies process of sucker rod repairing is shown in figure 4:

There are two kinds of technology treatments to improve the repairing quality of the sucker rod

1) medium-tempering

Based on *SY/T5551-92* standard, draw the revivification measure into it, adopt medium frequency induction heating, carry on carbonization with the superficial of the wasted sucker rod, afterwards the warmhearted stretching align is going on, This method may remove the fatigue stress of wasted sucker rod when using in the downhole, but it could not improve the tension resistance and fatigued life of the wasted sucker rod itself.

2) surface quenching

Based on *SY/T5551-92* standard, adopting CYP induction heating to handle the wasted sucker rod, after the induction heating the sucker rod still keep a certain self tempering temperature, it could remove the residual stress of sucker rod during the service process, the internal organization lattice dislocation caused by fatigue stress could be repaired either; through the thermal treatment, make the surface of the sucker rod exist quenching continous layers, the superficial residual stress could attain $-200MPa$ above, it could significantly improve the resistance and fatigued life of the wasted sucker rod. During the CYP quenching thermal treatment process, draw the wasted sucker rod further, make the

linearity of all sucker rod attain and meet the SY/T5029-93 standard. Adopting CYP induction heating to handle the wasted sucker rod, it is feasible in theory, is advanced in technology, is guaranteed in quality, is reliable in practical use.

3.3 The technologies of repairing sucker rod pump

Pump-barrel is the main component of the rod pump, its processing cost seizes 60% of the pump cost, so repairing the pump is mainly repairing the pump-barrel, the repairing method is that to the broken screw, slicing it and process it again, to the one that the inside is lightly worn and torn, it need to sewing polishes once more, then match suitable plunger.

3.4 Maintenance of the ground equipment such as pumping unit, progressive cavity pump

The maintenance of the ground equipment such as pumping unit, progressive cavity pump mainly contains repairing gears, shafts, motor and energy conservation reform of conventional pumping unit. Repairing gears, shafts mainly adopt special welding materials of our own self-developed to repair, the quality of repaired production has attained even overtake the finished product; repairing motor, the one, twines coil once more; the other, reform the common motor into dual speed motor, double PWR motor or permanent magnet motor etc. to satisfy oilfield energy conservation.

Energy conservation reform of conventional pumping unit is mainly in view of bad counterbalance effect, high energy consumption, reform the conventional pumping unit into downward beam balance weight pumping unit, with simple process, low cost, good energy saving effect.

4 Repairing effect of the mechanical equipment

The concrete situation of Daqing Oilfield decides that there are versatile species, huge amount wasted production to be repaired. Moreover, when generating wasted production every year, it need more new production to supplement, so in Daqing Oilfield there is not only the adequate wasted production to repair, but also the sufficient application market. Daqing Oilfield attaches great importance to the repairing assignment of mechanical equipment for decades, has construct 17 tubing repairing factories, 5 sucker rod repairing factories, 1 submersible pump repairing factory, 8 beam pumping unit repairing factories, 10 motor repairing factories, moreover, through compressing deliverability construct investment, reward etc. policy treatment, driving the repairing wasted production forward, at present, we have attained repairing 1,500,000m tubing, repairing 1,600,000m, sucker rod, repairing 3000 sucker rod pump, repairing 300 submersible pump, repairing 600 beam pumping unit, repairing 4000 motor, it could save production cost nearly 500,000,000yuan, it has an energetic affect to improve the economic benefit of the

oilfield, to increase the quantity of employment, to construct harmonious society.

5 The future development of repairing mechanical equipment

Entering 21th century, establishing circulation economy, holding sustainable development of the society has become topic of a conversation what every nation in world concern about. Remanufacturing engineering has the characteristic of saving resource and protecting environment, comprehensive utilizing information technology, nano technology, biotechnology etc. high tech as the core, sufficiently display the feature of Chinese own characteristic innovation. Remanufacturing could make the the value of the wasted resources obtain the utmost development and utilization, relieve the contradictory against resources wasting and resources lacking, decreasing the harm to the environment of the huge amount of failure, wasted production, it is the optimum formal and the preferred way to turn the wasted production into resources, is the important agency of saving resources. Remanufacturing engineering highly conjunct with the strategy requirement of establishing circulation economy, supply the gordian technique for it. Daqing Oilfield has stepped into the high water exploration stage, to establish century oilfield, to realize the sustainable development couldn't develop without the technology, integrate the wasted production or equipment repairing factory which is dispersed, low technical merit, small production capacity, start off from the strategy of the entire oilfield, establish one or more remanufacturing company which contains high technical merit, could meet the requirement of now and future, that is the inexorable trend of history development. Therefore, we carry on the following work:

5.1 Enforce the strength of repairing technologies

5.1.1 study on service life of remanufacturing productions

The wasted productions of oil company have the different characteristic compared with other professions', such as sucker rod, the broken form has snapping and dropping, snapping is divided into sucker rod body snapping and coupling snapping; the broken reasons include up fatigued fault or dropping, wearing fault or dropping and corrosion fault or dropping; application time is 5 or 10 years; the working conditions are differ in thousands of ways, different produced fluid character, different production parameters, different loads; as to the sucker rod itself, it is divided into material rod and process rod, the material and process is different, too. So, first of all, the remanufacturing of the oil production should carry on study with the residual service life of wasted production, and then study on the technology treatment how to increase the residual service life.

5.1.2 Study on nondestructive testing

To remanufacture the wasted rod/tubing, nondestructive testing is most important, for where there is 1% fault existing, there is 100% quality issues. in the light of this

could decide whether the wasted production could be remanufactured and then decide the remanufacturing method and treatment ;after that, the remanufactured production must be tested 100%, so that we could test the quality and the service of marked production.

5.1.3 Study on technology treatment of the performance of remanufactured production

The significant feature of remanufacturing is the target that the quality and performance of the remanufactured production attain even overtake the new production, to realize the target , we need to base on a series of technology treatment. In order to improve the quality and performance of repairing of the mechanical equipment , it need to overcome the following technologies:

1)thermal treatment technology

Thermal treatment is one of the most important technology to improve steel performance, based on the working feature and the broken degree of the rod, tubing, pump, adopting the well thermal treatment ,it is the most effective method to improve the steel performance.

2)Superficial treatment technology

Wearing and corrosion is the frequent broken forms of the rod, tubing and pump, applying the advanced superficial treatment technology, it could not only resume the size of the production, but also resume or improve the performance of the remanufacturing production, prolong the service life of the remanufacturing production.

3)laser technology

As a powerful , non-contact, clean energy , since laser technology entering the field, it has resolved many problems that the regular method couldn't process or hard to process, greatly improved the production efficiency and processing quality, to supply an advanced and effective technology method for remanufacturing. By using the laser cladding technology, it could repair the superficial crackle of gears and shafts, to improve the repairing quality and repairing efficiency.

4)cold treatment technology

For the corrosion and wearing of sucker rod, there is a considerable amount of the sucker rod couldn't be repaired at the current size, to these sucker rods, it could adopt cold treatment , that is cold-drawing the current size into the size of next level , in order to improve the success rate .

5)friction welding technology

Friction welding is the most effective method to make metal materials joint rapidly, to the rod and tubing with partly default ,slicing the default and then adopting friction welding to joint ,but the friction welding strength should be higher than the tubing itself.

5.2 enlarge the repairing sorts, improve the repairing amount

On the repairing sorts, limited to the technology, the wasted progressive cavity pump couldn't be repaired, we'll do all what we can to overtake the PCP repairing technology; on the repairing amount, the amount is just 1/3 of the repairing amount to deal with, it is a huge space to develop, we'll do our best to realize the

repairing amount increased by times and saving production cost increased by times in 5years.

Compared with other profession home and abroad ,the repairing technology of mechanical production equipment in Daqing Oilfield is still low, it doesn't attain the requirement of remanufacturing far away, to improve the repairing quality and repairing efficiency further, enlarge the repairing scale , we would like to coordinate with the relative company, college and research institute home and abroad, with the research results and successful experience of remanufacturing technology received in military territory and automobile territory, promote the repairing work developing in depth. We believe that ,with the exploitation of the oilfield , repairing of mechanical production equipment must do a great contribution to the sustainable development of the oilfield.

6 Conclusion

Repairing of mechanical production equipment is the important treatment to realize green oilfield, high efficiency oilfield, from the beginning period of exploitation, the repairing of mechanical production equipment is valued, through the effort for several years, it has established dozens of repairing factories with large scale, the repairing technology is improving by year, the economic benefits and society benefits is considerable. On the new period, it proposes a higher requirement to save resources and energy , comprehensive utilizing information technology, nano technology, biotechnology ,it provides a huge development space to improve the repairing technology of the mechanical production equipment , Daqing Oilfield will sufficiently utilize the present resources, hold the rare favourable circumstances of the history development, to realize the technology of repairing of the mechanical production equipments reaching a higher stage of development.

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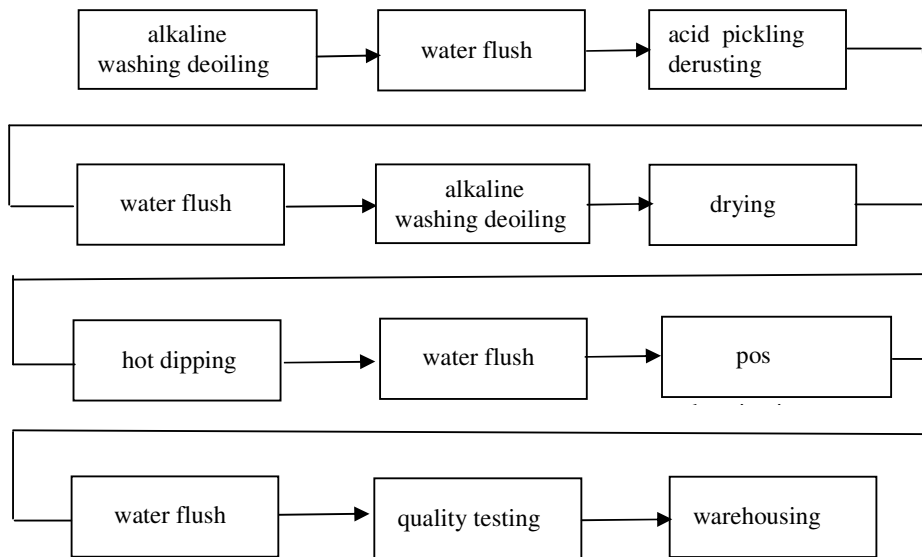


Figure 1 Technological process figure of Zn-Al rare earth alloying tubing

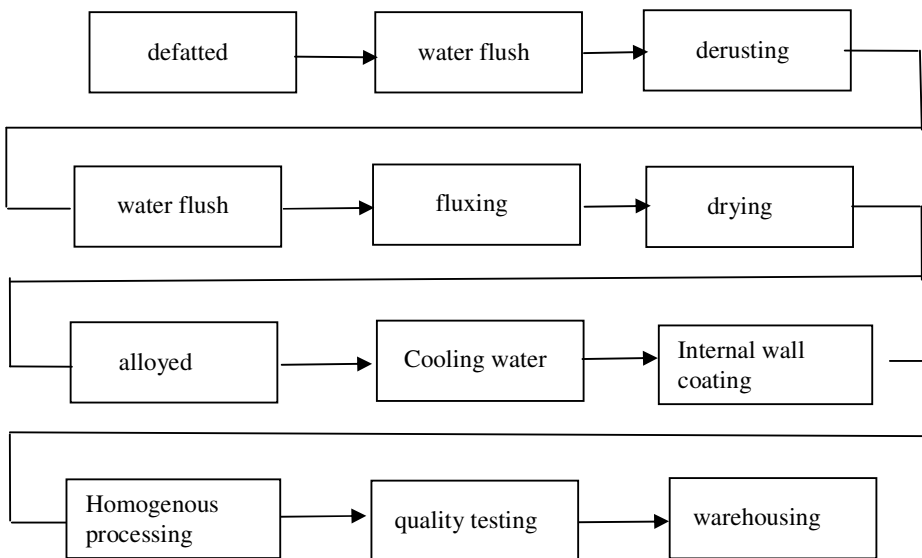


Figure2 Alloyed nanometer hot dipping technological process

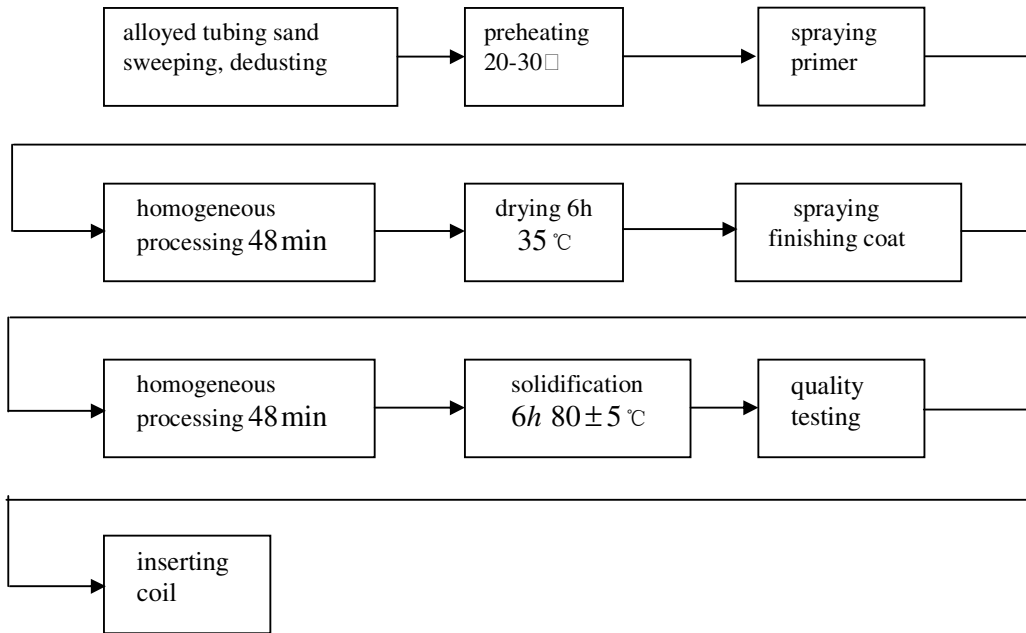


Figure 3 Technologies process of composite coating

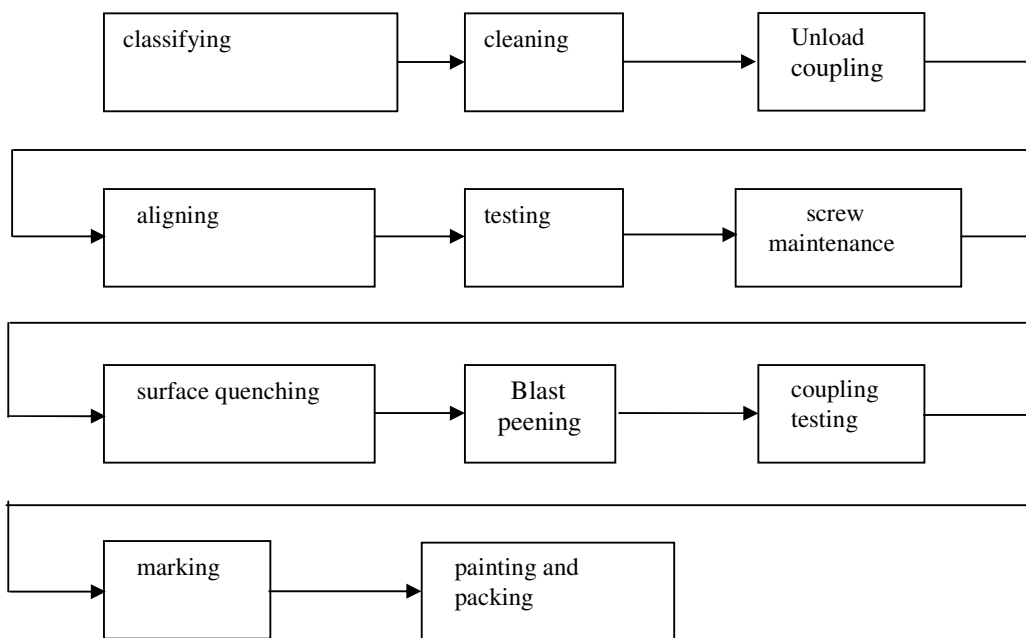


Figure 4 Technologies process of sucker rod repairing coating