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A COMPREHENSIVE STUDY ON THE RESIN COATED PROPPANT USED IN THE WELL STIMULATION TECHNIQUE

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Abstract: Fracturing is an important stimulation in hydrocarbon exploration and development. Proppant, the core material during fracturing and is the key to increasing fracturing success rate and stimulating effect.

The main function of conventional proppant is to provide and maintain conductive fractures during well production, and proppant must meet closing stress requirements and exhibit resistance to diagenesis under downhole conditions. Various proppant of different types, sizes, shapes, and uses have been developed in the oil and gas industry. Proppant, such as sand, ceramic, and resin coated proppants, are used to keep fractures open to produce hydrocarbons in hydraulic fracturing operations. A fundamental challenge for resin coated proppant lies in their overall thermochemical-mechanical stability at elevated temperatures and pressures in the presence of fracturing fluids. Our goal is how it will be implemented economically, the manufacturing process and specifications for resin-coated proppant, and so far, resin-coated materials are more suitable site for the life of the wellbore it acts as an ideal proppant in many respects and is economically justifiable compared to uncoated proppant.

I. INTRODUCTION

Today there is a continuously increasing demand for primary, secondary and tertiary recovery processes. Hydraulic fracturing (HF) is therefore known as the most important and effective method for increasing oil and gas recovery. It has made a great contribution to the oil industry.

A. HYDRAULIC FRACTURING:-

Hydraulic fracturing has been used for decades to improve oil and gas production from underground reservoirs. In other words, in this process, frac fluid is pumped at high pressure into selected sections of the well. This fluid pressure creates one or more cracks across the rock medium containing oil or gas.

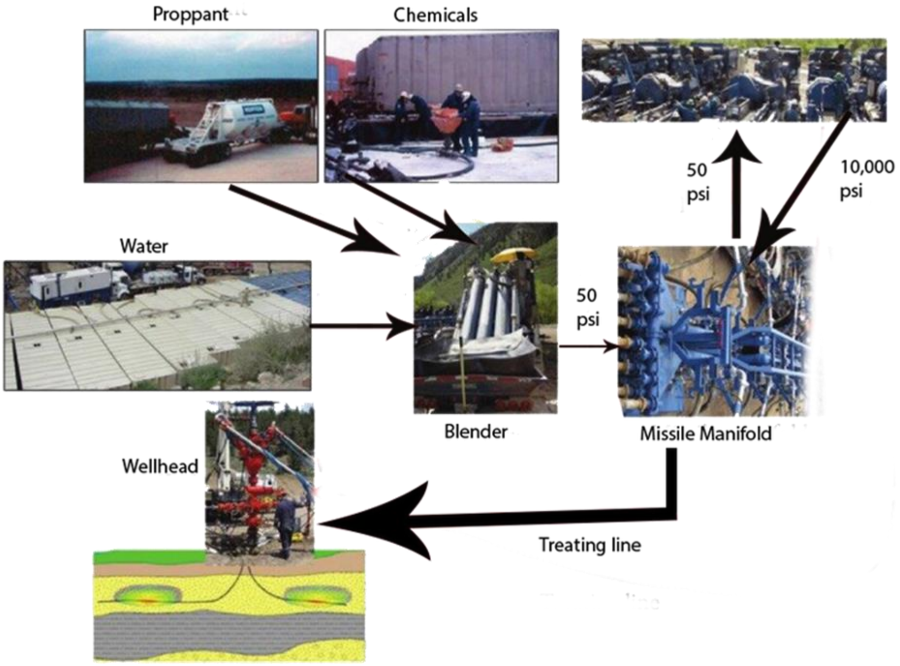

Fig1: - Treatment of proppant in hydraulic fracturing

As shown in the diagram,
All materials (water, proppant, and chemicals) used in the fracturing fluid are fed into a mixer, which mixes the materials into a slurry and is pumped into the manifold ay 50 psi supplied. The manifold that distributes the liquid slurry to high-pressure pump.
These high-pressure pumps increase the pressure of the fluid to the pressure required to frac the well (sometimes up to 20,000 psi) and return it to the manifold at high-pressure. This fluid stream is conveyed to the wellhead through a high-pressure treatment line and forced through the wellhead and wellhead ‘frack’ strings into the perforations and reservoir rock. This is how hydraulic fracturing is implemented.

B. PROPPANT:-

Proppant is a small particle used in conjunction with the fracturing fluid to hold open the fracturing created during HF processing. Proppants can be divided into two categories. Traditional & Advanced.
Traditional proppants include sand, ceramics, nut shells, and glass beads. Advanced proppant coated with a thin layer of polymer are known as resin coated proppants.

Various combinations of fracking fluid and proppant can be designed based on individual wellbore condition. The ideal proppant should be low density, resistant to breakage and corrosion, strong, and readily available at low cost. Proppants as derivatives of combinations of synthetic or natural based materials are used to keep fractures open.

The HF process consist of two main components: proppant and fracturing fluid. Proppant is the material used in HF to keep cracks open to aid extraction. The fluid used to carry the proppant to the fracture is known as the fracturing fluid. To place the proppant within the fracture is known as the fracturing fluid. To place the proppant within fracture, the proppant is suspended in a liquid and pumped into the sub surface formation. A viscous fracturing fluid is often required to prevent particles from settling before reaching the end of the fracture. The best way to control the viscosity of fracking fluids is to add synthetic or natural based polymers.

Artificial proppants should have a high potential to withstand high closing pressure that tend to deform the proppant particles. They must be able to withstand aggressive drilling fluids such as moisture, acid gases and saline solutions. Generally, the availability of the newly created fracture area is limited for production, if no proppants are placed in the fracture to keep it open.

Various types of fracturing fluid along with proppants can be used based on the various well condition and this comprehencively reflects in the below figure.

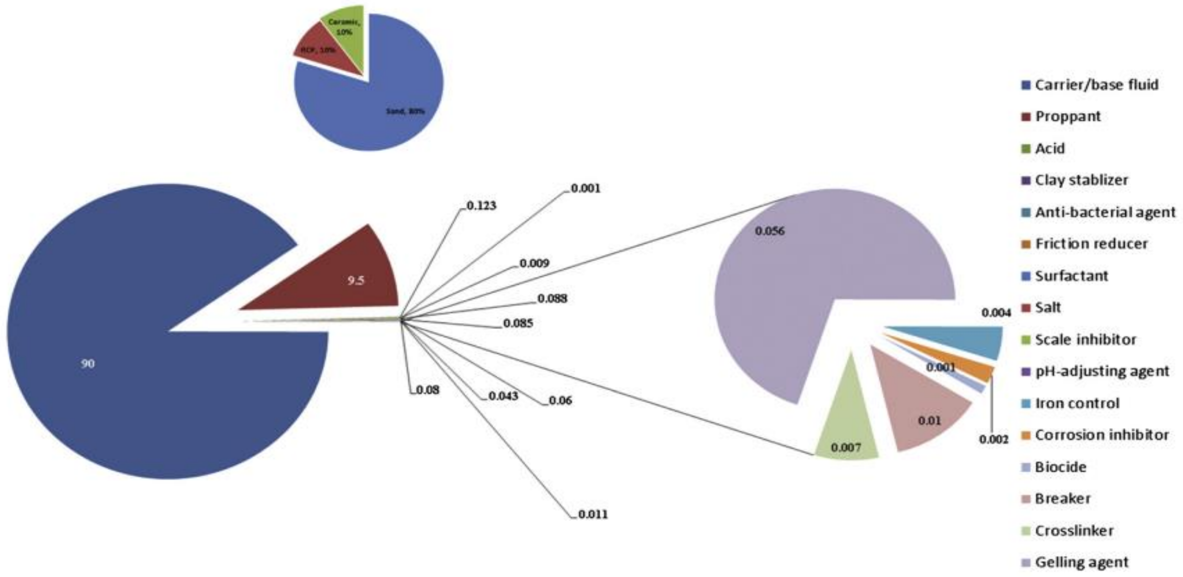

Fig2: -different proppant and their combination with fracturing fluid

C. HOW RESIN COATED PROPPANTS ARE DIFFERENT FROM OTHER TRADITIONAL PROPPANT

Firstly, we analyse, that there are three main types of proppants that are widely used by the industry in which it is explain below
Ceramic proppants: - These are manufactured using corundum, mullite, or zirconia-based materials and said to provide support functions at high boundary stresses. These are the more expensive proppants.

Fig3: -ceramic proppant

Resin coated proppant: - More costly than sand only. They can be pre-hardened (to distribute stress and reduce particulate migration) or hardened (to reduce proppant backflow).

Fig4: -Resin coated proppant

Sand: - These are extracted or quarried from natural sources such as riverbeds, flat sandstones. The usual proppants in this category are Brady, Ottawa, Jordan and Native sands (Indian). They vary from white to yellow to brown sand.

Fig5: -Sand Proppant

II. RESIN COATED PROPPANT

Coated proppant has provided many benefits to the upstream petroleum industry. Therefore, in this study, we examine the most common types of polymers used for proppant coatings, the advantages and disadvantages of polymer coatings, and their performance under various conditions. This paper also provides an overview of common proppant coating processes, the benefits of coating proppants with polymers, and proppant coating processes and methods.

Coated proppant has low density, high strength and low fracture rate and is widely used for sediment crushing and sand control. A major advantage of using resin to coat the proppant is that the resin coating can trap particle debris in the coating and prevent the proppant from flowing back into the wellbore.

Individual proppant particles can also be bonded together to prevent proppant backflow. As such, it is often used in the tail in fracturing process. RCPs can also be used to prevent sand formation in soft layers where sand control is required. The main drawback of resin coatings is that the coating materials are made of polymers and tend to have lower softening or decomposition temperatures compared to inorganic materials. The most commonly used resins for proppant coatings are epoxies, furans, polyesters, vinyl esters, and polyurethanes.

Epoxy resin is the main type of polymer used for proppant coatings, mainly because it has very good mechanical strength, excellent heat resistance and chemical resistance. Furan resin is another type of polymer used in proppant coatings. Furan is resistant to heat and water. However, furan does not provide sufficient mechanical strength. Polyurethane is another type of polymer that can be used for proppant coatings.

TYPES OF RCP

The resin coating can be uncured or cured. In general, uncured resin systems have poor mechanical properties. However, good properties are obtained by reacting the linear resin with a suitable curing agent to form a three-dimensional cross-linked thermoset structure.
This process is commonly called curing. Pre-hardened resin-coated sand is prepared by coating or "coating" silica sand with resin. No further hardening occurs in drilled holes. For proppants coated with hardening resins, after fracturing, the well is plugged and hardened. The curing process results in a consolidated proppant bed with a coating of cured resin surrounding each proppant granule. Proppant performance depends on the properties of the cured resin material.

Therefore, the comparative sand could not withstand the high closing stress. Ceramics were introduced to overcome this problem, but their use is now limited due to their high specific gravity. As a result, proppant settling occurred before the end of fracture was reached. The use of glass beads as another type of conventional proppant has been limited due to high energy and production costs. In addition, its application was limited to certain depths due to its low resistance to high fastener loads. The nut shell is deformable under high closing stresses and fracture seals occur as the closing pressure increases. Problems arising from the use of conventional proppants have led us to look at the use of polymers to improve proppant quality. Therefore, to improve the ability of conventional proppants to withstand high closing stresses, polymers are added to (1) prevent backflow, (2) make the formation cleaner, and (3) prevent proppant settling.

A coated proppant consists of a substrate (that is, proppant) and one or two polymer layers. The part of the particle that is coated with polymer is called the substrate. Sand, glass beads, ceramics, carbon particles, bauxite, crushed nut shells, and other natural fibers have proven suitable for use as substrates for polymer coatings. Coating lignocellulosic materials with suitable polymers yields proppants with low specific gravity, high strength and low settling velocity, known as lightweight and ultralight proppants. Modification of the surface properties of substrates is accomplished by polymer coatings to achieve beneficial effects such as changes in surface topography, wettability, and chemical reactivity. The attachment of polymers to particles, which can be physical in nature, can be achieved through chemical bonds formed between the substrate and polymer components. Chemical bonds are usually covalent, ionic, or both. Note that during polymer-substrate interaction, some components of the polymer coating may diffuse, penetrate, or impregnate the particles, resulting in physical or chemical bonding, or both.

For Coating substrates requires studying the surface's ability to repel or absorb water. However, different types of proppants do not have the same tendency to repel or absorb water. The surfaces of sand, glass beads and ceramics are hydrophilic. This means that it easily absorbs water. As a result, there is a need for hydrophobic polymers whose surfaces can be hydrophobically modified. Among conventional proppants, nut shells generally have hydrophobic-hydrophilic surfaces. Coating nut shells requires the use of hydrophobic polymers.

Table1. Comprehensive information about various types of proppant

Proppant	Conventional Sand	Low density	Ceramic Intermediate density	High density	Nut shells	Glass beads	Resin coated sand	Advanced ultra-low weight	Low weight
Specific gravity	2.5-2.65	1.75	2.7-3.3	3.4-3.75	1-1.35	2.65	2.55	1.25-1.75	1.6-2.1
Bulk density	1.49-1.55	1.65	1.84	1.91	0.85-1.04	1.55	1.65-1.75	0.86-1.15	0.95-1.3
Closure pressure(psi)	2500-6000	5000-8000	5000-10000	>10000	2500-5000	3000-5000	6000-10000	5000-8000	7000-10000
Price	Low	High	-	-	Low	High	High	High	High
Eco-friendly	No	No	-	-	Yes	No	No	No	No
Renewable	No	No	-	-	Yes	No	No	No	No
Settling velocity	Low	High	-	-	Low	High	High	Low	Low
Strength	Low	High	-	-	Low	Low	Appropriate	Appropriate	Appropriate
Advantages	Inexpensive	High strength, capable with high closure pressure	-	-	Low density, inexpensive	-	High strength	Low weight, high strength	Low weight, high strength
Disadvantages	Lower flow capability, brittle	Expensive, high density	-	-	Low strength, brittle	Low strength, brittle	Expensive, not eco-friendly	Expensive, not eco-friendly	Expensive, not eco-friendly

III. MANUFACTURING PROCESS OF RESIN COATED PROPPANTS

Process 1

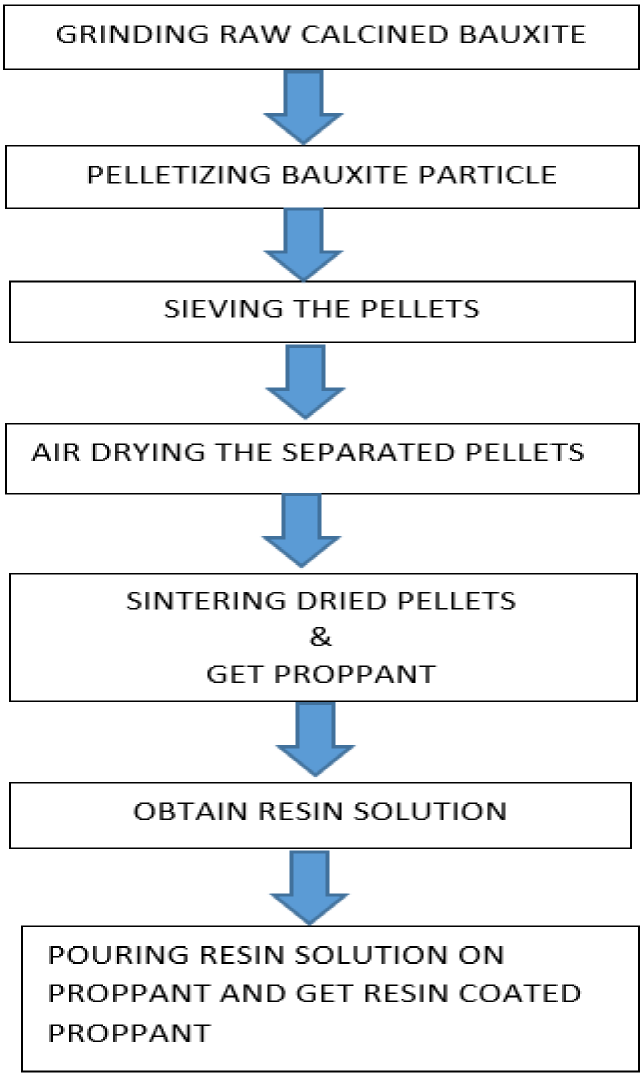

Fig6: - RCP manufacturing process

Process Description

1. Grind coarsely calcined bauxite to obtain ground bauxite particles having a particle size range of 50-100 microns.
2. Pelletizing the crushed bauxite particle obtained ground bauxite particles having a particles and rotating the machine for 5-15 minutes to obtain pellets.
3. Screen the pellets obtained in step (2) to separate pellets ranging in size from 425 to 850 microns.
4. Air-dry the separated pellets obtained in step (3) for 24-36 hours to obtain dry pellets.
5. Sintering the dried pellets obtained in step (4) at a temperature of 1350-1450° C. for 30-35 minutes to obtain proppant.
6. Dissolving 5 to 10% of a phenol-m-cresol-formaldehyde resin in a solvent to obtain a resin solution.
7. Stir the resin solution in step (6) into the proppant obtained in step (5) in a ratio ranging from 1:40 to 1:60 (w/w) for 30 to 35 hours. Pour while it is dried by heating at 40 to 50°C. for 1 minute and then dried by heating at 60 to 100°C. to obtain a resin coated proppant.

Process- 2

Ceramic proppant is an artificial proppant based on bauxite and kaolin. Ceramic proppant has a high anti-fracture rate and excellent thermal /chemical stability. However, ceramic manufacturing process, and high cost, which limit their widespread use. Compared to ceramic proppants, resin-coated proppants have a lower density and are easier to distribute to superior and distal fractures. At same time, resin-coated proppants are stronger due to their higher roundness and can provide higher stack densities for improved package strength. A small amount of resin-coated proppant is mixed with regular proppant during the hydraulic fracturing process. This increases oil and gas production efficiency, reduces the use of conventional proppant, and reduces proppant costs.

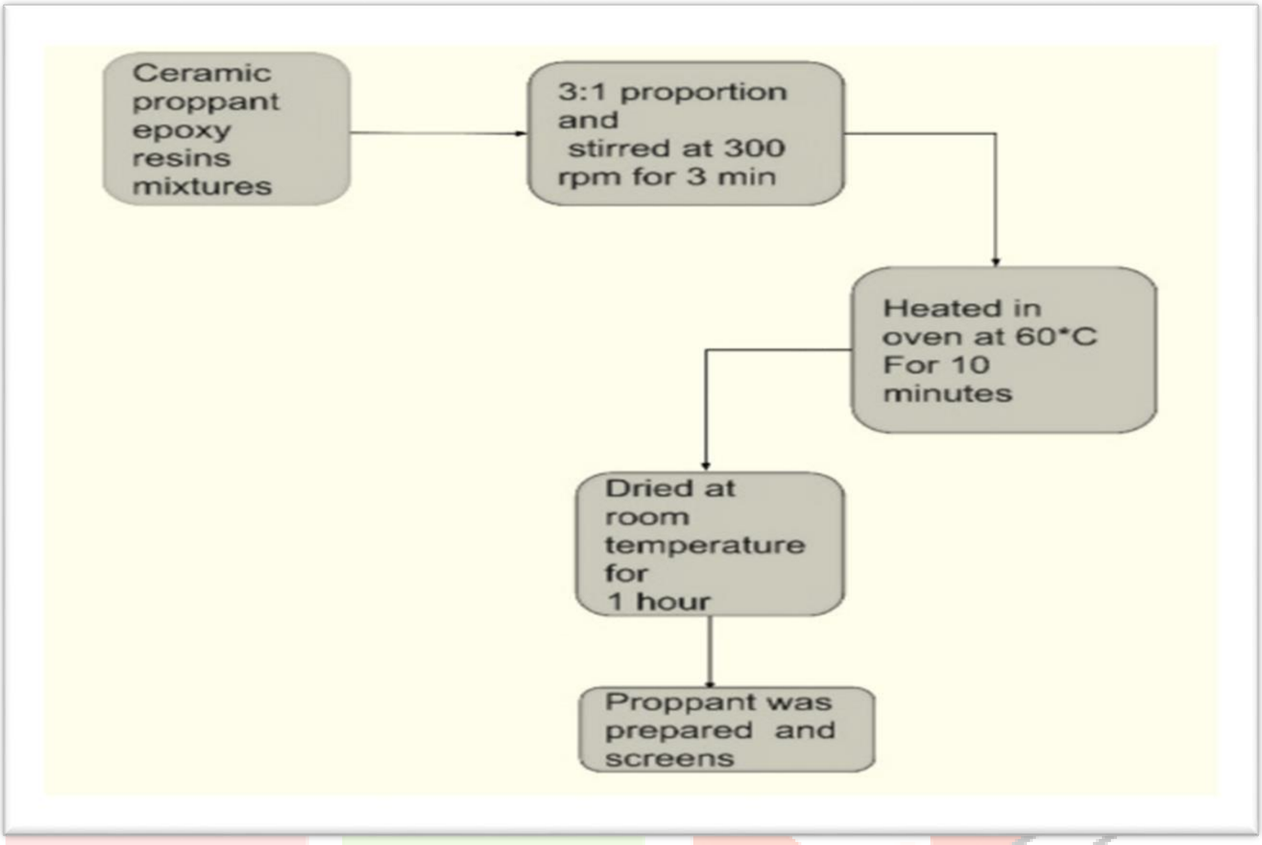

Fig7: - RCP manufacturing process

Process description

Step1. Experimental materials mainly include ceramic proppant (40/60 mesh), guar gum, epoxy resin E51, hardener T31 and absolute ethanol.

Step2. Ceramic proppant was added to the prepared epoxy resin liquid in a fixed ratio (epoxy resin e51: hardener=3:1) and stirred at 300 rpm for 3 minutes. Next, slate was added to the mixture at a constant mass ratio (shaly detritus: epoxy resin e51=3:7).

Step3. Mixture was heated in an oven at 60° C for 10 minutes.

Step4. After heating, the mixture was taken out and dried at room temperature for 1 hour.

Step5. Finally, the cooled blocks of proppant were ground and sieved.

IV. CONCLUSION

- Sand and ceramic proppant are two basic types of proppants. Modified proppants include resin-coated proppants and lightweight proppants. Proppant selection, including proppant type, size and shape, is a very important factor in stimulation design.
- Unconventional resources require proppants that are lightweight, strong, uniform in size, chemically inert and inexpensive.
- Resin-coated proppant offers several advantages over uncoated proppant. They can be used like regular proppants without altering the fracturing procedure and are the ideal for strength, ductility, chemical inertness, low specific gravity, availability, resistance to backflow and formation of beds in wellbore characteristics.
- Using the information presented, it is possible to select the optimal RCP material for a given set of wellbore conditions and tune controllable parameters during post-fracturing production to achieve both initial and long-term proppant flowback, can be minimized.

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