THE SUCCESSFUL USE OF INTERNALLY PLASTIC COATED TUBING IN ARTIFICIAL LIFT APPLICATIONS

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ABSTRACT

The reliability of tubing and sucker rods is critical to the successful long-term production of a well. Corrosion, erosion-corrosion and mechanical wear can significantly reduce the life of tubing and sucker rods.

Historically there have been concerns regarding the coatings ability to protect against wear from mechanical interventions involving the use of wireline and coiled tubing and artificial lift involving the use of sucker rods and plungers. Internal Plastic Coating (IPC) technology has evolved over the past 60 years and recent advancements in materials have significantly increased the abrasion resistance of the coatings for Oil Country Tubular Goods (OCTG).

This paper will discuss the recent advancements in technology and include field case histories where the use of abrasion resistant coatings have been successfully utilized in artificial lift applications, including rod pumping wells and plunger lift wells.

INTRODUCTION

High costs associated with tubing and sucker rod replacement include workover costs, replacement costs and lost production which can become significant for artificial lift applications in highly corrosive environments. The reliability of the tubing and sucker rods in an artificial lift production well can be greatly enhanced with an effective tubular and sucker rod integrity program. These programs can include: inspection services to verify the quality of the material, proper care and handling practices during transportation, storage and running operations, appropriate well design and optimization practices, and proper selection of corrosion control methods.

An important concern with corrosion in artificial lift applications, such as rod pumping and plunger lift, is the synergistic effects of erosion-corrosion. Erosion-corrosion is defined as acceleration in the rate of corrosion attack in metal due to the relative motion of a corrosive fluid and a metal surface. This acceleration can be exacerbated by the additional mechanical interaction associated with artificial lift applications. Erosion-corrosion can create significant metal loss within a short period of time due to the mechanical wear exposing fresh metal which is more susceptible to the effects of the corrosive fluids.

The high level of mechanical interaction from sucker rods and plungers can create concerns regarding the use of IPC tubing as a viable corrosion control solution in artificial lift applications. Historic IPC materials were not developed with intention of use in artificial lift applications. That mindset is changing with recent field successes of newly developed abrasion resistant coatings.

ROD PUMPING APPLICATIONS

Rod wear interactions between sucker rods and tubing can be detrimental to the integrity of both the tubing as well as to the sucker rods themselves. Recent advancements in abrasion resistant IPC technology has allowed the coating to become a viable corrosion control option to consider for tubing and rod life extension in corrosive environments. Historically, nylon based IPCs had limited success in rod pumping applications due in part to the extreme flexibility and natural lubricity from the nylon resin. In spite of their success there is a need for even more abrasion resistant materials.

In addition to the tubing losses due to corrosion, erosion-corrosion, and mechanical wear in rod pumping applications, the sucker rod string is susceptible to the same losses as it is exposed to the identical elements. Spray Metal Plastic Coated (SPMPC) sucker rods (Figure 1) have proven to provide life extension in sucker rods for severe service applications including highly deviated, high side-load, heavy solid and even sour service wells in certain applications. The spray metal material utilized is a 316 stainless steel that is applied 1 ½ - 2 mils (0.0015-0.002 in.) thick. Like other thermal spray materials, this type of application is known to produce a porous structure that can potentially provide pathways for corrosive fluids. The use of a 10 – 20 mil thick (0.001-0.002 in.) thermoset epoxy topcoat, applied over the spray metal, provides the most robust system by eliminating any potential corrosion pathways.

The use of rod guides can significantly assist in reducing rod and tubing wear in many applications where high deviations and high side-loads are experienced. Rod guides can also be beneficial along with the use of IPC tubing and SPMPC sucker rods by centralizing the rod string and reducing the contact area. Historically non-glass filled rod guide material were recommended to be used in the nylon based IPC tubing. Newly developed abrasion resistant epoxy coatings now allow for the standard glass-filled rod guide material to be used which can greatly increase the guide life.

Blast joints are commonly used in West Texas rod pumping wells to protect the tubing string from the abrasive blasting action from the discharge just above the downhole pump. The practice of internally coating these blast joints have proven to extend the life of this vulnerable area and the use of IPC tubing is present in a significant number of wells in the Permian Basin. The IPC helps to reduce the erosion-corrosion which can occur from pump movement/vibration, recirculating solids or high fluid velocities which proves difficult for effective chemical corrosion inhibitor treatments. The latest abrasion resistant coatings have proven to be effective in extending the life of the blast joints, thus reducing workover and lost production costs.

PLUNGER LIFT APPLICATIONS

The use of plunger lifts as an economical artificial lift method can present a challenge in regards to corrosion treatment methods. The continuous mechanical interaction between the plunger and the metal surface can be difficult for an effective chemical inhibitor program in certain applications. IPCs eliminate the concern of continuously replenishing the passive film formed by the chemical inhibitors. The use of IPC tubulars in plunger lift applications is becoming more common with the introduction of more abrasion resistance IPC materials.

There are many configurations of plungers which will provide a variety of wear interactions with potential IPC tubing use. Typically parameters of the well dictate which configuration of plunger is best suited for each individual application. When IPC tubing is considered proper plunger selection should also be considered in regards to compatibility with the IPC. Non-metallic brush style plungers are the preferred configuration eliminating any metal to coating contact during plunger cycles. A variety of padded, brush, solid and two-part (ball and cylinder) are currently being utilized in trial wells with no reported issues to date (Figure 2). The use of plungers with paraffin/scale scraper sections should be avoided (Figure 3).

ADVANCEMENTS IN TECHNOLOGY

Over the past ten years there have been advancements in IPC technology which are making the coating material more robust through proprietary advancements in filler material packages as well as increased resin abrasion resistance properties. There are many characteristics that must be balanced in the design of abrasion resistant coatings. For instance, it is also important to retain a high level of flexibility in coating systems designed for artificial lift applications in order to provide a more robust corrosion control solution. Having flexibility gives a coating more resistance to impact during handling as well as potential mechanical interactions in service, such as rod slap from cyclical tension/compression of a sucker rod string or impact from a plunger to the pin nose of an API eight round connection.

There are several laboratory tests used to determine the abrasion resistance of polymeric coating systems. For the purpose of this paper we will focus on the test ASTM D 4060 "Standard Test Method for Abrasion Resistance of Organic Coatings by Taber Abraser"[1] (Figure 4). This test uses a flat coated panel rotating under CS-17 abrasive wheels, with a 1 kilogram load for between 5000 to 10,000 cycles. The recorded data is the weight (mg) and thickness (mil) of coating material lost for every 1,000 cycles. Per the Tabor Abraser results listed (Table 1), the advancements in the abrasion resistance of the modified epoxy based system (0.02 mils lost) over the epoxy based system (0.70 mils lost) results in a coating system thirty-five times more abrasion resistant.

Previous advancements in abrasion resistant IPC materials using Tabor Abraser values have had proven field success. Since 1999, abrasion resistant IPC material applied to drill pipe have been used in aggressive completion operations demonstrating notable resiliency against high velocity, high pressure proppant. These types of successes are documented in SPE 77687 "Case History: Internally Coated Completion Workstring Successes"[2].

More recent advancements in abrasion resistant IPC materials have more than doubled the life of tubing in several artificial lift applications including rod pumping wells and plunger lift wells (Table 2).

FIELD PERFORMANCE

Case History #1

A major operator in Eastern Mississippi was having difficulty with short tubing life in a highly deviated rod pumping well. Bare J-55 tubing, historically would develop leaks in 3 to 4 months of production. A new abrasion resistant epoxy IPC product was installed in 2009 and allowed the well to produce for 27 months. During this time, the rod string had to be pulled 10 times and the tubing string was pulled and re-run twice for pump changes. Each time the tubing was evaluated, it showed little to no sign of abrasive wear and no sign of corrosion on the ID of the tubing. This customer is currently standardizing on this material for future rod pumping applications in this and other fields.

Case History #2

An operator in California was experiencing substantial erosion-corrosion issues on their newly drilled production wells which were producing heavy formation sands and residual proppant returns. Life expectancy of the bare tubing was 3-6 months due to the high erosion-corrosion experienced during the initial flow back of the well with high solids and deviations in the wellbores. It was decided to compare coated tubing with uncoated tubing. These wells are on rod pump and due to the extreme side loads expected they utilized Amodel Filled (AF) 7" rod guides. After 24 months of production all of the coated wells are reported to be operating successfully and to date there have been approximately 16 reported tubing failures on the bare strings installed during the same time frame.

Case History #3

An operator in Pecos County, TX was experiencing only 4-10 months of life on bare rods in their pumping wells due to the synergistic effects of corrosive fluids and heavy rod wear. In 2005 a program was re-introduced in the field using SPMPC rods and these wells now experience an average of 3 years life, greatly reducing workover costs and lost production. In addition to the use of SPMPC on the rods, they also began utilizing 3 guides per rod and slowed down the pumping rates to a 100" maximum stroke length and a maximum of 11 strokes per minute.

To date the customer is continuing to use 1" KD Class C sucker rods with SPMPC. Care and handling practices were emphasized with the running crews which have also contributed to the success of this sucker rod and tubing coating program.

Case History #4

A major operator in Northeast Colorado was experiencing corrosion issues on their plunger lift wells due to the mechanical wear leading to ineffective chemical treatment of the tubing. Bare tubing life expectancy was between 6-18 months. With the company's historic success with internal plastic coated tubing, they decided to trial two wells with a basic epoxy coating. The coated tubing was installed in 2005 and a two-piece ball-and-cylinder (Figure 4) was utilized. The two wells have been operating without issue to date.

Case History #5

A major operator in Crane County, TX was experiencing both tubing and rod string failures in less than three months of production associated with severe pitting and rod wear. As a part of the initial trial program which began back in 1989, 12 wells, which typically had high failure rate problems, were selected for the IPC tubing and SPMPC sucker rod program. Several of the wells had their corrosion inhibitor treating rates reduces by 30% and all of the SPMPC rod strings employed spray metal couplings. At the end of a two year trial period the rod failures were greatly decreased, previously averaging 2.3 rod failures per year and now experiencing 0.6 rod failures per year. The significant decrease in the percentage of rod body failures substantiates that the SPMPC is effectively protecting the rods and the cost for the SPMPC services is paid out in approximately one year, based on failure reductions in these high failure rate problem wells. Installation of internally coated tubing and SPMPC rods reduced the tubing leak failures and rod parts and has become a long running standard practice in this field.

CONCLUSION

Continuous advancements in IPC abrasion resistance technology are providing reliable solutions for life extension of tubing and sucker rods in artificial lift applications. Recent advancements have developed internal plastic coatings that are 35 times more abrasion resistant than coating materials of the past. Over the past couple of years, several ongoing field trials in artificial lift applications have produced successful results validating the improved abrasion resistance of IPC materials.

The successful use of internally plastic coated tubing in artificial lift applications is dependent upon selection of the appropriate IPC material based on the well conditions, chemical treatments and expected intervention operations. Also as important are the proper care, handling and installation of IPC tubing[3] and SPMPC sucker rods to ensure the integrity of the corrosion control system.

ACKNOWLEDGEMENTS

The author would like to thank NOV Tuboscope for permission to present and publish this paper.

REFERENCES

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2. Pourciau, Robert D. “Case History: Internally Coated Completion Workstring Successes”, SPE 77687, SPE Annual Technical Conference, 2002.
3. NACE Standard RP0291-96, “Care, Handling and Installation of Internally Plastic-Coated Oilfield Tubular Goods and Accessories,” NACE International, Houston, TX, 1996, www.nace.org.

TABLES

Table 1 - Laboratory Results for Coating Mechanical Properties

Coating System	Tabor Abraser Test Values	
	mg lost /1000 cycles	mils lost/1000 cycle
Epoxy	53	0.7
Epoxy Phenolic	67	0.6
Modified Epoxy Phenolic	9	0.18
Phenolic Novolac	7	0.06
Modified Epoxy	3.6	0.02
Modified Novolac	1.4	0.01

Table 2 – Case History Well Parameters

Case History	Tubing	BHT (^oF)	BHP (psi)	CO_2 (%)	H_2S (%)	Well Depth (ft)	Install Date	Pulled Date
#1	2 7/8", 6.50#, J-55, EUE, 8rd	120	1,000	4	0	5,600	November 2009	February 2012
#2	2 3/8", 4.70#, J-55, EUE, 8rd	130	900	20	1	2,400	2010	TBD
#3	2 7/8", 6.50#, J-55, EUE, 8rd	145	1,100	5	1	1,800	2009	TBD
#4	2 3/8", 4.70#, J-55, EUE, 8rd	209	5,836	0.3	0	14,525	2005	TBD
#5	2 7/8", 6.50#, J-55, EUE, 8rd	85	850	20	12	3,018	1989	1992

Figure 1 – Plastic Coated and Spray Metal Sucker Rods

Figure 2 – Examples of the padded, brush and solid and two part plunger configurations

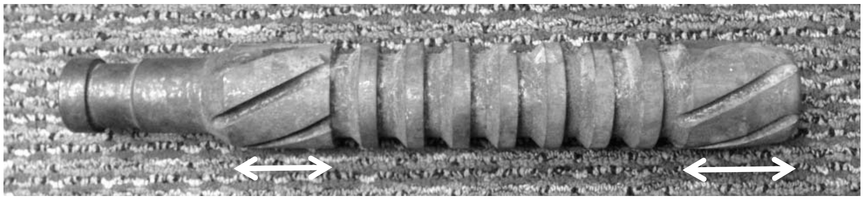

Figure 3 – Solid plunger with scraper sections highlighted in red

Figure 4 – Example Tabor Abraser Device