METAL FILM-COATED STUFFING BOX PACKING

Larry Angelo
J. M. Huber Corporation
Flow Control Division

Introduction.

Stuffing boxes on beam pumped wells have always required a high level of maintenance even though operators and manufacturers have constantly searched for ways to improve their performance. Essentially no documented research has been developed on which to base performance enhancing designs.

It is the purpose of this paper to offer two new concepts which could benefit stuffing box performance. Steel and rubber are known to be among the worst combinations of materials for applications where a low coefficient of friction is important. Therefore, the first concept is the introduction of a new friction reducing process which improves compatibility of steel polished rods and rubber packing.

The second concept is the introduction of laboratory test equipment which can be used to objectively shed new light on stuffing box designs. Because the coefficient of friction between rubber packing and the polished rod is one of many design variables that is important, the test equipment was used to measure this frictional effect as the starting point of a research project to improve stuffing boxes overall.

The information presented in this paper is only a start. It's not absolutely conclusive regarding the merits of either the new stuffing box packing or the laboratory equipment. But the results are exciting and suggest significant improvements to stuffing box performance may be in the offing.

Magion Process.

A new technology known as the Magion process has been developed by White Engineering Corporation in Dallas, Texas, to apply anti-friction metal coatings to stuffing box packing. The Magion process is the result of new high-tech improvements to old vacuum plating technology. The process involves a metal which is evaporated in a vacuum and ionized in a combined RF and DC field. The metal ions are accelerated across the field with an energy level high enough to penetrate the molecular lattice of a target substrate. The substrate may be a conducting material or a non-conducting material. Different metals may be used in the process to achieve the desired properties of the substrate.

When applied to rubber stuffing box packing, the Magion process produces several desirable characteristics. First, it produces a dry metal film that reduces the coefficient of friction between the packing and polished rod. Secondly, the metal penetrates and infuses below the surface of the rubber and forms a mechanical bond. The metal layer, which is measured in angstroms (1 angstrom = 10^{-8} cm), is mechanically locked in place. As a result, the metal becomes more than just a coating and is difficult to dislodge by abrasion. A third characteristic is the tendency of the metal coating to attract oil and repel water. Consequently, lubrication is enhanced and polished rod corrosion and scaling is reduced. Finally, the process retards thermal breakdown of the rubber compound--a feature that can increase packing life at higher operating temperatures.

Details of the Magion metal coating process can be found in several technical papers by White Engineering Corporation (Ref. 1, 2 and 3).

Arco Field Tests.

Arco pioneered field tests for Magion stuffing box packing. Between mid-1992 and early 1993, Arco tested 100 sets of this new metal coated packing in their heavy oil operations in California. The predominant style of stuffing box was the Huber Double Pack with cone style packing.

The Magion packing was peroxide cured nitrile rubber with a durometer in the range of 70. It was tested relative to Huber's Compound "C" which is a sulphur cured nitrile rubber with a slightly higher durometer.

A summary of the 16 wells included in the Arco test program is shown in Figure 1. The wells were divided into two groups. Ten wells had stuffing box temperatures below 200^{O} F and six had temperatures above 200^{O} F. All wells ran 24 hours per day.

The average life of Magion packing in the lower temperature group was 73 days as compared to 86 days for Compound "C" packing. The Magion packing did not last as long but periodic maintenance to tighten the stuffing box was less. Compound "C" packing had to be serviced on a more frequent basis to control leaks. This difference was subjective but obvious.

In the six wells with temperatures over 200^{O} F, Magion outlasted the Compound "C" packing by an average of 71 days. Magion ran for 119 days as compared to 48 days for the uncoated packing.

The average life of Huber's uncoated Compound "C" packing decreased from 86 days to 48 days as temperature increased. As a rule, life expectancy of any rubber packing decreases as temperature increases. The Magion packing, however, improved from 73 days to 119 days which is counter to usual performance.

Results of the Arco test suggest that Magion packing extended packing life at temperatures above 200^{O} F. Results also indicate the Magion packing had to be serviced on a less frequent basis than the uncoated packing for all temperatures encountered during the test.

Huber Field Tests.

In mid-1993, Huber's Flow Control Division obtained a license from White Engineering Corporation to market Magion packing. Huber applied the process to their existing Compound "C" packing and initiated a field testing program near Kilgore in East Texas. The metal coated version of Compound "C" will be referred to as "Magion C" in the following discussioin.

Huber initiated tests of "Magion C" in a field operated by a major oil company where wells produce large volumes of gas and water. In an attempt to reduce the volume of produced water, the downhole pumps had been set at or slightly below the working fluid levels in the wells. This operation is designed to "skim" the oil from a reservoir with a very active water drive. As a result, the stuffing boxes receive little lubrication from produced fluids and run dry during significant portions of the pumping cycles. The polished rods and packing consistently operate at higher friction-induced temperatures which result in loud squeaking noises emanating from the stuffing boxes.

In this case, noise pollution was a major irritant for nearby residents. Packing failure was not as much of a problem as was the loud squeaking noises originating from the hot, non-lubricated polished rods and stuffing box packing.

Huber personnel had been working with the operator to solve this noise problem before "Magion C" was available. Several different packing compounds had been tried with limited success. Only 2-7 days of noise-free operation could be achieved at best.

In early December of last year, one well was packed with "Magion C". At the time this paper was submitted for publication, "Magion C" had eliminated noise for 30 days.

This short field test is not enough to reach any final conclusions, but the results are encouraging. Like the Arco test in California, the Magion packing seems to have improved operations at higher operating temperatures.

Laboratory Test Equipment.

Field tests and cost/benefit analysis will ultimately be the acid test of Magion packing. But field tests alone have limitations. For example, it's very difficult to measure the coefficient of friction (drag) and leak rates originating between the polished rod and stuffing box in the field.

Huber designed and built special test equipment (Figure 2) that could be operated under controlled laboratory conditions to supplement data collected in the field. This research equipment is capable of measuring polished rod drag, leak rates and stuffing box temperatures under simulated well conditions. Because the equipment was designed as a research vehicle to test stuffing boxes, polished rods and packing in general, it was well suited to test "Magion C" packing.

As shown in Figure 2, a prime mover consisting of an electric motor, gear reducer and bell crank is used to generate linear motion. The linear motion is transmitted to a polished rod which is reciprocated through a Huber inverted cone stuffing box. The stuffing box is attached to a sealed reservoir with a constant pressure gas cap to simulate wellhead pressure.

The fluid reservoir is equipped with internal cooling coils and external heating bands to control the temperature of the reservoir fluid. Stuffing box temperature is measured with a thermocouple installed in the side of the stuffing box.

The stuffing box has a detection system to measure gas that leaks through the stuffing box packing. The system consists of a top seal and two elastomeric boot seals to insure no gas escapes to the atmosphere. These seals capture any leaking gas in a water trap. The gas displaces the water into a graduated cylinder which can be read directly to determine leak rates.

A bi-directional load cell installed between the prime mover and the polished rod is used to measure polished rod drag on the upstroke and downstroke. Drag is recorded on a single pen strip chart recorder.

Laboratory Test Conditions.

Two tests were conducted, one on "Magion C" packing and one on uncoated conventional packing. The conventional packing was a nitrile rubber typical of compounds used in the industry for stuffing box packing. Reservoir pressure, stroke length and reciprocating speed were the same for both tests. Each test was conducted using a 1-1/4" diameter "spray-metal" polished rod. Stroke length was 14 inches and reciprocating speed was 20 strokes/minute . Each set of packing was compressed just tight enough to establish a seal on the nitrogen gas cap which was controlled at a constant pressure of 50 psi. Initial seals were achieved by rotating the stuffing box packing nut 9-1/4 turns and 9-1/2 turns on the "Magion C" and conventional packing, respectively. Each test was conducted using fresh water in the reservoir with a 1 inch nitrogen gas cap. This test condition simulated severe service because it provided little fluid lubrication to the packing.

Laboratory Test Results.

Results of the "Magion C" tests are shown in Figure 3 and results of the conventional packing tests are shown in Figure 4. Both are displayed as strip chart recordings of polished rod drag *vs.* time. Polished rod drag on the upstroke is shown as positive drag. Drag on the downstroke is negative drag. The strip chart "zero" point was biased to offset the weight of the polished rod.

Pressure acting on the lower end of the polished rod produces an upward force. The effect of this force was eliminated by averaging drag on the up and down strokes in order to simplify interpretation of the data.

The most striking result is that the "Magion C" packing ran 114 hours before failing as compared to 10 hours for the uncoated conventional packing. Failure was that point in time where the packing began to leak.

One key observation involved the amount of polished rod drag in each test. The "Magion C" ran 17 times longer than conventional packing before drag began to increase. During the first 50 hours of the "Magion C" test, the drag was approximately constant at about 250 pounds. Beyond the first 50 hours, the drag increased slowly. Drag during the conventional packing test was also essentially constant at 300 pounds, but only during the first 3 hours of the test. After 3 hours, the drag increased rapidly.

The end points in both tests had similar distinctive signatures on the recording charts. In each test, failure occurred a few hours after the signature began. In the "Magion C" test, the drag increased above 1000 pounds during a 4 hour signature period prior to failure. The conventional packing drag reached magnitudes on the order of 1600 pounds for 5 hours before failure.

In both tests, the rise in temperature correlated with the increase in drag as was expected.

Conclusions.

Results of this research effort are encouraging. Field test data indicates the Magion process will extend packing life at higher operating temperatures and improve packing performance in dry operating conditions. Also, servicing requirements are reduced relative to conventional packing. The extended run times for Magion packing in the laboratory support field test results. In addition, it was demonstrated that the new laboratory test equipment will undoubtedly become a primary vehicle for future stuffing box research.

ACKNOWLEDGMENTS

The author wishes to thank Milton Hoff of Huber Flow Control for his critical review of the paper and Randall Ray, Dean Smith, Ed Reel and Mike Smith, also of Huber Flow Control, for their assistance in designing, building and operating the test apparatus. A special thanks is also extended to John Patterson of Arco Exploration and Production Technology Company for providing field test data, guidance on selection of test parameters and review of the paper. Appreciation is also extended to Gerald White of White Engineering Corporation for making the Magion process and packing available to Huber and for guidance in the discussions on the Magion process.

REFERENCES

1. White, G. W.: "Eliminating Galling of High-Alloy Tubular Threads by High Energy Ion Deposition Process", SPE 12209 presented at annual meeting, San Francisco, 1984.

2. White, G. W.: "Metal Lubricant Films Prevent Galling of Tubular Connections", Oil and Gas European Magazine, 1986.

3. White, G. W.: Technical Memorandum on Magion plating process.

WELL NUMBER	STROKE LENGTH inches	SPM	BBLS WATER	BBLS OIL	WELL TEMP deg F	MAGION RUN TIME days	HUBER RUN TIME days
1	100	10.5	50	175	190	92	85
2	86	9	65	117	198	99	94
3	100	10.5	631	48	168	74	120
4	64	8.5	26	32	144	29	43
5	86	9	83	49	162	85	> 90
6	86	10	222	30	192	57	42
7	86	9.5	91	91	176	108	> 119
8	42	8.5	3	4	77	66	> 90
9	86	9	72	17	163	49	64
10	42	9	22	27	123	73	> 111
		AVERAGE RUN TIME FOR WELLS < 200 F				73	86
11	100	11	131	223	204	161	54
12	100	10.5	160	145	233	134	43
13	100	10.5	165	245	213	116	32
14	86	9.5	135	195	244	93	46
15	86	10	99	99	209	123	91
16	64	12	143	102	211	89	21
		AVERAGE RUN TIME FOR WELLS > 200 F				119	48

Figure 1 - Arco test data
Magion coated packing

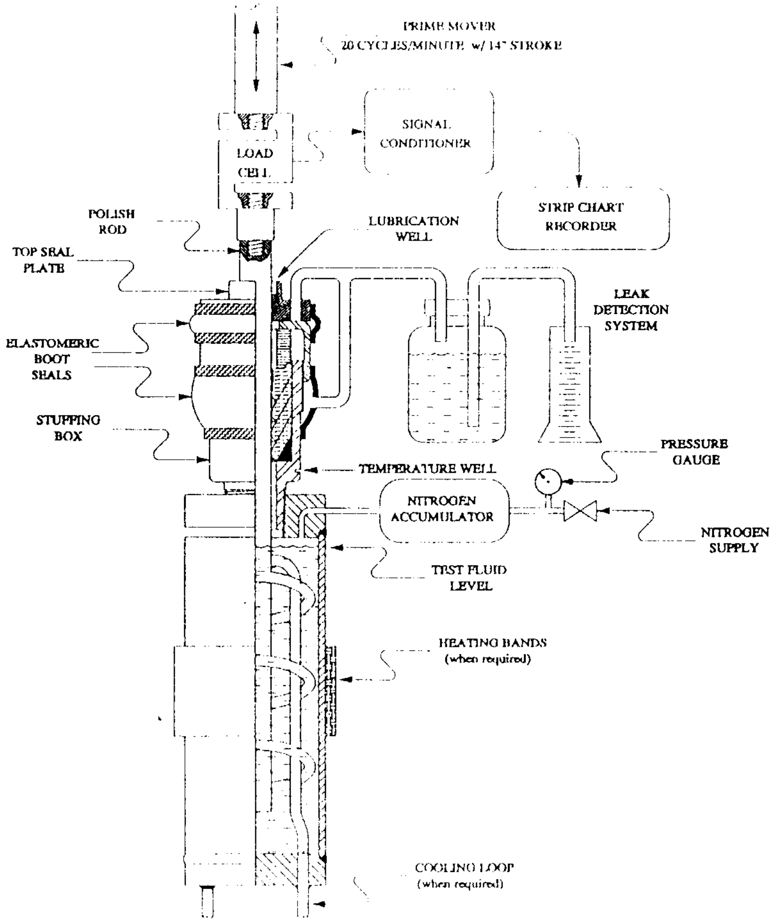

Figure 2 - Test apparatus

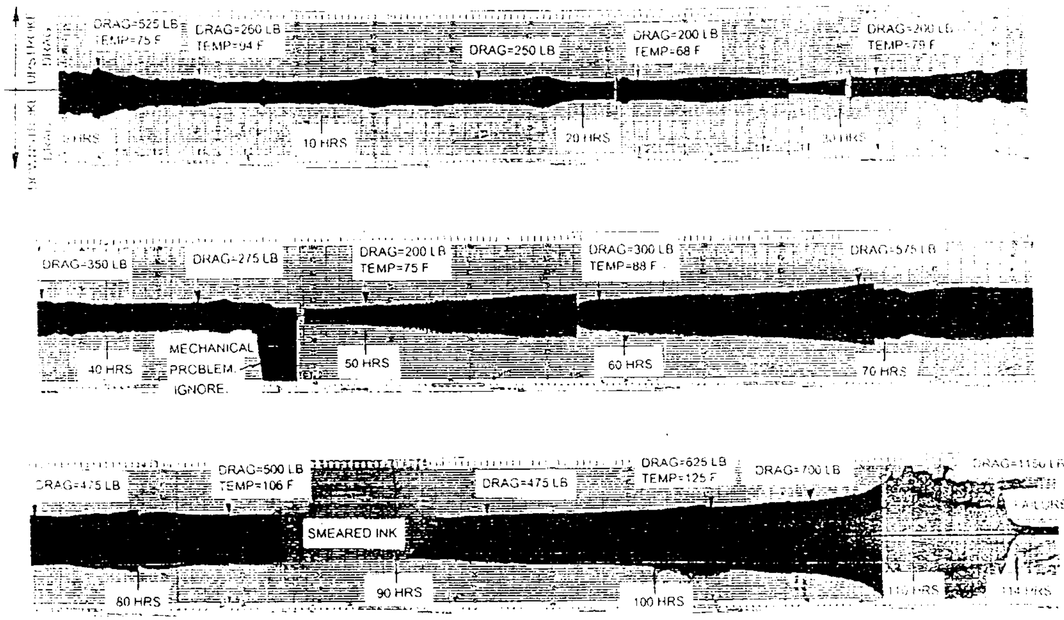

Figure 3 - Polished rod drag vs. time
"Magion C" packing

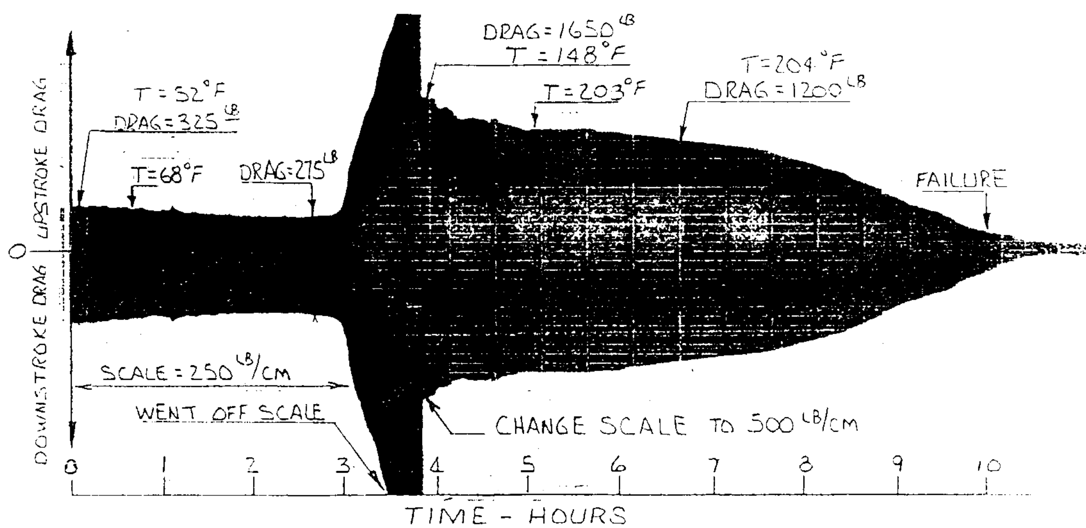

Figure 4 - Polished rod drag vs. time
Conventional packing