PRJ Vol 1, (January 1989); P. 34–36, 5 FIGS.

Short Note

FAILURE ANALYSIS OF A WIRE - LINE DUE TO CORROSION FATIGUE

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تحليل انهيار كبل معدني نتيجة كلال التآكل الكيميائي

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تتأثر الاسلاك المعدنية المصنوعة من الفولاذ بعملية كلال التآكل الكيميائى الذى يسبب فى قصر مدة استعمالها . ومن خلال عملية تحليل الأنهيار ، المعتمد على اساس ميكانيكية الكسر ، لكبل معدنى مقطوع لم تعمر فترة استعماله طويلا فى أحد الحقول النفطية التابعة لشركة آجيب ، تم التوصل الى توضيح ميكانيكية بدأ وانتشار التصدع خلال استعمال الأسلاك .

INTRODUCTION

Often steel wire-lines are operating in severe conditions due to alternating stresses, high bending moment and hostile environment. Therefore, the reliability of wire-lines plays an important role in securing efficiency of their multi-purpose operations.

CASE HISTORY

Few samples of 2.34 mm diameter steel wires were taken from a broken wire-line operated at a well of Agip Co. during a relatively very short time. Wire surface was smooth without the signs of general corrosion damage. The fractured surface from point A (Fig. 1) is inclined to the wire surface of about 30°.

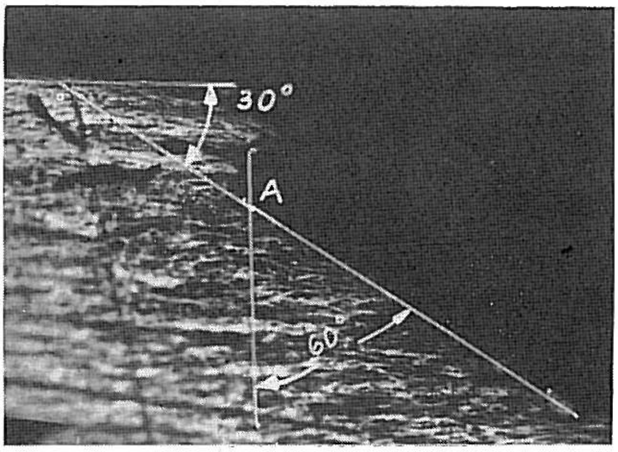

FIG. 1. Longitudinal cross-section of the broken wire-line Nital etched, magnification 300X.

The estimated maximum pull load applied during operations was 1580N. This load should not break the wire-line over a short time of operation.

RESULTS

To check the wire-line quality the two specimens were cut from the non working part. The mechanical tests were performed according to APJ Standard. 9/A Section. The results confirmed an excellent workmanship of steel-wire. It was produced from improved uncoated plow-steel of average tensile strength 1450 MPa. The reduction in area was 59%. This means that the steel-wire had enough high plasticity before the final fracture. Fractured surface of tensile tested specimens exhibited a typical ductile character.

The longitudinal cross-sections were prepared from the wire-line that failed during operation. Fig. 2 shows four short transverse cracks (marked A,B,C and D). Generally, the cracks started at a tiny surface defect similar to the corrosion pit shown by the arrow in Fig.3. After some distance (marked by A-B) the main crack changed direction along the path inclined of about 60°. Along this inclined path the crack produced a zig-zag pattern. A high optical magnification revealed that the zig-zag crack consists of short transversal (T) and parallel sections (A-A) visible in Fig. 4. Usually the transversal parts (T) ended by producing two arms (A-A).

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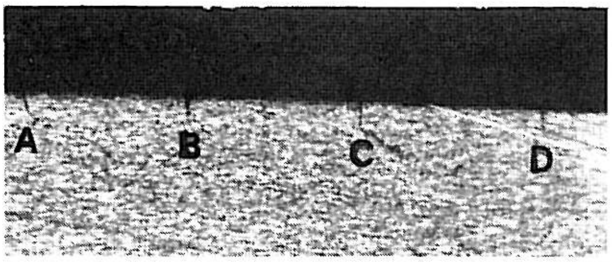

FIG. 2. Surface cracks marked by A, B, C, and D Longitudinal cross-section. Nital etched, magnification 60X.

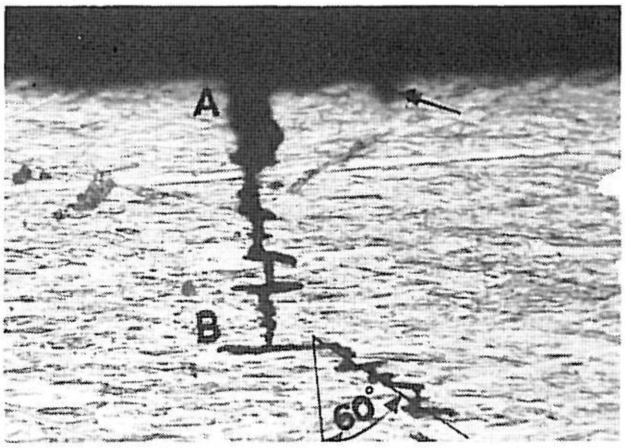

FIG. 3. Main corrosion fatigue crack started at point A. The zig-zag crack path started at point B. An arrow shows small corrosion pit as a site of corrosion fatigue crack initiation. Nital-etched, magnification 600X.

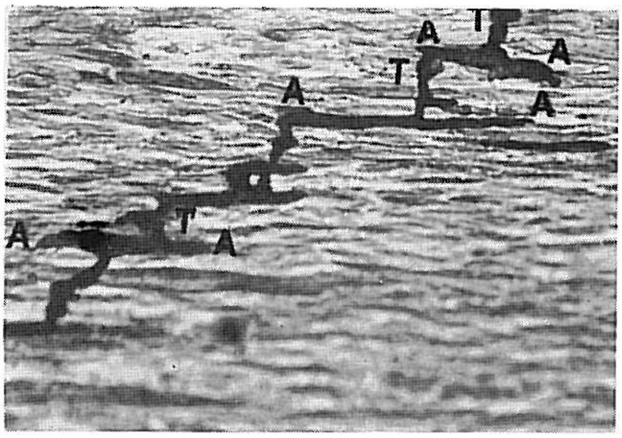

FIG. 4. Zig-zag crack pattern. Transversal part (T), parallel part (A-A). Nital etched, magnification 1200X.

DISCUSSION

A high cold drawn steel wire is characterized by unidirectional fibrous-like structure. A very high stage of cold deformation developed not only sharp crystallographic texture but also the pearlitic colonies oriented along the wire axis (1). Therefore, any of the transversal (mechanical) crack initiated at the surface had tendency to be arrested at the "interfibrous" surfaces situated parallel to the wire surface . The craks in the failed wire initiated at the tips of the small surface pits where stress concentration was high enough. Relatively low operational load produced stress which had been amplified at the wire surface by bending momentums during the passage of the wire-line over pulleys, blocks and reels. Such alternating stresses combined with the action of environment containing detrimental species like H_2S produced conditions for transgranular low-cycle corrosion fatigue cracks. Low-cycle corrosion fatigue is more destructive, for the steel, than high-frequency (2). The transversal part of the crack (section A-B in Fig. 3) was controlled mostly by bending fatigue stresses. They were high enough for crack propagation through the fibrous structure.

The corrosion also played some role in widening (dissolution effect) the upper part of a transversal crack as is cleary visible in Fig. 3. Therefore the parallel situated fibres could not effectively arrest a main crack.

According to fracture mechanics principles (3), in the situation shown schematically in Fig. 5, if the crack is longer (a / b ratio smaller) the stress-intensity factor K_I increases due to change in geometrical functions F_{1-3} (a / b) as indicated by the following equation :

$$K_1 = G_N \, a \, F_{1-3} (a/b)$$

Where :

G_N = (4M) / a^3

G_N is the nominal stress

M is the bending momentum

physically, K_I represents the plastic zone at the crack tip(A).

If the value of K_I is higher the plastic zone is more developed and materials resistance against brittle fracture also increases . Therefore at some distance the main crack becomes effectively arrested (See Fig.3 point B) developing two perpendicular arms until fatigue-corrosion process reaches a weak structural point where the next transversal crack can break a few metallic fibers. Then again, the crack is arrested and the process is repeated (see sequences T-A, T-A etc in Fig.4). Such zig-zag crack propaga-

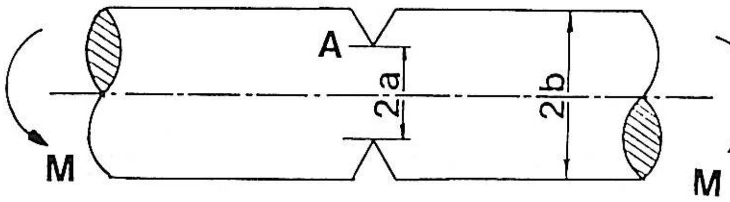

FIG. 5. Bending momentum acting in the wire with two surface cracks.

tion is typical for fracture of composite materials also. It is worth stressing that when the main crack changes the direction (about 60° inclination, see Fig.3) the process is similar to stress-corrosion cracking. It has been interpreted (4) that the stress distribution around the tip of a static crack is such that the maximum normal stress along the crack plane is significantly less than along planes inclined 60° to the crack tip. This was said to encourage development of "advance" cracks away from the plane of the main crack. Therefore, the final fracture is inclined about 60° to the transversal main crack initiated at the wire surface. Such final situation is shown in Fig.1.

CONCLUSION

Relatively short service-life of a tested wire-line was affected by low-frequency corrosion fatigue process. The wire-line operated at relatively high bending alternating stresses developed in the surface layers of the wire. The fatigue cracks have been initiated at the small corrosion pits and propagated due to destructive action of low-frequency fatigue and detrimental environment containing most probably H_2S and also Cl^{-2} in formation water. The simplest way to increase the wire-line service life is to increase the diameters of the pulleys and reels. This will decrease bending stresses at the steel wire responsible for the propagation of corrosion-fatigue crack.

ACKNOWLEDGEMENT

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PRJ Vol 1, (January 1989); P. 37–39, 5 TABLES.

Short Note

A VISCOSITY BLENDING MODEL FOR LUBRICATING OILS

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نمط خلط لتحديد لزوجة زيوت التشحيم

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تستعمل زيوت التشحيم فى الحياة العملية لاغراض متعددة ، وبالتالى فان مواصفاتها تختلف باختلاف تلك الاغراض ، واختيار الخلطة المناسبة من قطفات نواتج تكرير خام معين لتحضير زيت الاساس الذى هو العنصر الرئيسى للمنتوج النهائى يعتبر من أهم العوامل فى تحديد تلك المواصفات ..
ومن ناحية أخرى فان خاصية اللزوجة تلعب دورا أساسيا فى تحديد نوعية الزيت المنتج ، ويتم مراقبة لزوجة المواد المنتجة بالتحكم فى نسب خلط قطفات نواتج التقطير المستعملة فى تحضير زيت الأساس .
وتهدف هذه الدراسة لاستنباط نمط دقيق لتحديد نسبة خلطة قطفات خام البريقة الليبى لانتاج أنواع متعددة من زيت التشحيم وذلك قبل استعمال أى نوع من الاضافات أو استخلاص أى كمية من الشمع كما تهدف أيضا لحساب كمية الانتاج المتوقعة من تلك الانواع من الزيوت .
ويتوقع لهذه الدراسة أن تساهم فى تمكين مصافى التكرير التى تتعامل مع خام البريقة الليبى فى تحديد الكمية القصوى من كل نوع من أنواع زيوت التشحيم مع المحافظة على جودة هذه الزيوت من حيث مواصفاتها ودرجة خاصية اللزوجة بها ..

INTRODUCTION

Any suitable lubricating oil performance can be modified by controlling the amounts of different cuts and using additives so as to give lubricating oils a broad range of uses. Blending of different cuts of lubricating oil ranges of Brega crude had been investigated to obtain an optimum base oil before adding any additives.

Lubricating oils are best made from wax free crude oils. However, applications of solvent extraction and solvent dewaxing make it possible to use a wide range of crude oils in the manufacture of lubricating oils. The type and concentration of additives to lubricating oils vary depending on the applications, types of operations and the ranges of the cuts used in the blending program.

Lubricating oils are classified according to their viscosity. A useful system of Lubricating oil classification was developed by the Society of Automotive Engineers (1974) where maximum and minimum viscosities are specified at 110°F and 210°F, respectively.

The objective of the present study is to enable the users to determine the volume and ranges of the cuts to be used in order to obtain an optimum blend of lubricating oils. The blend must satisfy the requirements of viscosity which is essential for a given specific lubricating oil.

Cuts of Brega crude oil in lubricating oil ranges have been blended and the results are compared with the experimental work of this study. All possible combinations of the blended cuts were measured experimentally.

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