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HYDRAULIC SYSTEM MAINTENANCE

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ABSTRACT

Any problem in a hydraulic system in any hydraulic equipment, while working, may decrease the investment to outweigh the cost of maintenance or reconstruction. The hydraulic cylinder is a main component in the hydraulic systems. In most cases of forced stop, the equipment malfunctions in the hydraulic cylinder and its components. Therefore this study aims to repair the performance of hydraulic cylinder after corrosion and determine the best ways for the reconstruction and maintenance of hydraulic cylinder. Also, to study of the electroplating of internal surface of hydraulic cylinder, which is supposed to raise the economic life of the cylinders and consequently the economic life of machine. The studied factors were:(a) treating the surface of cylinder (before treatment, turning, polishing, chromium electroplating) and measuring the force needed to move the piston in the presence of three kinds of oils (ISO VG numbers are VG32 ,VG22 and VG10) as hydraulic liquids and (b) the effect of piston on the cylinder performance (without pressure ring, with one pressure ring and with two pressure rings) after each treatment on the cylinder surface, to evaluate the effect of the previous factors on the cylinder performance (measured by the specific force needed to move piston).. The final data indicated that electroplating of the inner surface of the hydraulic cylinder resulted in improving the performance of the hydraulic cylinder.

INTRODUCTION

Hydraulic systems are one of most important engineering applications used in Agricultural Mechanization. Tractors depend on the hydraulic systems to employ the joined machines. Also many agricultural equipments depend entirely on hydraulic machinery to carry out their functions.

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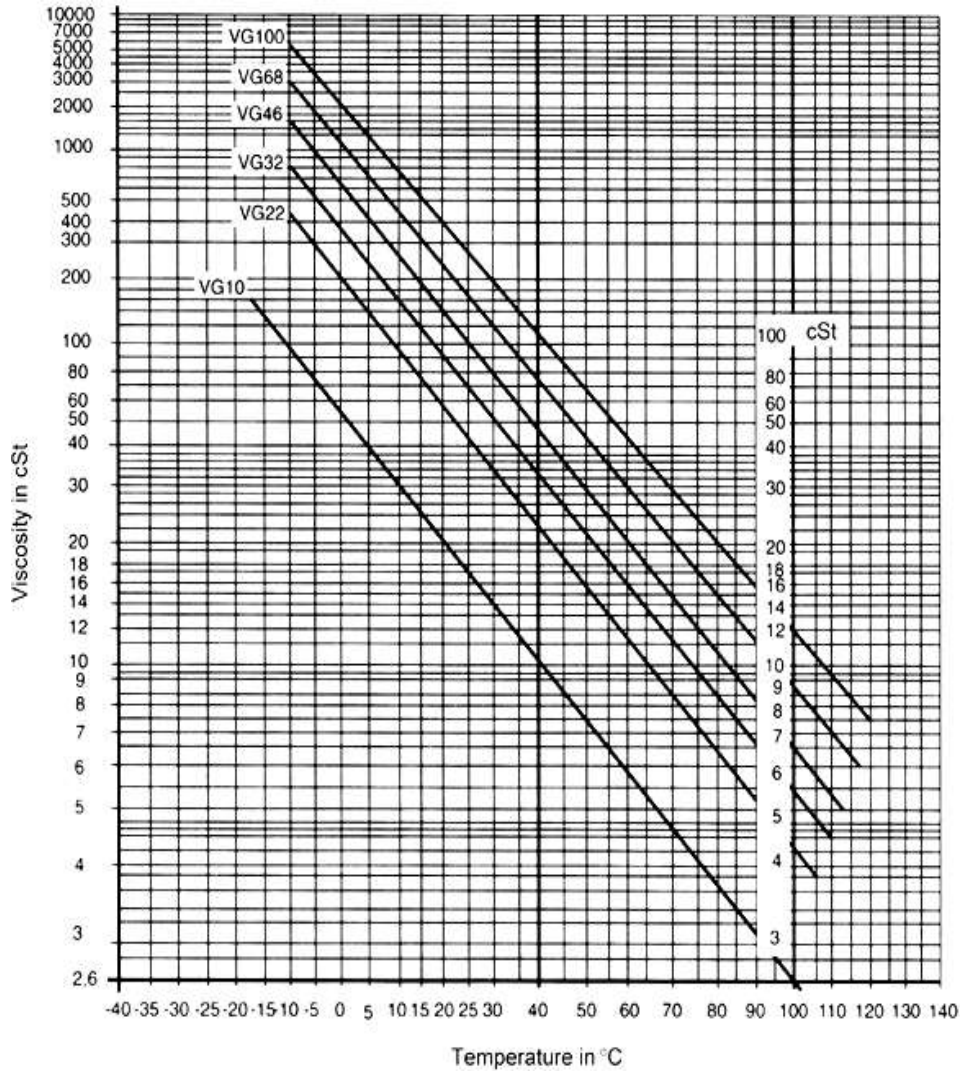
The use of a hydraulic system has several benefits in the transfer of movement, such as the transfer of power to distant parts. Hydraulic components are not damaged if they are exposing to high loads, easily reverse movement and ease of the resulting change in velocities. The failure of hydraulic cylinders of the soil cutting equipments causes economic losses. Most of the hydraulic equipment stop while working due to hydraulic fluid leak.The leak from the piston seals, causes a decreases of capacity and low efficiency. The external leaks from rod seals cause loss of power and loss of the hydraulic fluid. Hydraulic cylinder choice is discussed with regards to cylinder design rod buckling, tension and compression failures, stop collar, rod bearing failure, operating principle and thrust calculations. The right cylinder for a given load is discussed by ***(Macnab,1984*)**. Regeneration of hydraulic cylinders of grain combines by arc metallization using various coating materials was studied under laboratory conditions. The degree of adhesion, hardness and microstructure of the applied layers were examined. The test results showed the suitability of arc metallization method for the regeneration process with chromium-nickel-molybdenum proved the most effective coating ***(Fras,1986*)**. The construction and wear of hydraulic cylinders were investigated by visual inspection, measurement and air-tightness tests. Based on their results, the wear distribution was defined and it was concluded that 70-80% of components which are scrapped could be reconditioned ***(Fras and Nieckol,* 1985).** ***(Casey,2002)*** *stated that* most hydraulic systems will operate satisfactorily using a variety of fluids, including multi-grade engine oil and automatic transmission fluid (ATF), in addition to the more conventional anti-wear (AW) hydraulic fluid - provided the viscosity . Once these parameters are known, the correct viscosity grade can be determined using the viscosity/temperature curve of a suitable type of fluid - commonly AW hydraulic fluid defined according to ISO viscosity grade (VG) numbers figure (1). ***(Casey, 2006)****stated that* priority number one in hydraulics maintenance is maintaining fluid temperature and viscosity within optimum limits. This involves defining an appropriate fluid operating temperature and viscosity range for the ambient temperature conditions in which the hydraulic machine operates and selecting a hydraulic fluid with a

suitable viscosity grade and additive package and ensuring that both fluid temperature and viscosity are maintained within the limits defined. ***(Whitlock,2003)*** *stated* that top four causes of hydraulic seal failure are due to– (1) improper installation, (2) hydraulic system contamination, (3) chemical breakdown, and (4) heat degradation. **(*Casey 2008)*** *stated* that a popular misconception about hydraulic cylinders is that if the piston seal is



leaking, the cylinder can creep down.

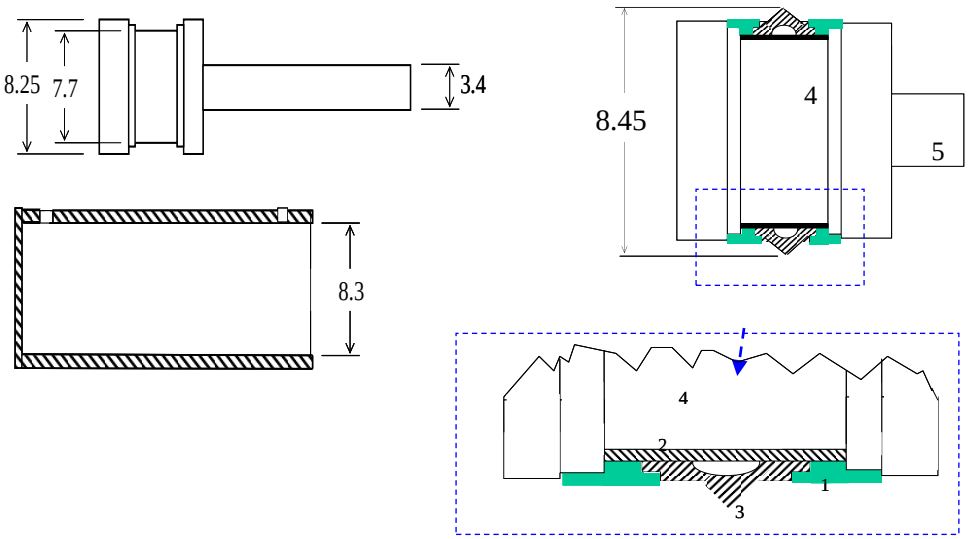
Figure 1. ISO temperature viscosity diagram.

(Omer, 2005) *stated* that electro coating process done in the basin is called galvanic basin or coverage basin. This basin is made of iron covered with rubber. The process is summarized in the following steps: (1) good conductivity of the metal with negative charge and this connectivity may setup negative with cathode or earth, (2) increasing solution temperature the appropriate temperature because the appropriate temperature helps to regularity of distribution coverage (increasing temperature using electric heaters), (3) stirring the basin using motors. That gives the benefits of increased systematic distribution of the solution concentration and compensation between the anode and cathode. Without good stirring, the process of electro coating will not be successful, and – (4) adding some components to the solution, called levelers, improve adsorbing on surfaces, has a big role in surface softer and the stability after the electro coating.

MATERIALS AND METHODES

Selection of the hydraulic cylinders

The selected Hydraulic cylinders for this study were taken from agriculture grader. Figure (2) shows a diagram of the hydraulic cylinder and its components. These specifications of cylinder, piston, rod and the length of the cylinder are used in many agricultural machinery applications, like suspension system in some tractors, especially the kind that has four hitch points. Also they are used in graders and for control of the trailed plows and for other purposes.

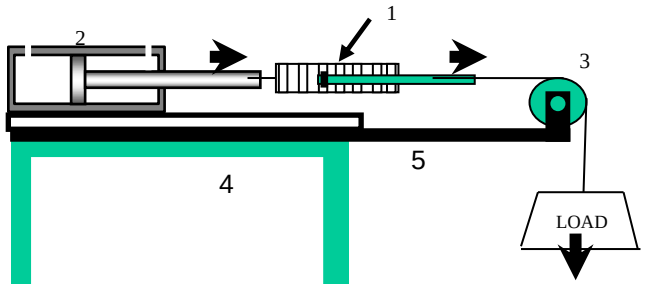


1- O ring 2- Presser ring
3- Oil seal 4- Piston
5- Rod

Figure 2: Piston and cylinder diameter and the sealing system.

Cylinder test system

This system was designed to test the effect of the cylinder surface treatments (such as turnery, polishing, and electroplating) on the force needed to move piston.



1- Spring balance
2- Hydraulic cylinder
3- Pulley
4- Table
5- Board

Figure 3: Cylinder testing system.

By increasing the load gradually, the balance spring increases its reading value gradually. The reading when piston begins movement in a constant acceleration is the force needed to move the piston (coefficient of movement

friction of the piston) .This test is conducted on the same hydraulic cylinder to study the effect of various treatments on the cylinder surface. After each treatment, the obtained reading gives the force needed to move piston. The low force needed to move the piston is an evidence of the low friction and therefore low erosion rates and low damage of seals and surfaces.

The goal of electroplating process

Electric coverage of the hydraulic cylinder is designed to cover the internal surface of cylinder by another metal. Its specification is better than the original metal of cylinder. The metals chosen for electroplating must be resistant to the mechanical erosion and chemical corrosion and scratch and roads, which gives the cylinder a long life and less rate of erosion or damage of seals and thus lower rates of forced stop of the equipment thus give a long economic life for equipment. Often, cylinders are manufactured from steel or carbon steel which is chemically active. It has significant role in the oxidation of hydraulic liquid, which is caused by the rust in cylinder metal, despite its isolation from the atmosphere, and thus causing damage to the internal surface of the cylinder and other components of the hydraulic system. The oxidation of certain types of hydraulic fluid causes rising in viscosity, forming of greases that cause difficulty in the movement of the piston and damages the protection valves from high pressure.

Conditions of the electroplating process to fit the cylinder surface

1- Concentration of electrolyte solution must be high to suit the large inner surface of the cylinder.

2. Relatively raising the solution temperature to increase the speed of the process and regularity of the coating distribution on the cylinder surface.

3- Increasing the movement of electrolyte solution by motor if using basin methods.

4- The anode surface area (metal coating) should have an enough large surface to help for regularity coating distribution.

The success factors of cylinder surface coverage

1. The outer surface of the cylinder must be covered using un electrical material before the start of the process, if the coating done in the galvanic basin.
2. Emphasis on the quality of connections and the location on the cylinder.
3. The cylinder must be immersed in the electrolyte solution at a proper temperature and concentration of the electrolyte.
4. The appropriate type of coating for the cylinder surface must be chosen.
5. Using levelers that are chemical compounds having adsorption on the surface of cathode to realize the glitter of the surface, and the good distribution of the sediment layer.

Selection of the appropriate metal for cylinder electro coating

There are lots of minerals used in electro coating processes such as copper, nickel, nickel chrome, tin, zinc and lead. The metal to be used for electro coating must be characterized by**:**

1. Coherence with the original cylinder metal.
2. Resistance to chemical and mechanical corrosions.
3. Durability.
4. Ability of full coverage of the cylinder surface.
5. Low cost.

These factors have been selected in some electroplating materials like chrome, nickel chrome and bronze. These metals are used for lots of engineering purposes like the protection from corrosion.

Coating the internal surface of the cylinder using chrome

Electrical plating using chrome has a great importance; especially with hard chromium in many different industrial applications .It is harder than iron and more coherent with iron and also one of the most resistant metals to mechanical erosion. It is also widespread so that it was selected to cover the internal cylinder surface.

Processing on the cylinder surface before electroplating

First**,** the surface of the cylinder must be free from scratches by polishing using rotary brushes or emery paper, polishing.

Second**,** the surface should be cleaned before the electroplating by organic solvent to remove grease and oils in order to obtain good coverage and coherence. The organic solvents (gasoline or toluene or fourth carbon chlorine) should be:

1- Cheap and available in the market.
2- Able to remove most types of oils.

Third, chemical activation process for the cylinder surfaces (called acidification) is the final process before electroplating. The degree of adhesion depends on the accuracy of sedimentation process of acidification. The results of the acidification are:

1 - Removing oxide and expose metal surface.

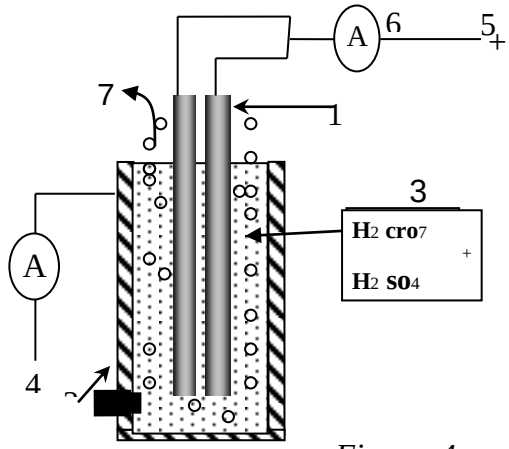
2 - Improving the distribution of layer deposited.

3 – Strengthening the adhesion between the cylinder metal and deposited layer.

Acidification process of the internal surface of the cylinder is developed by using eush solutions as: (1) sulfur acid 800 grams / liter, (2) B chromatic potassium 20 grams / liter, for time about 0.5 to 1 minute. Increasing the acidification time may cause reaction with the surface and leads to deformation. The most important thing after acidification is to transfer the cylinder to electroplating process quickly to prevent reaction between active cylinder surface and air.

Special method of hydraulic cylinder chromium electroplating

This method is successful in full coverage of the inner cylinder surface. In this method the cylinder is used as a basin. The anode is put inside the basin (Figure 4). This method is designed only for hard chrome coverage (in which, stirring is assured by gas rising). It illustrates the process of rising gas (H_2 + O_2 +H_2CrO_7) as bubbles in large quantities. Gas bubbles help in the stirring process and improve temperature, which results in a good systematic deposition.



1- Anode of chrome
2- Cathode cylinder.
3- Electrolyte
($H_2CrO_7+H_2SO_4$).
4- The connection to cathode.
5- The connection to anode.
6- Ameter
7- The gas bubbles ($O_2 + H_2 + H_2CrO_7$) + heat

Figure 4. special method of inner surface chromium electroplating

The maintenance treatments of the cylinder surface

Some specifications define the non-suitability of cylinders for work:

1- On the internal surface there are cavitations.
2- Presence of rust on the cylinder and rod surface.
3- The emergence of scratches on the surfaces of rod and cylinder.
4- The movement of piston with noise.

In the presence of the last factor, special maintenance treatments of the cylinders begins:

1. Turnings: to remove the cavation and deep scratches but in the most cases not needed because of the problems of deformation in surface and diameter.
2. Polishing: to smoothen the surface and remove the effects of tool of turnings and flat the surface.
3. Sleeking (for softer surface): to increase the protection of the piston seal. Sleeking is important before the electroplating.
4. Electroplating to cover the inner surface of the cylinder to protect it from scratches, corrosion, chemical pollution, dust pollution and minimize potential damage of seals.

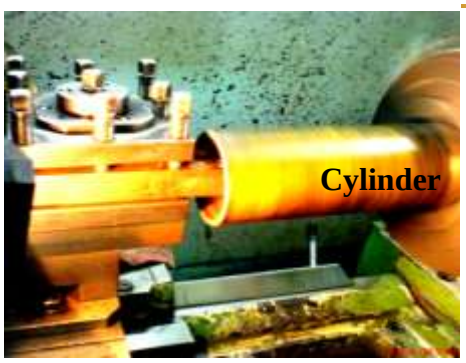


Figure 5. Boring lathe cylinder(0.3 mm depth of cut).

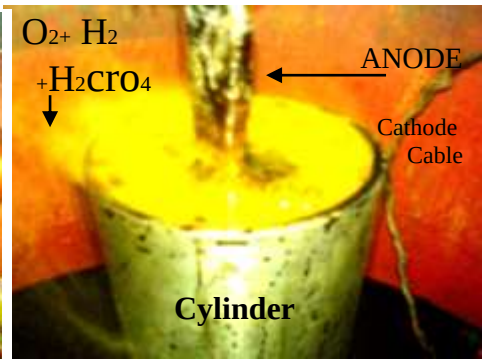


Figure 6: Chromium electroplating using the special method.

The measurement of treatment effects

First, the effect of the grease on the piston movement can be measured by the specific force needed to move piston when cylinder is in its original state and measuring this force after washing the cylinder surface using gasoline.

Second, following each treatment on the cylinder surface, (the original situation and the status of turnings, polishing and electroplating) measure the force needed to move the piston by the cylinder test system under the following conditions:

1. The presence of three different types of oils (VG10, VG22, and VG32,) when piston is used without pressure rings.
2. The presence of three different types of oil when piston is used with one pressure ring.
3. The presence of three different types of oils with double pressure rings.

The viscosity of the three types of oils is known by following ISO temperature viscosity diagram at 25 C° and VG lines are (VG10, VG22, VG32,) in Figure (1).

RESULTS AND DISCUSSION

The effect of the grease deposited on the surface of the cylinder

The chemical change of the hydraulic liquid results from the high temperature and the presence of iron (the original cylinder metal) as an

oxidizer, which results in hindering the movement of piston and increasing the stress on the hydraulic system. For this reason, the force needed to move the piston depends on the presence of the grease.

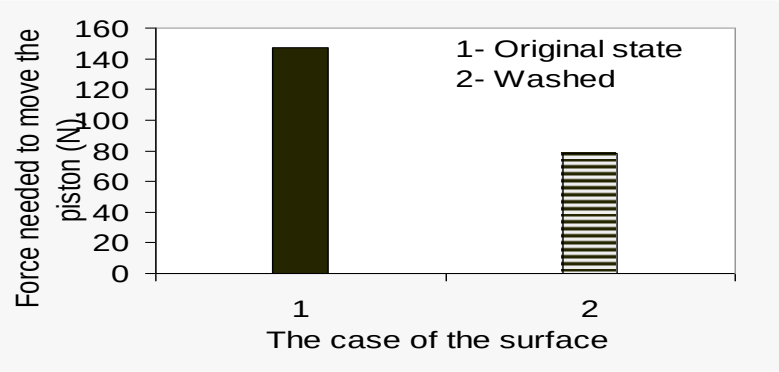


Figure 7: Effect of grease deposited on the cylinder surface on the resistance of the piston movement.

This test was selected to determine the effect of the deposited grease on the surface of the cylinder because they impede the piston movement. The resistance of movement leads to damaging the seals, especially in the presence of sand particles that leads to more of hydraulic fluid leakage, which could cause a forced stop for the equipment. Grease results from the oxidation of the hydraulic liquid; the iron (cylinder metal) has a big role in this oxidation.

Effect of different types of the hydraulic liquids

Many kinds of oils may be used to operate the cylinders in a machine attached with the tractor. These kinds of oils are the engine oils, the oil of the differential device or the gears oil. However, the equipment which contain a separate hydraulic system contain a special hydraulic reservoir with a standard hydraulic oil. In other cases, the heavy oils are used to minimize the leakage. So the effects of the different types of hydraulic fluids (with different viscosities) and different cylinder surfaces were studied.

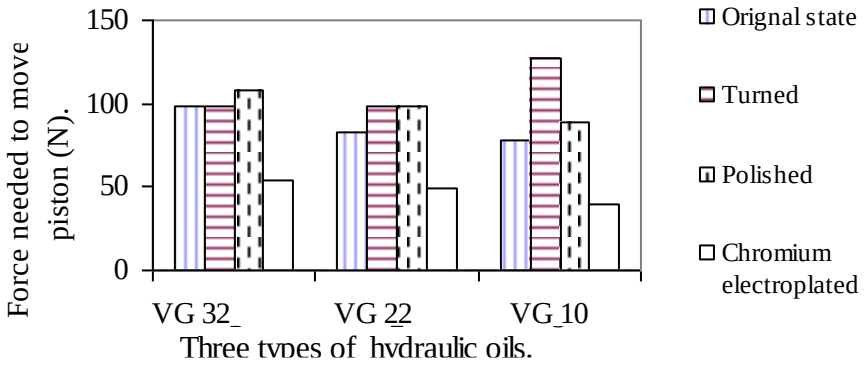


Figure 8. The effect of cylinder surface treatments with three types of the hydraulic oils (for piston without presser ring).

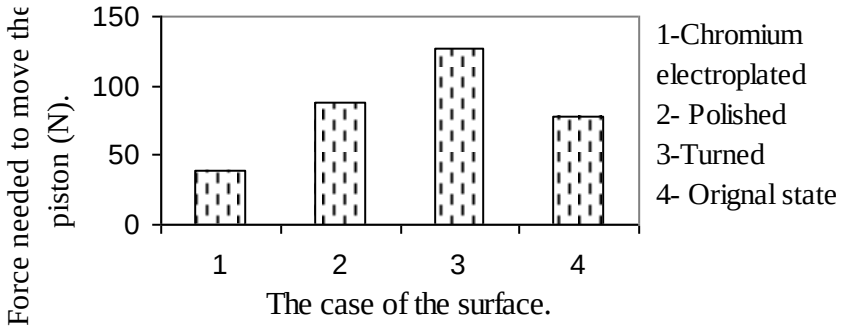


Figure 9: Force needed to move piston after cleaning with gasoline (for piston without pressure ring).

The effect of installing the pressure rings

The pressure ring installation was done for the following purposes:

1. To control the pressure between the piston seals and the cylinder.
2. To reduce the oil leakage by increasing the seal pressure on the surface of the cylinder.

Installing of more than one pressure ring gives more sealing. The thickness of a pressure ring that was 0.3 mm (made of plastic).

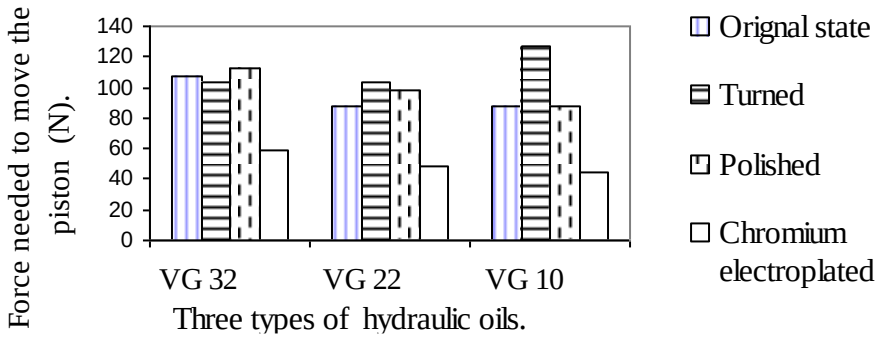


Figure 10: Effect of the cylinder surface treatments with three kinds of hydraulic oil (for piston with one pressure ring).

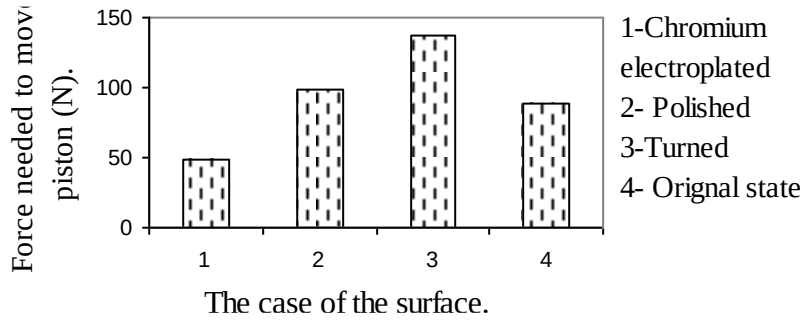


Figure 11: Force need to move piston after cleaning with gasoline (for piston with one presser ring).

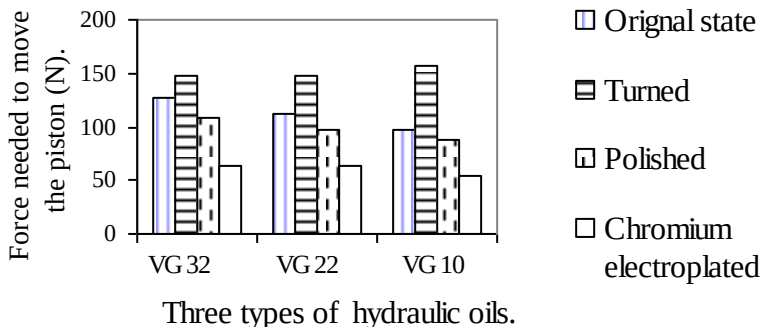


Figure 12: Effect of the cylinder surface treatments with three types of the hydraulic fluids (for piston with double presser ring).

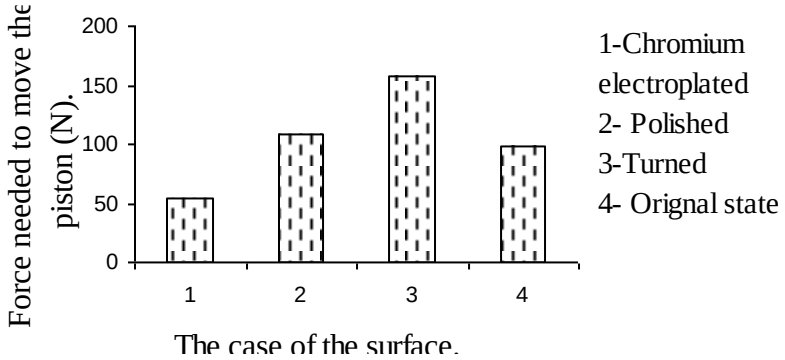


Figure 13: Force need to move piston after cleaning with gasoline (for piston with double presser ring).

Interest generated from the chromium plating process

To know the basic causes of hydraulic problems, it may be difficult because they are complex and connected with many reasons. The causes of the hydraulic problems are indicated in the diagram in figure 14. It summarizes most problems of the hydraulic cylinders and the relations between them. The electroplating, such as chromium electroplating can fix the basic causes of failure that happen to the hydraulic cylinders.

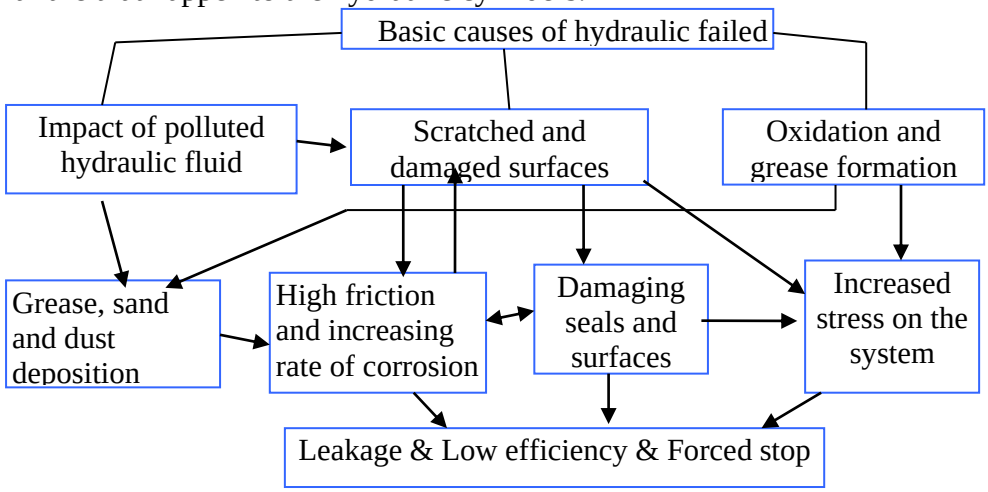


Figure (14): Relation between the hydraulic system problems and forced stop.

Recommendations for protection of hydraulic equipments

1 - Periodic maintenance has a great role in protecting the equipment from the forced stop.

2 - In most cases the agricultural equipment work in a very dusty environment that makes the periodic cleaning of the filters insufficient.

Different types of hydraulic filters have means of warning when they are exposed to clogging. Means of filter clogging include sand, which could cause serious damage to cylinders and other components.

3 - The electroplating of the cylinder surface may be expensive but it is important because it has a big role in reducing the forced stop because it will eliminate most of its causes.

4 - The contact between hydraulic fluid and iron metal with temperature causes danger of the oxidations of the hydraulic fluid. Painting of fluid reservoir if made of iron and any other components such as pipes or links made of iron would help solving this problem.

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الملخص العربى

صيانة النظام الهيدرولي

***أ د/محمد احمد الشيخة **د/محمد عبد الفتاح مصطفي *م/محمد صلاح محمد عبد السلام

تعتبر الاسطوانات الهيدرولية من أهم مكونات النظام الهيدرولي. و ترجع معظم حالات التوقف الجبري للمعدات إلي أعطل في الأنظمة الهيدرولية وخصوصا الاسطوانات الهيدرولية ومكوناتها. لذلك تهدف الدراسة إلي: الوصول إلي أفضل الوسائل لتعمير وصيانة الاسطوانة الهيدرولية بغرض رفع العمر الاقتصادي لها وبالتالي للإلة التي تعتمد علية. تقليل حالات الفشل أو التوقف الجبري أثناء العمل و الناتج عن أعطال في الاسطوانات الهيدرولية، حيث قد يتسبسب التوقف الجبري في خسائر لبعض الحالات قد تفوق كلفة الصيانة.معاملات الدراسة:(١ –الخراطة - ٢ - التجليخ - ٣- دراسة و إنجاح الطلاء الكهربي للسطح الداخلي للاسطوانات الهيدرولية).
عملية الطلاء الكهربي: تهدف إلى تغطية السطح الداخلي للاسطوانة بمعدن أخر ذي مواصفات أفضل من المعدن الأصلي بهدف وقايتة حيث يجب أن يكون المعدن المستخدم أكثر مقاومة للتآكل الكيميائي والالي وأكثر صلادة بحيث يقاوم الخدش والطرق وبالتالي إطالة عمر لاسطوانة وبذلك يتم تقليل معدلات تأكل وتلف موانع التسرب، و بالتالي تقل معدلات التوقف الجبري للمعدات، وأيضا تقليل التفاعل الذي يحدث بين معدن الاسطوانة والزيت الهيدرولي، وبالتالي رفع العمر الاقتصادي للمعدة. تم تصميم نظام لدراسة أداء الاسطوانة عن طريق معرفة القوي النوعية ألازمة لتحريك المكبس بعد كل معاملة علي سطح الاسطوانة، وفي وجود ثلاثة أنواع من الزيوت الهيدرولية مختلفة في اللزوجة. وقد أظهرت النتائج أنة يوجد تحسن كبير في أداء الاسطوانة الهيدرولية بعد تغطية السطح الداخلي لها بالكروم.

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