"IMPROVING WEAR RESISTANCE OF VALVE SEAT USINGELECTROPLATING"

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Abstract—In the internal combustion engine valves and valve seats are used in the cylinder head. The problem of replacing the valve seat is frequently encountered in the IC engine. The valves are used to do a sequence of operations repeatedly. Due to this valve seats are damaged frequently. This project is an attempt to suggest a method to improve the performance of the valve seat by reducing the wear. The improvement in the wear resistance is achieved by various methods by applying the Chromium coating on the surface of the valve seat. Chromium coating is given to valve seat for improving wear and corrosion resistance by doing the electroplating process. Chromium coating is applied on the cast iron valve seat, after completion of electroplating process layer thickness increases in the range of 0.015mm to 0.020mm approximately. While conducting this process tensile and compressive strength, hardness, wear resistance of the material will increase.

Index Terms: -Valve Seat,Electroplating,Process

INTRODUCTION

1.1 VALVE SEAT ARRANGEMENTS IN ENGINES

An internal combustion engine is an engine where the combustion of a fuel occurs with an oxidizer (usually air) in a combustion chamber that is an integral part of the working fluid flow circuit. In an internal combustion engine the expansion of the high-temperature and high-pressure gases produced by combustion apply direct force to some component of the engine. The force is applied typically to pistons, turbine blades, or a nozzle. This force moves the component over a distance, transforming chemical energy into useful mechanical energy. The first commercially successful internal combustion engine was created by Etienne Lenoir around 1859.

Typically an internal combustion engine is fed with fossil fuels like natural gas or petroleum products such as gasoline, diesel fuel or fuel oil. There's a growing usage of renewable fuels like biodiesel for compression ignition engines and bioethanol for spark ignition engines. Hydrogen can be used as a fuel, where it would act as an energy carrier rather than as a primary energy source because it's not found unbounded in nature in appreciable quantities. It's possible to generate pure hydrogen from energy. The term internal combustion engine usually refers to an engine in which combustion is intermittent, such as the more familiar four-stroke and two-stroke piston engines, along with variants, such as the six-stroke piston engine and the Wankel rotary engine. A second class of internal combustion engines uses continuous combustion: gas turbines, jet engines and most rocket engines.

Internal combustion engines are quite different from external combustion engines, such as steam or Sterling engines, in which the energy is delivered to a working fluid not consisting of, mixed with, or contaminated by combustion products. Working fluids can be air, hot water, pressurized water or even liquid sodium, heated in a boiler. Internal combustion engine are usually powered by energy-dense fuels such as gasoline or diesel, liquids derived from fossil fuels. While there are many stationary applications, most ICEs are used in mobile applications and are the dominant power supply for cars, aircraft, and boats.

In this project, the valve seat is the component that located in the cylinder head whereas valve seat insert is component that fitted into the cylinder head. Both are working at the similar environment and have a closer relationship as ultimate goal of both of them are to control the exchange of gases in internal combustion engine. They are intended to seal the working space inside the cylinder against the manifolds. Valve is precision engine components used to open to permit the burned gases to exhaust from cylinders. Therefore exhaust valve are exposed to serve thermal loads and chemical corrosion. Valve seat insert is the surface against which an intake or an exhaust valve rests during the portion of the engine operating cycle when that valve is closed.

It is critical component to ensure complete. Sealing of the combustion chamber so that the required compression and ignition pressures can be generated inside cylinder. Generally the material for manufacturing exhaust valve and exhaust valve seat insert basically have properties of working at high temperature continuously and resistance to corrosion due to their surrounding environment that expose to them. Process involved for both products also basically need high dimensional accuracy and heat treatment since both have direct contact during functioning in cylinder to ensure complete sealing of the combustion chamber.

1.2 VALVE SEAT

The valve seat in ancombustion gasoline or diesel engine is the surface against which an intake or an exhaust valve rests during the portion of the engine operating cycle when that valve is closed. The valve seat is a critical component of an engine in that if it is improperly positioned, oriented, or formed during manufacture, valve leakage will occur which will adversely affect the engine compression ratio and therefore the engine efficiency, performance (horsepower), exhaust emissions, and engine life.

Valve seats are often formed by first press-fitting an approximately cylindrical piece of a hardened metal alloy, such as Satellite, into a cast depression in a cylinder head above each eventual valve stem position, and then machining a conical-section surface into the valve seat that will mate with a corresponding conical-section of the corresponding valve. Generally two conical-section surfaces, one with a wider cone angle and one with a narrower cone-angle, are machined above and below the actual mating surface, to form the mating surface to the proper width (called "narrowing" the seat), and to enable it to be properly located with respect to the (wider) mating surface of the valve

Fig.1.1Valve Seats

Inexpensive engines may have valve seats that are simply cut into the material of the cylinder head or engine block (depending on the design of the engine). Some newer engines have seats that are sprayed on rather than being pressed into the head, allowing them to be thinner, creating more efficient transfer of heat through the valve seats, and enabling the valve stems to function at a lower temperature, thus allowing the valve stems (and other parts of the valve train) to be thinner and lighter.

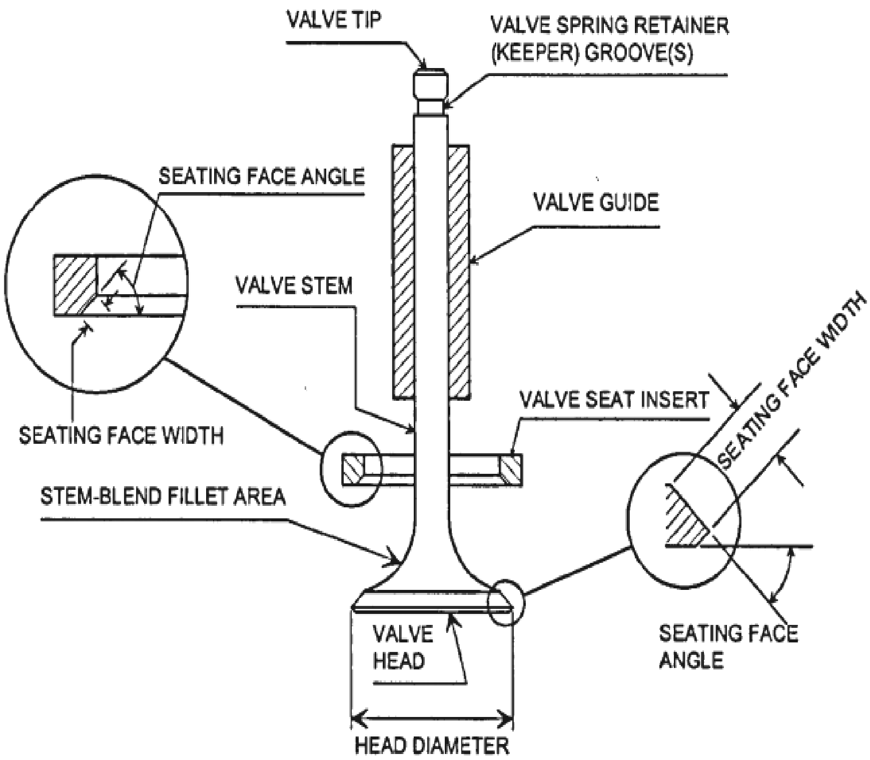

Fig.1.2Engine Valve Seat terminology

There are several ways in which a valve seat may be improperly positioned or machined. These include incomplete seating during the press fitting-step, distortion of the nominally circular valve seat surfaces such they deviate unacceptably from perfect roundness or waviness, tilt of the machined surfaces relative to the valve guide hole axis, deviation of the valve seat surfaces from concentricity with the valve guide holes, and deviation of the machined conical section of the valve seat from the cone angle that is required to match the valve surface. Automated quality control of inserted and machined valve seats has traditionally been very difficult to achieve until the advent of digital holography which has enabled high-definition metrology for measuring all of these listed deviations.

In a combustion engine the valve seat is the surface against which intake and exhaust valves rest when they are closed. It is a very critical component in the operation of a combustion engine for if it is not properly positioned, oriented, or formed during manufacturing valve leaking will occur, resulting in a loss of compression. Valve seats are usually formed by first press-fitting a cylindrical piece of a hardened metal alloy, such as Stellite, into a cast depression in a cylinder head above each valve stem position, and then machining several conical-section valve seat surfaces to form the valve seat into a shape that will match the mating surface of the valve. Automated quality control of inserted and machined valve seats has traditionally been very difficult to achieve until the advent of digital holography which has enabled high-definition metrology for measuring all of these listed deviations.

An improperly installed or machined valve seat can happen several ways:

- Incomplete seating during press fitting.
- Distortion of the circular valve seat surfaces.
- Tilt of the machined surfaces relative to the valve guide axis.
- Deviation of the valve seat surfaces from concentricity with the valve guide holes.
- Deviation of the machined conical section of the valve seat from the cone angle of the valve.

Fig.1.3 Valve Seat Damage

1.3 VALVE SEAT TECHNOLOGY

Modern engines put much higher levels of thermal and mechanical stress on valve seat inserts. To handle the more severe conditions within this new of engines, the OEM is equipping them with high tech sintered valve seats. The normal cast chrome and other alloy iron seats will not adequately withstand the demands of this new engine environment.

Fig.1.4 Valve Seat Rings

Dura-Bond's patented materials and processing of these powder metal valve seats offer excellent machinability, along with low wear and high heat resistance. These inserts have finely dispersed tungsten carbide residing in a matrix of tempered tool steel and special alloy iron particles to provide all the properties an application requires.

Special compositions and processing have been developed to perform in the most extreme duty applications. Complete in-house capabilities, from development and tooling to testing, reduces lead time and cost.

1.4 ELECTROPLATING

Electroplating is a process that uses an electric current to reduce dissolved metal cations so that they form a thin coherent metal coating on an electrode. The term is also used for electrical oxidation of anions on to a solid substrate, as in the formation of silver chloride on silver wire to make silver/silver-chloride electrodes. Electroplating is primarily used to change the surface properties of an object (such as abrasion and wear resistance, corrosion protection, lubricity, aesthetic qualities), but may also be used to build up thickness on undersized parts or to form objects by electroforming.

1.4.1 Electroplating Process

The process used in electroplating is called electro deposition. It is analogous to a concentration cell acting in reverse. The part to be plated is the cathode of the circuit. In one technique, the anode is made of the metal to be plated on the part. Both components are immersed in a solution called an electrolyte containing one or more dissolved metal salts as well as other ions that permit the flow of electricity. A power supply supplies a direct current to the anode, oxidizing the metal atoms that it comprises and allowing them to dissolve in the solution. At the cathode, the dissolved metal ions in the electrolyte solution are reduced at the interface between the solution and the cathode, such that they "plate out" onto the cathode. The rate at which the anode is dissolved is equal to the rate at which the cathode is plated and thus the ions in the electrolyte bath are continuously replenished by the anode.

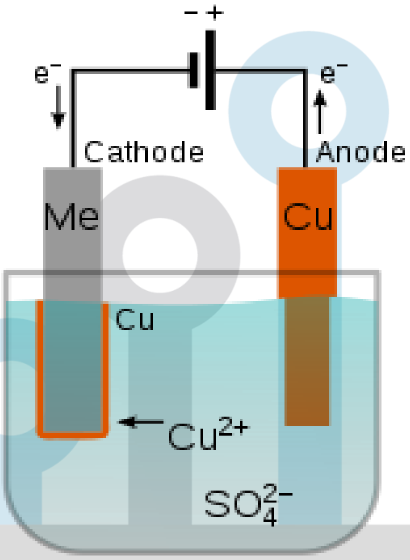

Fig.1.5 Electroplating

Valve seat wear has been a small but serious problem to engine designers and manufacturers for many years. It has been described as:"One of the most perplexing wear problem in combustion engines”

3.5.1 Problem Definition

Fundamental problem of the valve seat wear in the internal combustion engine defined below:

- Frequently occurs wear & tear in the valve seat
- It will reduce the engine performance, and engine efficiency
- Poor Combustion
- Valve Leakage
- Miss – Firing

1.8 CAUSES FOR VALVE SEAT FAILURE

Non-integral valve seats can fail for a number of reasons. Most of the seats that end up being replaced are replaced because they are either cracked or too worn to be reground or re-machined. Seats can crack from thermal stress (engine overheating usually), thermal shock (a sudden and rapid change in operating temperature), or mechanical stress (detonation, excessive valve lash that results in severe pounding, etc.).

A small amount of valve recession results from normal high mileage wear, but it can also occur when unleaded gasoline or a "dry" fuel such as propane or natural gas is used in an engine that is not equipped with hard seats. Recession takes place when the seats get hot and microscopic welds form between the valve face and seat. Every time the valve opens, tiny chunks of metal are torn away and blown out the exhaust. Over time, the seat is gradually eaten away and the valve slowly sinks deeper and deeper into the head. Eventually the lash in the valve train closes up and prevents the valve from seating. This causes the valve to overheat and burn. Compression is lost and the engine is diagnosed as having a "bad valve." The seat also has to be replaced, but it many instances it may not be recognized as the underlying cause of the valve failure. As a rule, a seat should be replaced if the specified installed valve height cannot be achieved without excessive grinding of the valve stem tip (less than .030 in.), or if the

specified installed spring height cannot be achieved using a .060 in. spring shim. This applies to integral valve seats as well as no integral seats.
The only other alternative to replacing the seat is to install an aftermarket valve that has an oversized head (.030 in.). This type of valve rides higher on the seat to compensate for excessive seat wear or machining, and can eliminate the need to replace the seat.
A seat may also have to be replaced if it is loose or if the cylinder head is cracked and requires welding in the combustion chamber area (the seats should be removed prior to welding).
One way to check a seat for looseness is to hold your finger on one side of the seat while tapping the other side with a hammer. If you feel movement, the seat is loose and should come out (so it does not fall out later!).
The seats in an aluminum head may also loosen or fall out when the head is being cleaned in a bake oven or preheated in an oven for straightening. The same thing can happen to the guides.
Whether or not this occurs depends on the amount of interference fit between the seats and head. The less the interference, the more likely the seats are to loosen and fall out when the head is baked. If you do not want the seats to fall out, turn the head upside down or stake the seats prior to baking.

1.11 ELECTROPLATING METHODS
In the electroplating method various methods available in the field.the following methods commonly used in the metal coating process
Copper plating
Chromium Plating

1.11.1 Copper Electroplating

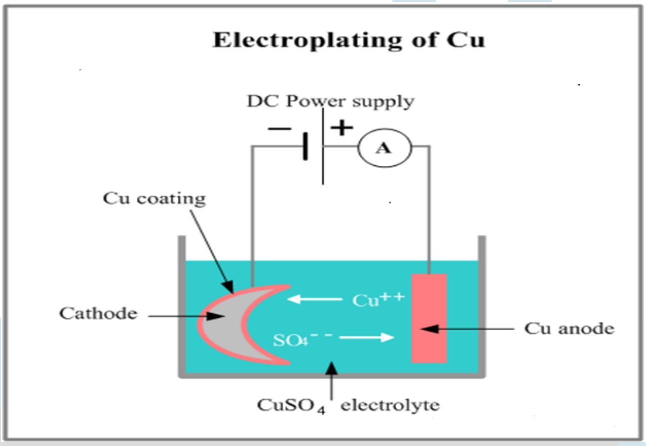

Fig.1.6 Copper Electroplating Machine

Electroplating processes may use a non-consumable anode such as lead or carbon. In these techniques, ions of the metal to be plated must be periodically replenished in the bath as they are drawn out of the solution. The most common form of electroplating is used for creating coins, valves and valve seat which are small zinc plates covered in a layer of copper.
Electroplating of a metal (Me) with copper in a copper sulfate bath The cautions associate with the anions in the solution. These cautions are reduced at the cathode to deposit in the metallic, zero valence state. For example, in an acid solution, copper is oxidized at the anode to Cu^{2+} by losing two electrons.
The Cu^{2+} associates with the anion SO_4^{2-} in the solution to form copper sulfate. At the cathode, the Cu^{2+} is reduced to metallic copper by gaining two electrons. The result is the effective transfer of copper from the anode source to a plate covering the cathode.
The plating is most commonly a single metallic element, not an alloy. However, some alloys can be electrodeposited, notably brass and solder. Many plating baths include cyanides of other metals (e.g., potassium cyanide) in addition to cyanides of the metal to be deposited. These free cyanides facilitate anode corrosion, help to maintain a constant metal ion level and contribute to conductivity.

1.11.2 Chromium Electroplating
Chromium plating is generally used for one of two purposes: for decorative uses or for engineering purposes. This report deals with the engineering uses of chromium plating and its effect on BAL Seal performance in rotary and reciprocating services. Chromium plating is used to provide a very high degree of hardness on the surface of a metal to enhance wear resistance, reduce friction, provide anti-galling properties, and, in some cases, improve corrosion resistance.

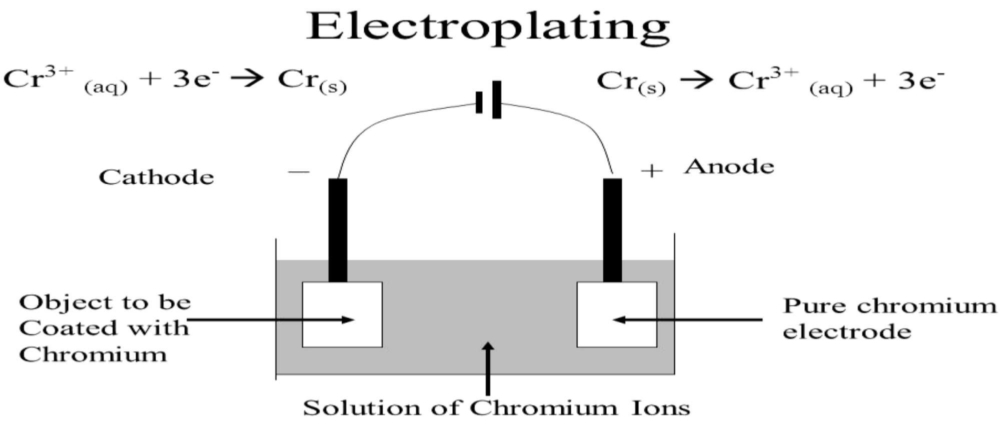

Fig.1.7 Chromium Electroplating

1.11.3 Purpose of Chromium Plating.

Chrome plating is an electrolytic process that can be applied to regular steel, stainless steel, aluminum, and other materials. This report details the application of chrome plating to valve seat surfaces.

Fig.1.8 Chromium Coated Valve Seat

1.12.3 Chromium Plating Process

Chromium plating a component typically includes these stages:

- Degreasing to remove heavy soiling
- Manual cleaning to remove all residual traces of dirt and surface impurities
- Various pretreatments depending on the substrate
- Placement into the chromium plating vat, where it is allowed to warm to solution temperature
- Application of plating current for the required time to attain the desired thickness

There are many variations to this process, depending on the type of substrate being plated. Different substrates need different etching solutions, such as hydrochloric, hydrofluoric, and sulfuric acids. Ferric chloride is also popular for the etching of Mnemonic alloys. Sometimes the component enters the chromium plating vat electrically live. Sometimes the component has a conforming anode made from lead/tin or platinized titanium.

A typical hard chromium vat plates at about 1 mil (25 µm) per hour. Various finishing and buffing processes are used in preparing components for decorative chromium plating. The overall appearance of decorative chromium plating is only as good as the preparation of the component. The chromium plating chemicals are very toxic. Disposal of chemicals is regulated in most countries.

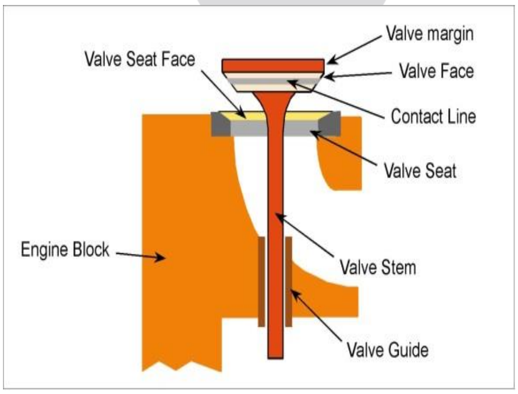

Fig.1.9 Valve Seat after Electroplating

1.13 TESTING METHODS
In this valve seat manufacturing various types of testing methods available in the field. They are described following topics.

1.13.1 Hardness Test
The hardness represents the resistance of the material surface to abrasion, scratching and cutting. Hardness tests were carried out on the matrix aluminium alloy and composite material specimens on a Brinell hardness testing machine. The specimens were metallo graphically polished for conducting the hardness test. A define force is mechanically applied on the specimen for about 30 seconds.

1.13.2 Tensile Strength Test
One of the mechanical properties of a composite is tensile strengths. The dimension of the test valve seat. This test is done with the computerized ultimate tensile testing machine (UTE40), at room temperature (30°C). The universal testing machine also known as a universal tester, materials testing machine or materials test frame, is used to test the tensile stress and compressive strength of the materials. Since it is a computerized machine, the break-point and results are recorded accurately.

1.13.3 Wear test
The surfaces of the valve seat were slides using emery paper (80 grit size) prior to test in order to ensure effective contact of fresh and flat surface with the steel disc. The valve seat and wear track were cleaned with acetone and weighed (up to an accuracy of 0.0001 gm using microbalance) prior to and after each test. The wear rate was calculated from the height loss technique and expressed in terms of wear volume loss per unit sliding distance.

1.14 VALVE SEAT INSTALLATION
Once the counter bore in the head has been machined for the desired interference fit and a replacement has been selected, the next step is to install the seat.
As mentioned previously, the hole must be clean and have a smooth surface finish. The seat should be placed with the radius or chamfer side down and lubricated (ATF works fine) prior to being pressed or driven in with a piloted driver (recommended to prevent cocking).
If the replacement seat has a sharp edge, it should be chamfered or rounded so it won't scrape any metal off the head as it is being driven into position. If metal gets under the seat, it will create a gap that forms a heat barrier. This, in turn, will interfere with the seat's ability to cool the valve and premature valve failure will likely result.
Preheating the head and/or chilling the seats with dry ice or carbon dioxide (do not use Freon because it damages the ozone!) will make installation easier and lessen the danger of broaching the counter bore as the seat is being installed.
If you choose to peen or stake the seats after they have been installed as added insurance to prevent them from falling out (which should not be necessary if the seats have the correct interference and were properly installed), several engine rebuilders we interviewed recommended rolling or peeking rather than staking. Their reason? Staking creates stress points and potential hot spots. That wraps up our overview of valve seat replacement. As we said at the beginning of this article, seat replacement involves a number of important decisions. So measure your counter bores carefully, chose the "right" seat for the application, double check your machine work and make sure the seats are installed correctly.

Fig1.10 Valve Seat Installation

1.15 VALVE SEAT REFINISHING
Once the seats have been installed and the guides have been replaced, relined, or reamed to accept valves with oversized stems, seat concentricity should be checked with a dial indicator. Seats must be as concentric as possible to ensure a vacuum-tight seal

with the valves, and to prevent valve flexing, which can cause metal fatigue and valve failure. A good number to is less than .001 of run out per inch of seat diameter. Less is always best.

CONCLUSION

By completion of this project, the wear resistance of the valve seat has been improved using chromium coating by electroplating method. By decreasing the wear of valve seat, rust formation is eliminated, increase the hardness range, valve seat layer thickness is increase, corrosion resistance is increase, good appearance, hardness, tensile, compressive strength is increase, temperature maintenance will decrease and lifetime of the valve and valve seat has improved.

REFERENCES

1. Chang-Woo Park, Keyoung-Jin Chun and Sung-Chong Chung,et.al., in this work "Wear Measurement of Valve Assemblies by using the Machine vision"
2. Earle et.al., (1978) in his work "Method For Fusibly Bonding A Coating Material To A Metal Article"
3. Edgar E. Vera-Cardenas1*, Roger Lewis2, Tom Slatter2, et.al.,(2017) in their research entitled "Sensitivity Study of a Valve Recession Model"
4. Edgar E. Vera-Cardenas, Roger Lewis, Tom Slatter, et.al.,(2017) in their research entitled "Sliding Wear Study on the Valve-Seat Insert Contact"
5. Krzysztof Siczek, MaciejKuchar,et.al., (2015) "The Simulation Researches On The Wear For Elements Of The Seat Insert-Valve-Valve Guide Assembly"
6.Lewis, R., Dwyer-Joyce, R.S., Slatter, T. and Brooks A, et.al., (2004) in their research entitled "Valve recession: From experiment to predictive model"
7.Osawa et.al.,(1975) in his work "Valve Seat Materials For Internal Combustion Engines"
8. R Lewis and R S Dwyer-Joyce, et.al., (2002) in their research entitled "Wear of diesel engine inlet valves and seat inserts"
9.Roger Lewis, Rob Dwyer-Joyce1, Alan Brooks, Thomas Slatter,et.al., (2004) in their research entitled "Valve Recession: From Experiment To Predictive Model"