FluoroelastomerIs the Best Material for Water Header Gasket of Diesel Engine

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Abstract-Lot of mechanical, chemical, thermal, physical and functional properties of gasket materials can involve in determining their performance under specific sets of conditions. The selection of gasket materials is complex and based upon the interpretation of numerous interrelated factors which may affect performance. Certain guidelines may be employed to facilitate the selection process in a systematic manner with a good level of reliability.

With the latest improvements in automotive engine performance, the operating conditions for the cylinder water header gasket are becoming more critical. Today's water header gasket is required not only to ensure high durability, but also to contribute to improving engine performance.

This paper introduces a best material for water header gasket consisting goodthermal, mechanical, chemical properties, because of this gasket has several superior characteristics for diesel engineof capacity more than 50 liter and two stage turbo charging. Seal ability and durability were significantly improved.

1. INTRODUCTION

The gasket material selected must be capable of sealing mating surfaces, resistant to the medium being sealed, and able to withstand the application temperatures and pressures.

Water header gasket is placed between water header cover plate and water header block of engine.Coolant is surrounded around the cylinder liner and lube oil cooler, so that temperature of water at this area is above 200°C. Exhaust manifold also is in contact with this area so it is in very high temperature. Exhaust gas pressure and running condition of engine effect on the water header gasket and coolant is also in contact with gasket so chemicals also affects the gasket, by considering this factor it is necessary to select the best material for water header gasket. Water header gasket is most critical joint component, loosening of bolt torque affects the sealing ability causing the water leakage and overall efficiency of cooling system. So it is necessary of being water header gasket most reliable at all points of view for that proper and perfect gasket material selection is important.This paper will suggest the best material for water header gasket that will be compatible with the application service.

The optimum gasket material would have the following characteristics:

- It would have the chemical resistance of PTFE;
- The heat resistance of Flexible Graphite;
- The strength of steel;
- It requires a zero seating stress, such as with soft rubber; and,
- It should be cost effective.

II. GASKET

A gasket is a compressible material, or a combination of materials, which when clamped between two stationary members prevents the passage of the fluid across these members. To prevent passage of fluid, the gasket must be able to flow into (and fill) any irregularities in the mating surfaces being sealed, while at the same time be sufficiently resilient to resist extrusion and creep under operating conditions. The seal is effected by the action of

force upon the gasket surface (usually by bolts), which compresses the gasket, causing it to flow into any surface imperfections. The primary purpose of a seal is to contain a fluid and protect the immediate environment from contamination. A gasket is used to create and retain a static seal between two relatively stationary parts. A static seal aim to provide a complete physical barrier against the fluid contained within by blocking any potential leakage path. In this paper information is given on the best material for water headed gasket.[1]

Water header gasket

Water header gasket is placed between water header cover plate and water header block of engine.Coolant is surrounded around the cylinder liner and lube oil cooler, so that temperature of water at this area is above 200°C. Exhaust manifold also is in contact with this area so it is in very high temperature,so it is necessary to gasket construction and material is must be perfect to seal gas and water.

III. GASKET MATERIAL

Wide varieties of materials are used in the manufacturing of gaskets. This section is aimed at providing a brief overview of the common elastomeric materials and selection of proper material for water header gasket. Gasket can be classified on the basis of material as follows:

- Metallic gasket
- Nonmetallic gasket
- Composite gasket

Among different varieties of gasket on basis of construction we are selecting edge molded gasket for water header gasket because it is more reliable and has good sealing ability and can be withstand at high temperature and pressure. Edge molded gasket is constructed as following:

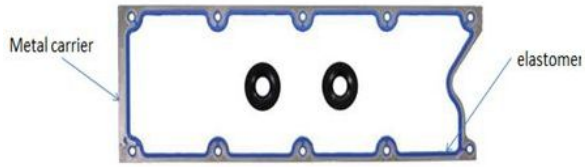


Fig.1. Basic construction of edge molded gasket[6]

Edge molded gasket have three main parts

- Elastomer
- Metal carrier
- Coating material

In this paper we are selecting only elastomer. In the edge molded gasket main sealing element is elastomer. Gasket is subjected to predetermined load of torqued bolt. Elastomer is in contact with water, high temperature, high pressure, metal carrier, water header block material, oil and exhaust gases so elastomer material selection is most critical requirement in edge molded gasket. Edge molded gasket are designed for high temperature range, long life, chemical resistance, high seal ability

Characteristics of good elastomer material

- Stable mechanical properties;
- Resistance to hardening or softening over a wide range of service temperature
- Resistant to engine oil
- Good compression set and compression stress relaxation
- Good aging in hot fuel vapors
- High fatigue life;
- Coolant chemical resistance with good heat resistance.
- Excellent bonding properties.

Various elastomeric materials used for elastomer of edge molded gasket and its properties:

They are the “entry level” to sheet sealing products. More commonly, they act as the binder when compounded with various fibers and fillers. They are made in various compositions and are available in

specification grade and commercial quality.[5]

1. *Chlorosulphonated polyethylene*
An elastomer with excellent chemical resistance against acids and alkalis. Good oil resistance and outstanding fire protection properties.

2. *Ethylene propylenediene (EPDM)*
Elastomer which offers good resistance to ozone, steam, strong acids and alkalis, but is not suitable for solvents and aromatic hydrocarbons.

3.*Fluoroelastomer*
A fluorinated hydrocarbon which offers excellent resistance to acids, aliphatic hydrocarbons, oils and many corrosive applications. Not suitable for amines, esters, ketones or steam.

4. *Natural rubber (NR)*
Excellent for recovery properties. Good resistance to most inorganic salts, mild acids and alkalis. Not recommended for oils and solvents, or where exposure to ozone, oxygen or sunlight is prominent.

5. Neoprene (chloroprene, CR)
Excellent resistance to oils, ozone and weathering. Suitable for moderate acids, alkalis, salt solutions, petroleum, solvents, oils and fuels. It is not recommended for strong acids or hydrocarbons.

6. *Nitrile (NBR)*
Improved chemical resistance and temperature capabilities over neoprene. Good resistance to hydrocarbons and oils. Not suitable for chlorinated hydrocarbons, esters, ketones and strong oxidizing agents.

7. Silicone
Excellent temperature properties, and unaffected by ozone and sunlight. Not suitable for many hydrocarbons and steam.

8.Styrene butadiene (SBR)
Suitable for use with weak organic acids and moderate chemicals. Not suitable for strong acids, most hydrocarbons or ozone.[1]

GASKET MATERIAL SELECTION

Elastomer material have the various type as per there basic construction and composition. Basic elastomer is categorized above have various property as per its composition. Graphite have high temperature capability but graphite have low creep value it is easily crack, elastomer have high compression but due to high compression carrier material get affected so it is necessary to combine various metallic material with nonmetallic material and composite material is formed they have combined properties of metallic and nonmetallic material. These satisfied the required condition of elastomer required to edge molded gasket.
Following table describes the all necessary properties and working ranges of various elastomers

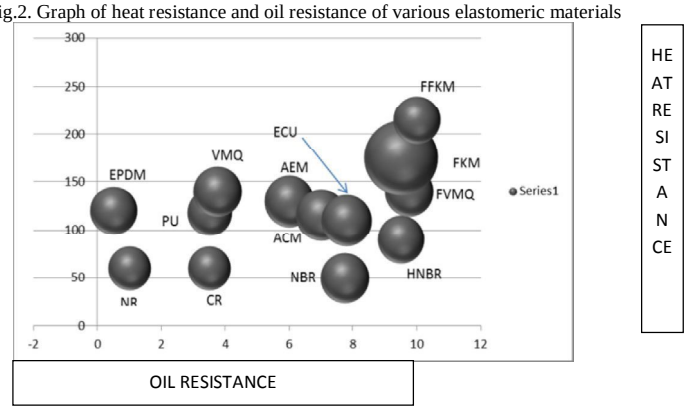
Table 1

Types of elastomers[4]

Chemical Description	Initialism	Properties	Temperature Range	Hardness Range	Chemical Defiance
Perfluoroelastomer	FFKM FFPM	Excellent chemical resistance against low molecular weight aldehydes and ketons.	From -12°C + 350°C	From 55 to + 85 m IRHD	Excellent resistance in aldehydes and ketons.
Fluoroelastomer	FKM FPM	Excellent resistance against chemical agents, lubricants , heat and flames. Outstanding behavior to compression set. Excellent behavior in ozone and U.V. rays.	From -20°C +240°C	From 50 to + 90 m IRHD	Special chemical agents for which excellent resistance in a wide temperature range is guaranteed: aliphatic, chlorinated, aromatic, hydrocarbons, fuel, mineral and vegetal oils and fats, hydraulic fluids and general.
Flurocarbon	TFE/P	Characteristics similar to fluorocarbon compounds, with higher chemical resistance in special environments. Steam, basic oils.	From -15°C +245°C	From 55 to + 85 m IRHD	In addition to chemical agents for fluorocarbon compound, good resistance to saturated steam up to 180/200°C, acids and strong mineral bases and their solutions.
Flurocarbon	TFE/P/VDF	Good resistance to steam and basic agents.	From -25°C +235°C	From 65 to + 95 m IRHD	Excellent resistance in basic oils and amines. Excellent resistance in basic oils and amines.
Fluorosilicon	FVMQ	Similar to silicon but with higher chemical resistance against lubricants oil ecc…	From -45°C +180°C	From 25 to + 85 m IRHD	Good in aliphatic hydrocarbons, mineral oils, ozone and UV, fair in fuel
Hydrogenated Nitrile Butadiene Rubber	HNBR	Excellent field of mechanical values. Excellent abrasion resistance. Good compression set. Good ageing behavior.	From -45°C +160°C	From 45 to + 80 m IRHD	Mineral oils, hydrocarbons, water, steam, gas, vegetable oils.
Ethylene-Propylene Diene Rubber	EPDM	Outstanding resistance to heat, atmospheric agents and ageing. Exceptionally low embrittlement temperature (-94°C)	From -55°C +145°C	From 55 to + 90 m IRHD	Good resistance to aggressive chemicals and to oxygenation
Silicone Rubber	VMQ	Not affected by temperature changes, excellent insulator and when properly formulated perfect no-toxicity and possibility of conductive grades.	From -70°C +190°C	From 30 to + 85 m IRHD	Very good in water solutions, exposure to weather, ozone and UV rays, in animal oils and glycols.
Nitrile Butadiene Rubber	NBR	Outstanding resistance to oils heat, and ageing. Good mechanical properties. Low compression set and low permeability to gas.	From -60°C +140°C	C From 40 to + 80 m IRHD	Minerals oils, hydrocarbons, water, steam, gas, vegetal oils.
Chloroprene Rubber	CR	Fair resistance to oils. Excellent resistance to ozone sea water and ageing. Good shear strength, abrasion and combustion resistance.	From -45°C +125°C	From 45 to + 95 m IRHD	Petroleum derivatives, sun light and atmospheric agents, ozone, flame.
Acrylic Rubber	ACM	Better resistance to oils and temperature than NBR (anti-oil)	From -30°C +155°C	From 45 to + 85 m IRHD	Aliphatic oils, heat, oxygen, ozone.

Above detail of the gasket material its hardness, temperature range, chemical properties, category of elastomer by above chart it is found that FKM is best material to elastomer. FKM has the desired properties to resist chemicals, high thermal stability also the good hardness and it give good working performance for long life. So FKM is best selection of material to water header gasket. HNBR, NBR also have desired properties but why FKM is best is compared by following two graphs. On graph FKM, HNBR, NBR, EPDM,VMQ,PU,CR material are given its properties are compared.

Fig.2. Graph of heat resistance and oil resistance of various elastomeric materials



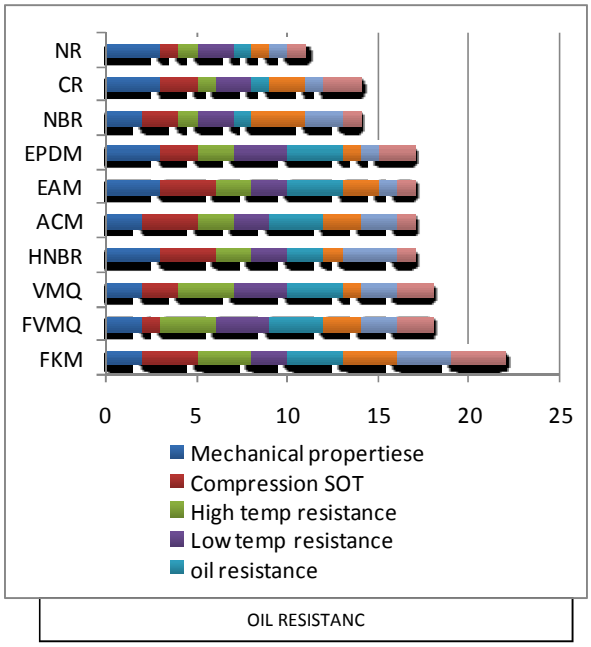


Fig.3. Graph of properties comparison of various elastomeric materials

By graph it is easily understood that FKM has the good water resistance, fuel resistance, oil resistance, ozone resistance, low temperature resistance, high temperature resistance, compression set and mechanical properties so we can conclude that FKM is good elastomer compare with NBR, HNBR and EPDM so selection of FKM is obviously convenient to edge molded gasket elastomer.

FLUOROELASTOMER MATERIAL INTRODUCTION

Fluoroelastomers are a class of synthetic rubber which provides extraordinary levels of resistance to chemicals, oil and heat, while providing useful service life above 200°C. The outstanding heat stability and excellent oil resistance of these materials are due to the high ratio of fluorine to hydrogen, the strength of the carbon-fluorine bond, and the absence of unsaturation.

ATTRIBUTES OF FKM

Fluoroelastomers are a family of fluoropolymer rubbers, not a single entity. Fluoroelastomers can be classified by their fluorine content, 66%, 68%, & 70% respectively. Fluoroelastomers having higher fluorine content have

increasing fluids resistance derived from increasing fluorine levels. Peroxide cured fluoroelastomers have inherently better water, steam, and acid resistance. Since one of the primary attributes of fluoroelastomers is its fluids resistance, it is necessary to define the capability of each type of FKM to various environments. These products have resistance to a variety of gas turbine engine oils, including high thermal stability (HTS) oils, fuels, and hydraulic fluids, but usage is not limited to such applications. Each application should be considered separately. This fluorocarbon (FKM) has a service temperature range of -60 to +400°F (-51 to +204°C) in air. Generally speaking, with increasing fluorine content, resistance to chemical attack is improved while low temperature characteristics are diminished. There are, however, specialty grade fluorocarbons that can provide high fluorine content with low temperature properties.[3]

Fluorocarbon elastomers have grown to major importance in the seal industry. Due to its wide range of chemical compatibility, temperature range, low compression set, and excellent aging characteristics, fluorocarbon rubber is the most significant single elastomer developed in recent history. Fluorocarbon elastomers are highly fluorinated carbon-based polymers used in applications to resist harsh chemical and ozone attack.
The working temperature range is considered to be -26°C to +205°/230°C (-15°F to +400°/440°F).
For short working periods it will take even higher temperatures.
Special compounds having improved chemical resistance are also available with new types always being develop

IV. CONCLUSIONS

Fluoroelastomers are a high value in use class of synthetic rubber which provides extraordinary levels of resistance to chemicals, oil and heat, and service life above 200°C which is the requirement of water header gasket. Fluoroelastomers can be fabricated into seals, O-rings, and hoses for a variety of high performance applications in the automotive, aerospace, and petrochemical industries. Fluroelastomer have wide temp range minimum to maximum so it is suitable for water header gasket. In water header gasket chemical resistance is also required, FKM have good chemical so it is desirable finely it is conclude that FKM is best material for water header gasket.

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