Fibre Gaskets- Ensuring a Sealed Market

By: Dr.J.Hayavadana &
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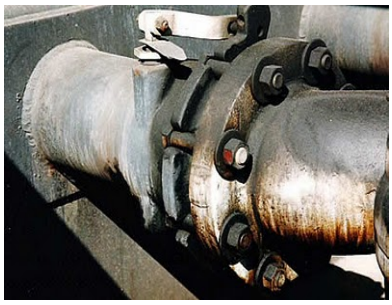
Often, we hear a lot about oil leaks from the joints between different castings of the engine, fluid leaks from the pipes, wear & tear of the flanges, and unwanted passage of the fluids. All the above phenomena are undesirable. Hence, there is an urge for a system which surpasses all the challenges and gives a good performance. It has been a biggest challenge to the engineers to design a system which ensures a seal between the flanges and remains durable over a period of time. No longer, a day has come where the gaskets, proved themselves ideal for such systems.

A Gasket is a sealing material, which is static in nature that clamps or joins two stationary parts at their faces. The joint formed may not be a fixed one, as it can be separated occasionally as per the requirement. It acts as a barrier or a separator against the fluid that is flowing through the assembly and thus blocks the leakage. Based on the type of application and its nature, the gasket must be capable of creating a perfect seal between the flanges, under all conditions and maintain it. The pressure between the gasket material and the flange is responsible for performing the real seal function preventing the fluid to escape. The gasket is selected in such a way that, it will fill the gaps and irregularities between the surfaces that are to be sealed. At the same time withstand all the conditions like temperature, pressure etc. based on the application. In order to maintain a perfect seal, the total compressive pressure on the gasket between the surfaces must be higher than pressure exerted internally by the flowing media.



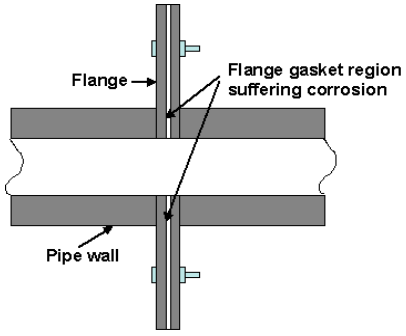


Fig.1. Gaskets

Prerequisites of Gaskets

In order to ensure a good performance based on specific usage, the gaskets should,

1. be user friendly
2. possess non stick properties with the mating surfaces
3. ensure zero leakage
4. be flexible during usage by allowing considerable expansions and contractions
5. prevent the irregularities between the mating surfaces
6. reduce the wear and tear of the flanges
7. have good tensile strength
8. be both thermal and chemical resistance
9. possess good dimensional stability and excellent recovery
10. have excellent blow out resistance and creep resistance
11. be economical and give maximum expected durability
12. have good torque retention
13. possess superior load bearing capacity
14. have good vibration resistance

Fig.2. (From left) Hydraulic gasket, Engine gasket

Selection Crediterion

The selection of the material for gasket application depends upon,

1. Chemical compatibility with the medium that is flowing through the assembly
2. Compressibility of the material to withstand loads
3. Capability to withstand various temperatures and pressures
4. Nature of the joint desired between various assemblies
5. Cost of the material
6. Environmental issues

Compatibility of the gasket with the media

The various parameters that should be taken into consideration for using a specific gasket material with respect to the media flowing through the assembly are,

1. Concentration of the fluid flowing through it
2. pH of the fluid
3. Pressure and temperature of the fluid
4. Viscosity of the fluid
5. Chemical and corrosive nature of the fluid

Suitable Materials for gaskets

The important property of the sealing material that calls for gasket application is “Compressibility”. The material selected must be compressible and should tightly fill the gap or other irregularities between the flanges. A very good material selection is always necessary and important for manufacturing a gasket. There are many materials that are widely used for manufacturing gasket like paper, elastomers, metals, fibers, coated papers etc.

Types of gaskets

On the basis of the materials used, Gaskets are categorized into three main types,

1. Metallic gaskets
2. Semi-metallic gaskets
3. Non-metallic gaskets

Metallic gaskets

Metallic gaskets are designed and made either from a single metal or an alloy containing combination of metals based on the requirements. The Gaskets are designed according to the shape, size and other desired properties based on the application. One of the important properties that must be taken into consideration while using a metal gasket is “Galvanic Corrosion” (caused due to electrochemical process). Hence appropriate care must be taken in selecting a metal for the gasket, such that it reduces the phenomenon. To prevent this, the metal must be near to the electrochemical series.

The various types of Metallic gaskets include welded, ring joints etc. A wide range of metals and alloys find application in metallic gaskets. Few of them include Carbon steel, nickel, Titanium, Aluminium, Copper, Ni/Cr/Fe alloy steel, Ni/Cr/Fe/Mo/Cu alloy steel, Ni/Cu steel. The convention of these materials is called based on the application they perform.

Fig.3. Metallic gaskets

Semi-Metallic gaskets

Semi-metallic gaskets are designed using both metallic and non-metallic components. The compatibility of both the components must be ensured to give combined performance. The metallic material provides strength, stability, resilience and the non-metallic material provides compressibility, ability to seal etc. Semi-metallic gaskets are suitable for all low, moderate, high temperatures and pressures. The various types of semi-metallic gaskets include metal reinforced soft gaskets, corrugated metallic gaskets etc.

Fig.4.Nonmetallic gaskets

Non-Metallic gaskets

Non-metallic gaskets are also referred as “Soft gaskets”. They usually contain composite sheet materials that are used for low to medium pressure applications. They mostly contain fibrous materials along with binders, elastomers and other chemicals. The compatibility of the chemicals and the base fibrous material must be ensured depending on the sealing application required.

The compressed fibre gasket materials must withstand the chemical degradation with the flow media and provide resistance. The various types of soft gasket materials include non Asbestos synthetic materials, PTFE, Asbestos fibrous base, graphite etc.

Textile fibres for gasket application

Textile fibres are widely employed for the gasket application, as they are popular for providing strength and superior temperature resistance. Both Natural and synthetic fibres offer good performance for the gaskets.

Natural fibres

As the name suggests, the fibres that are available in the nature are termed as Natural fibres. The various Natural fibres that find their application in the gaskets are,

1. Cellulosic fibres
2. Asbestos fibres

Cellulosic fibres

These are natural fibres that come from vegetable origin. They are unsuitable for high temperature and high pressure applications but can withstand low temperatures and medium pressures. Since the flow media comes in contact with the gasket, Cellulosic gaskets are resistant to almost all types of fluids except strong acids as the conditions of acidity hydrolyses the cellulosic polymer and destroys it rapidly. Cellulosic fibres have strength which can be attributed to the order and alignment of the polymer systems.

Since Cellulosic fibres are hygroscopic in nature, they naturally absorb moisture if exposed in the atmosphere, which tends to a change in the structure of the fibre. As a result the whole structure, dimensions and stability will have a effect. Hence, they can be used in combination with other fibres for the construction of gaskets.


Fig.5. (From left) Cellulosic fibres, Compressed Cellulosic gaskets

Asbestos fibres

The unique mineral fibre that occurs in nature is Asbestos. It is obtained from an ore and when crushed separates itself in the form of fibres. It has superior properties like flexibility, good strength, excellent fire and thermal resistance as it is a bad conductor of heat. It is chemically inert. The sheets containing Asbestos served many industries in the form of gaskets for the last 60 years. They proved to be virtually good in preventing the leakage between different types of joints. Day by day, Asbestos gaskets were gradually replaced by non Asbestos fibre gaskets and EPA's (Environment Protection Agency) ban on its production and distribution added to the decrease. The ban is layed due to many respirable diseases caused by inhaling the fibres like Asbestosis, Lung cancer, Mesothelamia etc. to the personnel working with it and exposed to it for a long period of time. Asbestos fibres when inhaled led to many hazardous and pulmonary toxic effects. Hence many organic fibres were made as substitutes to gaskets in many applications.

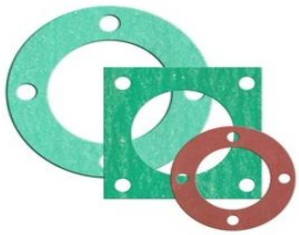



Fig.6. (From left) Asbestos fibres, CAF (Compressed Asbestos Fibre) Gaskets

Synthetic fibres

These are the fibres that are chemically synthesized by man and can be manufactured based on the desire in terms of mechanical, thermal, chemical, electrical, surface and bulk properties.

The various synthetic fibres that are usually employed in gaskets are,

1. Carbon fibres
2. Glass fibres
3. Aramid fibres
4. Mineral wool
5. Sulfar fibres
6. Ceramic fibres
7. Acrylic fibres
8. Novoloid fibres

Carbon fibres

This is one of the high performance fibre having excellent mechanical and thermal properties. It is a long thin filament having carbon as the principal constituent. The fibre is known for its excellent tensile strength, temperature withstanding capabilities upto 1500ºC and superior chemical resistance.

Various precursor materials like Rayon, PAN, and Pitch can be used for the preparation though rayon as precursor was a old method. Owing to its high thermal properties, they can be used in gaskets at high temperatures and pressures. Their superior chemical resistance offers a wide scope to the usage of various fluids and chemicals at different pH range. Comparatively they are lighter they are lighter than Asbestos with a specific gravity of 1.5-1.7.

Fig.6. (From left) Carbon fibres, Carbon fibre gaskets

Glass fibres

They are also one of the oldest yet popular high performance fibres which are not very flexible. The inflexibility can be attributed due to the high crystalline structure of this inorganic fibre. They have outstanding properties like high tensile strength, transparency, good resilience, high temperature stability.

They are prepared from silicon dioxide, Aluminium oxide, Calcium oxide and few other metal oxides. They are one among the popular industrial materials today with excellent chemical resistance, making them suitable for gasket applications with various fluids. They have good resistance to acids, alkalis etc. and are suitable for medium to high temperature gasket application.


Fig.7. (From left) Glass fibres, Glass fibre gaskets

Aramid fibres

Today, Aramid fibres are being commonly employed for most of the gasket applications. They are the most suitable reinforcing fibres for sealing applications. The gaskets with aramid fibres are enormously used for low to medium temperatures and pressures making them compatible wide range of flow media like oil, water, organic solutions, acids, alkalies and other chemicals. They have astounding properties like high chemical resistance and thermal resistance. They possess resistance to shrinkage caused by heat.

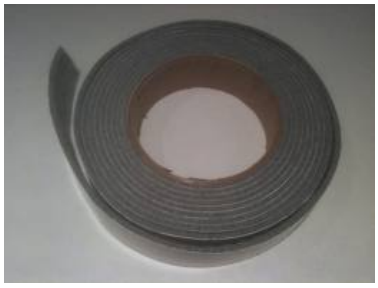



Fig.8. (From left) Aramid fibre segments, Aramid fibre gasket tape

Mineral wool

The name 'Wool' is attributed to these fibres, as when observed the fibres are randomly oriented. These are special purpose fibres that are categorized as " Synthetic Inorganic Vitreous fibres" containing metal silicates. Most of these fibres find their applications for electrical insulation, acoustical insulation and fire protection.

They are of three types namely, Glass wool, Slag wool and Stone wool, which are sometimes referred as Man made mineral fibres. The types differ in the raw materials they are made from. They find their applications in gaskets and are suitable for medium to high temperature ranges.


Fig.9. (From left) Mineral wool, MMMF gasket

Sulfar fibres

Sulfar fibre is a excellent thermal resistant fibre. The technical definition follows as the fibre in which the fibre forming substance is Polysulfide synthetic chain in which 85% of sulfide linkages are directly attached to two aromatic rings. They are used widely for gasket applications as they offer many advantages like excellent thermal resistance, superior resistance to acids, alkalis and other organic solvents. The fibres are meltspun from PPS(Poly Phenylene Sulfide) polymer.

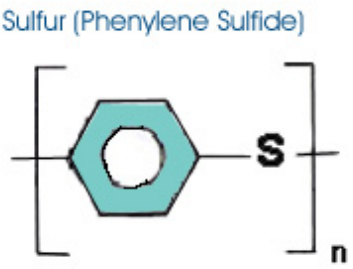


Fig.10. Sulfar fibres

Ceramic fibres

Ceramic fibres are synthetic fibres that are characterized into wide range of amorphous or crystalline forms. They are known for their superior stability at high temperatures. Hence they are usually used for high thermal and high performance applications.

They are made of alumina, silica and other monoxides which are molten and the fibrous structures are blown out of the molten mixture. They are widely used in high temperature gaskets as they can withstand very high temperatures.

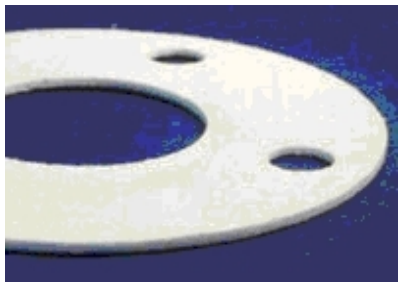


Fig.11. (From left) Ceramic fibres, Ceramic fibre gasket

Acrylic fibres

Acrylic fibres offer a wide range of their applications in gaskets. The application is attributed to their inherent properties like higher thermal resistance, excellent environmental and chemical resistance. They are resistant to most of the organic solvents, acids, alkalies and lubricants. The application of acrylic fibre for gaskets gives greater flexibility, uniformity and dimensional stability to them. They are available at moderate costs and have good tensile properties.


Fig.12. (From left) Acrylic fibres, Acrylic fibre gaskets

Novoloid fibres

Novoloid fibres are categorized under organic thermo sets, and are melt spun from Novolac resin. They are known for heat resistance and excellent resistance to many chemical and other fluids. They have high specific strength and good friction properties. They find wide applications in sealings like gaskets, as their convention is attributed to the superior resistance to steam and corrosion of flanges. Flexibility and compatibility with the matrix are excellent characteristics of these fibres. They are known under the trade name of “Kynol”.


Fig.13. (From left) Novoloid, Novoloid gaskets

Binders

Binders are the polymeric materials that are employed in gaskets, where they are used in conjunction with the compressed fibre sheet under external heat and pressure to provide bonding capacity. The various binders that are in use are,

1. Neoprene
2. Butyl
3. Silicones
4. EPDM
5. Hypalon
6. Polyurethane
7. Fluorocarbon
8. NBR & SBR

Manufacturing techniques for gaskets

According to Daniel.E.Czernik as stated and explained in [5], gaskets are manufactured using four techniques like,

1. Beater addition
2. Compressed process
3. Graphite process
4. Reinforcing process

Characterization of gaskets

Generally gaskets are tested for various physical and mechanical properties. The various tests usually practiced are,

1. Stress tests- load is applied to check leakages and dimensional changes
2. Blow out test- Gaskets are subjected to varying internal pressure and failures are analyzed.
3. ASTM F36: Compressibility of gasket materials
4. Temperature test
5. Chemical compatibility test
6. Nitrogen gas combustion test
7. Vacuum testing
8. ASTM F38: Creep relaxation of gasket materials

Defects in gaskets

Sometimes virtually, though a high quality gasket material is used, various failures may arise whose detection becomes difficult many a times. Failures of gaskets may be attributed to various factors like,

1. Type of gasket material
2. Type of fibre
3. Improper gasket selection
4. Improper thickness of gasket
5. Damage during storing
6. Damage during installation
7. Degrading over a period of time
8. Excessive pressure on gasket
9. Excessive temperatures used
10. Gasket blow out
11. Gasket reused
12. Improper alignment with respect to static flange surface
13. Improper flanges

Fig.14. Various gasket defects
Source: Sealing sense, Pumps & Systems, May 2006, January 2010

Storage of gaskets

When we value a product, the storage of the product becomes necessary, as it is the basic initial step which if properly followed ensures significant performance. Most of the products manufactured both domestic and industrial demand for the storage requirements. The gasket materials age and tend to degrade when unused, as they are exposed to various kinds of environment over a period of time. Non metallic gaskets are made of fibres, which gradually degrade, weather when exposed and since, binders are also employed in the gaskets which age and degrade, based on the type of storing conditions and the type of finish given. Improper storage of the finished gasket sheets may result in defects like Distortion, Stretching, Cracking and Sticking.

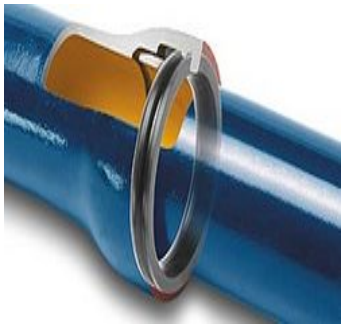
Hence the storage of gaskets becomes predominant; the various optimum storage conditions as explained in [22] are,

1. The condition of the room where the gaskets are stored must be regulated at 40-75% Relative humidity and 40-80 °F temperature.
2. It must be ensure that the storage rooms have no windows.
3. The lightning in the room should be free from UV rays.
4. The storage room should be free from dust, dirt and other chemicals

Applications

Compressed fibre gaskets are employed for various applications like,

1. providing outstanding sealing for oil, fuel and low pressure steam
2. small engine and compressor applications
3. air and coolant applications
4. providing torque retention capacity for heavy duty applications
5. usage in junctions of steam line, pipe flanges
6. Oval manhole applications
7. gaskets for hydraulic systems
8. Steam and exhaust systems
9. Refrigeration and air handling systems



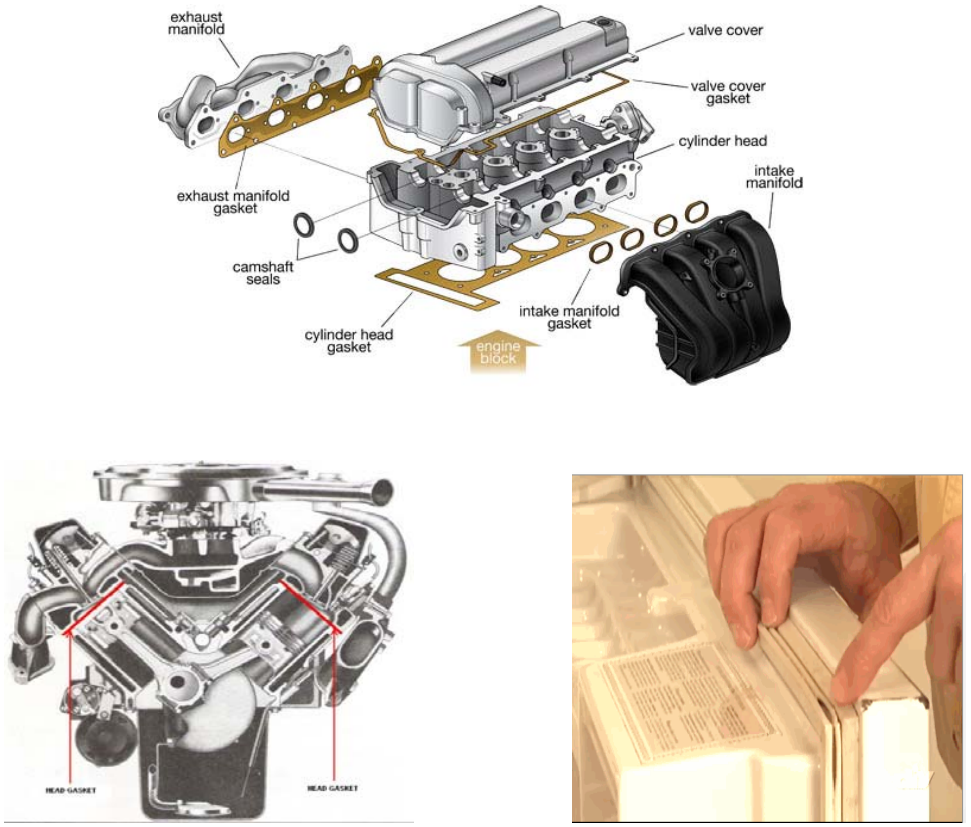


Fig.15. Figures showing gaskets used for various applications

The Market for the gaskets though decelerated during the economic recession, showed a remarkable recovery later. Since they are mainly used in the mechanical machines and allied industries, the growth is predominant and expected to go well in the years to come. The Automobile industry, being a major contributor for the economy generated shows a safe market. The driver behind the success and economy of the sealing industry would be the Non metallic gaskets, as the significant uses of Non metallic materials like Synthetic fibres and elastomers were identified and being practiced now. “Innovation” became a basic necessity for a defined product, as the competition among the players is tremendous globally. Hence, all the contributors to the gasket industry say Raw material manufacturers, converters must thrive hard to make new innovations and give their maximum contribution to create a niche market in the years to come.

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