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Review on Various Gaskets Based on the Materials, their Characteristics and Applications

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Abstract

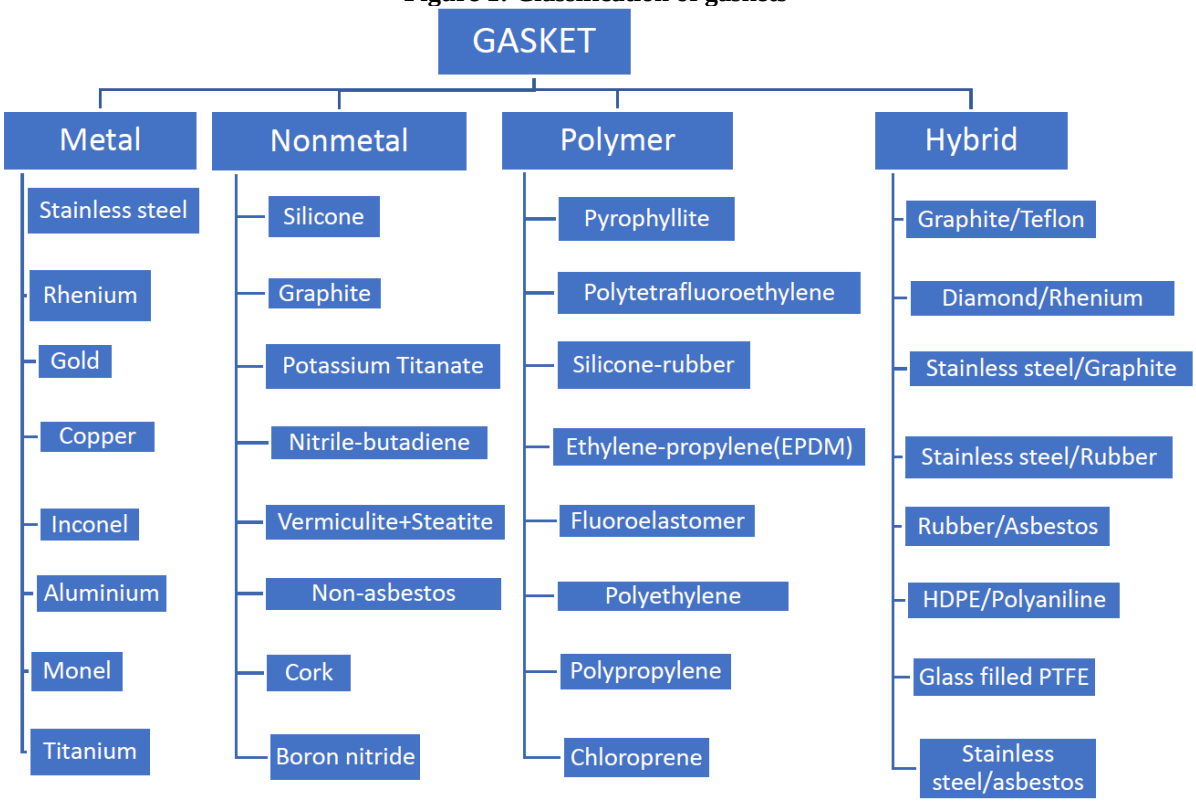
Gaskets are extensively utilized in compound and petrochemical enterprises like refineries for most high-pressure framework applications such as channelling frameworks, joint associations, and ribs. Gaskets are also utilised in internal combustion engines, devices used in the medical field, electronics and instrumentation devices, electrical devices such as motors, transformers, generators, etc. Gaskets are traditionally used to give a seal between the mating countenances of the flanged joint, filling-in surface unpleasantness, unevenness and abnormalities in the mating confronts attributable to machining and assembling flaws or impediments. When all is said and done, the reason for gasket fixing is to lessen the outflow rate of media from the framework. In this paper, we have studied about the various classifications of the gasket, their properties and applications. The preliminary studies reveal that gaskets are mainly classified into a) metals b) non-metals c) polymers d) hybrid and each gasket can be utilized for some specific applications. Selection of the wrong gasket can lead to failure of the system and cause significant damage to the surfaces.

Keywords: metal gasket; non-metallic gasket; polymeric gasket; hybrid gasket.

I. Introduction

A gasket is a compressible material or a blend of materials which when cinched between two stationary individuals, keeps the entry of the media over those individuals and keeps up a boundary against the exchange of liquid over the mating surfaces of a mechanical coupling, impervious to the medium being fixed and ready to withstand the temperature and pressure.

Figure 1: Classification of gaskets



A seal is affected by the activity of constrain, which packs the gasket, causes it to course through the miniaturized scale blemishes of the flange. The mix of contact stress, produced by the connected constrain between the gasket and the spine, and the densification of the gasket material, keeps the escape of the limited liquid from gathering. Keeping in mind the end goal is to guarantee the upkeep of the seal for as long as possible, adequate stress must stay on the gasket surface to forestall spillage. The hydrostatic end force against the gasket must be lesser than the residual bolt load on the gasket. The internal pressure that acts to separate the flanges is the hydrostatic end force. Many parameters ought to be considered while selecting a gasket to guarantee its practicality for the proposed application. Gasket properties, its configuration and application are the points of interest for the determination of the parameters. The choice of the gasket material must be done keeping in mind that it will withstand the pressure applied against the gasket, agreeably oppose the whole temperature range to which the conclusion will be uncovered and withstand destructive assault of the limited medium. Gaskets are arranged by their materials, in particular metals, non-metals, polymers and hybrid.

II. Metallic gaskets

Metallic gaskets can be manufactured in an assortment of shapes and sizes prescribed for use in high weight/temperature applications. Metallic gaskets can have creased development or they can be made as plain sheets. Metal gaskets are further classified into Stainless steel, Rhenium, Gold, Copper, Inconel, Aluminium, Monel, Titanium. Stainless steel is used as a gasket material. Stainless steel has decent corrosion resistance, decent tensile strength. It can also withstand elevated temperatures. Change in the bolt load causes deformation of the gasket. Stainless steel gaskets are used in flanges. [1] Rhenium is also used as gasket material, as it has a very high boiling point. Rhenium is one of the rarest elements on earth, thus it is costly. The use of rhenium gasket results in Less hole deformation and higher sample stability. Rhenium is used as gasket material to contain hydrogen in diamond cell experiments aimed at the metallization of hydrogen. Another application is exploration of high pressure hydride chemistry. [2] Gold is utilised as a gasket material. It is chemically very stable and malleable, but expensive. Wafer level packaging and wafer level encapsulation are applications of the gold gasket. The bond pressure applied and surface area of the gold gasket used are factors which decide the wafer gap assembly. [3] As gold is very malleable and soft, during installation of gold gaskets the gold fills in the surface irregularities providing a better sealing performance. Copper is widely utilised as a gasket material. The use of copper as a gasket material has many advantages. It is malleable as it is a soft metal. It is a good conductor of heat. Copper gaskets when used provide a good sealing capability. At high temperatures, the copper gasket expands a bit, thus providing a better seal and performance. The coefficient of thermal expansion varies with the change in the bolt load. Copper gaskets are used in a wide range of applications. It is used in internal combustion engines and other high temperature applications. [4] Inconel is also utilised as a gasket material. It exhibits properties such as corrosion resistance and high creep strength. Fatigue resistance of Inconel is also very appreciable. Therefore, Itl is highly suitable for high temperature applications. Heat exchangers, components in the aerospace industry, exhaust systems are some applications of Inconel gasket. [5] Aluminium can also be used as a gasket material. It is a soft and ductile metal. Machinability of this metal is also good. It is also light in weight. Heat and current conduction capability of aluminium is also fair. The use of aluminium gaskets in systems working under vacuum pressures will result in an efficient working system. They are used in internal combustion engines, adverse environment conditions which are prone to corrosion, vacuum pressures. [6] Monel is also utilised as a gasket material. Work hardening tends to occur quickly, thus it has poor machinability. Chemical and corrosion resistance of Monel is good. It is expensive than regular metals. It can be used for high pressure applications. Due to such properties Monel is preferred at highly adverse corrosion prone environments. Monel gasket is also used in a diamond anvil cell. [7] Titanium can also be used as a gasket material. It exhibits excellent strength to weight ratio. It is light in weight. It has a high melting point. Corrosion resistance of titanium is respectable. Titanium gaskets can be used to provide a seal when working with high temperature fluids. [8] Table 1 shows the characteristics and applications of the metallic gaskets.

Table 1: Metallic gaskets, their characteristics and applications

SR NO.	MATERIAL	CHARACTERISTICS	APPLICATIONS
1	Stainless Steel	• Decent corrosion resistance • Decent tensile strength • Can withstand elevated temperatures	High temperature applications
2	Rhenium	• Less hole deformation • Higher sample stability	High pressure applications
3	Gold	• High corrosion resistance	Small c/s area applications

4	Copper	• Good sealing capability	High temperature and pressure applications
5	Inconel	• Good corrosion resistance • High creep strength	High temperature applications
6	Aluminium	• Good corrosion resistance	Corrosion prone environments
7	Monel	• Good chemical resistance • Good corrosion resistance	High pressure applications
8	Titanium	• Good corrosion resistance	High temperature applications

III. Non-metallic gaskets

Non-metallic gaskets are generally used where corrosion resistance is of utmost importance. Low to high pressure and temperature are general applications of non-metallic gaskets. Non-metallic gaskets are highly customised to any shape and size according to the requirement. Non-metallic gaskets are extensively used where metallic gaskets are unable to provide the sealing performance required. Previously asbestos was widely used as a gasket material. But studies have shown that the use of asbestos caused health hazards and deaths. Thus the use of asbestos as a gasket is discontinued in favour of health concerns. Non-metallic gaskets are further classified into Silicone, Graphite, Potassium titanate, Nitrile butadiene, Vermiculite + steatite, Non-asbestos, Cork, Boron nitride. Silicone is utilised as a gasket material. It is heat resistant. It has fair thermal insulation as well as electrical insulation. The chemical degradation and hardness of Silicone increases with time. The dynamic mechanical properties are independent of time. Silicone is a material of choice in Proton exchange membrane fuel cell. [9] Graphite is also used as a gasket material. Graphite is a good conductor of electricity. The resistivity decreases with an increase in temperature for any thickness. With an increase in power and decrease in thickness the heat output increases which thus increases the temperature. This makes it suitable for use in Electromagnetic Interference shielding. [10, 11] Potassium titanate is also used as a gasket material. It has good chemical stability. The tensile strength is also fair. Applications are high temperature insulating material, radiation shields in vacuum furnaces and Infrared opacifier. [12] Nitrile butadiene is also utilised as a gasket material. Nitrile butadiene is resistant to normal diluted acids and alkaline. It has poor tensile strength. It can be easily stretched. Sealing at low torque is an application of nitrile butadiene. [13] Vermiculite + steatite is also used as gasket material. It can be made in the form of sheets thus manufacturing of the gasket is easy. It has good service life. There is no creep at ambient temperature and also there is no burn off at elevated temperature. It is used for sealing solid oxide fuel cells. [14] Non-asbestos can also be utilised as a gasket material. The use of asbestos created health problems thus non-asbestos materials were introduced for safe and healthy working conditions. Non-asbestos has good operating characteristics. It is used in pressure vessels and piping. [15] Cork is also utilised as a gasket material. It has good compressibility. It is also flexible. Cork gaskets are useful for low temperature and low pressure applications. Cork gaskets can also be used in feeder systems. [16] Boron nitride is also used as a gasket material. It has fair chemical resistance. Thermal stability of boron nitride is excellent. Boron nitride gaskets are utilised at high pressure applications such as diamond anvil cells. [17] Table 2 shows the characteristics and applications of non-metallic gaskets.

Table 2: Non-metallic gaskets, their characteristics and applications

SR NO.	MATERIAL	CHARACTERISTICS	APPLICATIONS
1	Silicone	• Good thermal insulation • Good electrical insulation	Low temperature and pressure applications
2	Graphite	• Good electricity conductor	High temperature applications
3	Potassium Titanate	• Good chemical stability • Good tensile strength	High temperature applications
4	Nitrile-butadiene	• Low tensile strength	Low torque applications
5	Vermiculite + Steatite	• Good service life	High temperature applications
6	Non-asbestos	• Good operating characteristics	Moderate pressure applications
7	Cork	• Good compressibility	Low temperature and pressure applications
8	Boron nitride	• Good chemical resistance • Excellent thermal stability	High pressure applications

IV. Polymeric gaskets

Polymeric gaskets are synthetic materials used in the industry. They offer exceptional corrosion resistance while maintaining a good sealing performance. Polymeric gaskets are further classified into Pyrophyllite, Polytetrafluoroethylene (PTFE), Silicone rubber, Ethylene-Propylene-Diene(EPDM), Fluoroelastomer, Polyethylene, Polypropylene, Chloroprene. Pyrophyllite is utilised as a gasket material. It has excellent thermal stability and it has good machinability. Pyrophyllite has good pressure-transmitting efficiency. Large volume presses use pyrophyllite as a gasket material. [18] Polytetrafluoroethylene is also used as a gasket material. PTFE is hydrophobic in nature and has a very low coefficient of friction. Thermal stability and compressibility of PTFE is also good. At higher temperatures the mechanical strength of PTFE undergoes major deterioration. PTFE has widespread applications in fluid sealing and gasketing. [19] Silicone rubber is also used a gasket material. Silicone rubber has extreme resistance to temperature and environmental conditions. It is stable in nature and can be easily shaped and sized as per requirement. It operates exceptionally at low and high temperatures. It is a material of choice for moderate strength and elasticity applications. [20] Ethylene propylene diene monomer is utilised as a gasket material. It has exceptional insulating ability to electricity. EPDM is easily stretched. It has low tensile strength. Chemical stability of EPDM is fair. Applications of EPDM include sealing gaskets in tunnel segment joints, polymer electrolyte membrane fuel cells and stacks. [21, 22, 23] Fluoroelastomer is also utilised as gasket material. It has excellent operating performance at elevated temperatures. It has good chemical stability against degradation. It is used in polymer electrolyte membrane fuel cells and stacks. Polyethylene is used a gasket material. Ductility of Polyethylene is very good. The heat resistance of Polyethylene is good and the tensile strength is also average. It has commendable electrical insulating properties. Resistance to petroleum based products of polyethylene is adequate. It is a good choice for moderate strength and elasticity applications. Polypropylene is also utilised as a gasket material. It is not expensive. Electrical insulation of polypropylene is also fair. It has good abrasion resistance too. It is reliable to use. It is flexible and has fair strength. One thing to keep in mind that UV radiation causes degradation of this material. Polypropylene gaskets can be utilised at many places. Polypropylene is used in lithium ion batteries as a gasket. [24] Chloroprene is also used as a gasket material. Weathering resistance of chloroprene is good. Resistance to petroleum based fluids is moderate. Ozone resistance is outstanding. Applications include sound isolation on windows with fair results. Another application includes use of chloroprene gasket in the marine industry. [25] Table 3 shows the characteristics and applications of polymeric gaskets.

Table 3: Polymeric gaskets, their characteristics and applications

SR NO.	MATERIAL	CHARACTERISTICS	APPLICATIONS
1	Pyrophyllite	• Excellent thermal stability • Good pressure transmitting capability	High pressure applications
2	PTFE	• Good compressibility • Good thermal stability	Corrosion prone environments
3	Silicone-rubber	• Good machinability • Temperature resistant	Low and high temperature applications
4	EPDM	• Excellent insulator of electricity • Low tensile strength	Low temperature and pressure applications
5	Fluoroelastomer	• Excellent operating performance at elevated temperatures. • Good chemical stability	High temperature applications
6	Polyethylene	• Good heat resistance • Average tensile strength • Good electrical insulation	Moderate strength applications
7	Polypropylene	• Good electrical insulation • Good abrasion resistance • Fair strength	Corrosion prone environment
8	Chloroprene	• Good weathering resistance • Moderate resistance to petroleum based fluids	Sound insulation

V. Hybrid gaskets

Hybrid gaskets consist of a combination of metallic and non-metallic materials. Hybrid gaskets offer the features of metallic gaskets and non-metallic gaskets both in one material. The high sealing performance of non-metallic gaskets and the strength of metallic gaskets can be combined in a hybrid gasket. Applications of hybrid gaskets include high and low temperature and pressure applications. Hybrid materials are further classified into Graphite/Teflon, Diamond/Rhenium, Stainless steel/Graphite, Stainless steel/Rubber, Rubber/Asbestos, HDPE/Polyaniline, Glass filled PTFE, Stainless steel/Asbestos. Graphite/Teflon is utilised as a gasket material. The gasket provides a good sealing performance. Optimum pre-stresses should be given to avoid slippage of the gasket. The gasket can be used for high temperature applications. [26] Diamond coated rhenium is also utilised as gasket material. It can withstand high operating pressures. It is used in Diamond anvil cell (DAC). [27] Stainless steel with graphite is also used as a gasket material. Due to its structure and reinforcements, it can withstand high temperatures. Chemical resistance of this material is also good. Machinability is also decent. It has fair gasket seating stress. It is used in pressure vessels and piping. Stainless steel with rubber can also be used a gasket material. It has a higher contact pressure which results in a better sealing performance. Applications include head gaskets in diesel engines. [28] Rubber with asbestos is used as a gasket material. Sealing capability of rubber with asbestos is dependent on the thickness of the gasket used. Applications formerly included joints and pipes of pressure vessels subjected to variable pressures. [29] High density polyethylene (HDPE)/Polyaniline is also used as a gasket material. HDPE has high strength to density ratio. It has good corrosion resistance. Polyaniline has good electrical conductivity. It has fair tensile strength. Applications include electromagnetic shielding. It is used in high pressure applications also. [30] Glass filled PTFE is also used as a gasket material. The use of glass filled PTFE results in increase in compressive strength. Reduction in creep is also noted. The functional life of the gasket is also good. Glass filled PTFE gasket is used in the aircraft industry. Areas that require reduction in the cold flow, glass filled PTFE is used. [31] Gaskets made out of stainless steel with asbestos are also used. The outer ring is made of stainless steel and the filler used is asbestos. Instead of asbestos any other filler may also be used. Pipe flange connections use stainless steel with asbestos as a gasket material. The performance of the gasket is good. [32] Table 4 shows the characteristics and applications of hybrid gaskets.

Table 4: Hybrid gaskets, their characteristics and applications

SR NO.	MATERIAL	CHARACTERISTICS	APPLICATIONS
1	Graphite/Teflon	• Good sealing performance	High temperature applications
2	Diamond/Rhenium	• Good strength	High pressure applications
3	Stainless steel/Graphite	• Good chemical resistance • Fair gasket seating stress	High temperature applications
4	Stainless steel/Rubber	• Good sealing performance • Higher contact pressure	High temperature and pressure applications
5	Rubber/Asbestos	• Good temperature resistance	Variable pressure applications
6	HDPE/Polyaniline	• Good corrosion resistance	High pressure applications
7	Glass filled PTFE	• Good compressive strength • Good creep resistance • Good functional life	High temperature applications
8	Stainless steel/Asbestos	• Good gasket performance	High pressure applications

VI. Conclusion

Various gaskets are used in the industry as per the requirement and application. Selection of gaskets for an application depends upon the various parameters such as operating conditions, cost, gasket properties, etc. Metallic gaskets have high tensile strength and high creep resistance thus they are used in high temperature and high pressure applications. Non-metallic gaskets offer good chemical stability and average tensile strength and thus are used for low-medium temperature and low-medium pressure application. Polymeric gaskets have good pressure transmitting efficiency and good thermal stability making it feasible to be used in moderate pressure applications. Hybrid gaskets have a mixture of the properties of metallic and non-metallic gaskets. They have the strength of metallic gaskets and the chemical stability of non-metallic gaskets and hence they are widely used in high and low pressure and temperature applications.

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