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Review on non-woven polymeric Gaskets 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 non-woven polymeric gaskets are mainly classified into a) Polymer with metal gasket b) Polymer with metal non-metallic gasket c) pure polymeric gasket d) hybrid polymeric gasket 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: Polymer with metal gasket; Polymer with non-metallic gasket; pure polymeric gasket; hybrid polymeric gasket.

I. Introduction

Gaskets are used in major manufacturing sectors such as aerospace, automotive, electronics and military industries. Gasket is a sealing device molded in shape of ring or sheet. Gaskets are made of deformable materials. Gaskets prevent unwanted gas or liquid emissions between stationary components, relying on a compression seal by creating a pressure-tight seam. Their are many specifications for gaskets. Gasket selection is an important step in the manufacturing processes.

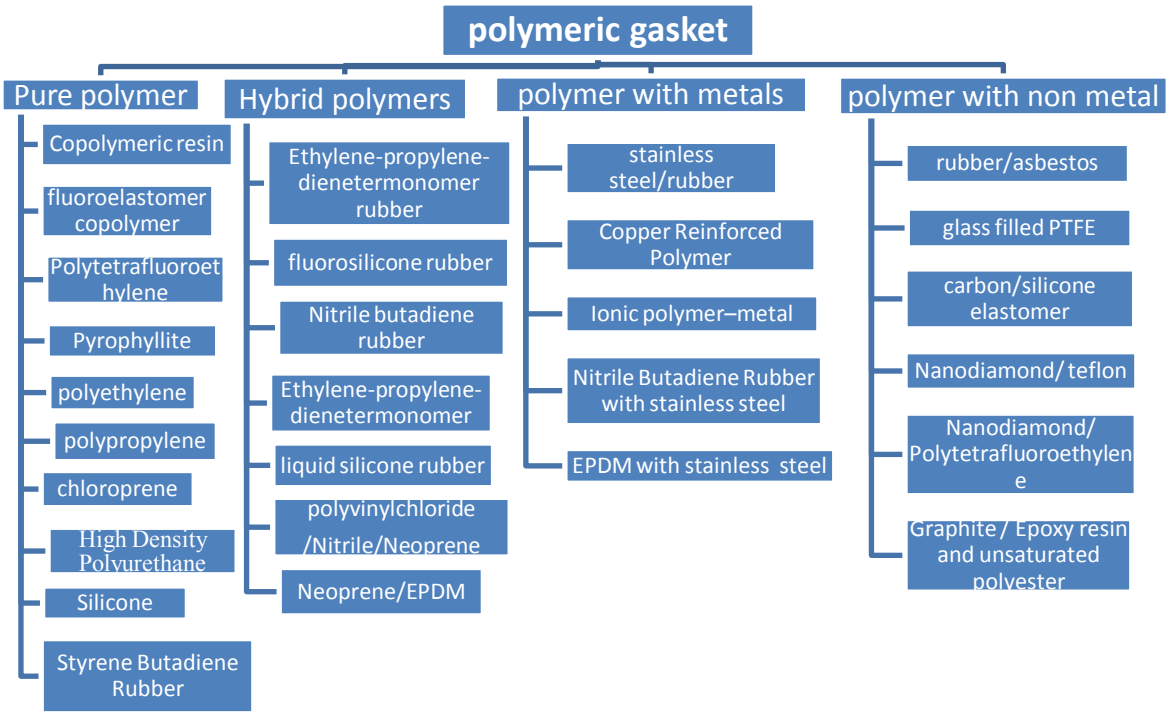

Figure 1: Classification of Polymeric gaskets

A seal is affected by the activity ofconstrain, 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. Excellent properties are shown by the polymeric composition used in making seals and gaskets. These polymeric gaskets offer. Excellent dimensional stability, sealing characteristics, low compression set and temperature flexibility is shown by polymeric gaskets. Its resistance to heat and ultra-violet light is also good. Polymeric Gaskets are arranged by their materials, in particular pure polymer, hybrid polymers, polymers with metals and polymer with non-metals.

II. Pure polymer

Copolymeric resin elongation is 400%, Relative density/g cm_3 is 1.08, Tear strength/PPI is 241, Tensile strength/Mpa is 9 and Work temperature/_C is (-40 to 316) [1]. It is used for proton exchange membrane (PEM) fuel cell seal applications. Fluoroelastomer copolymer[2] has elongation of 200%, Relative density/g cm_3 is 2, Tear strength/PPI is 144, Tensile strength/Mpa is 9 and Work temperature/_C is (-7 to 200)[3]. It is used for the same as the copolymeric resin for PEM fuel seal applications[4]. Its Hardness is 60 to 90, Compression Set, flex cracking resistance, abrasion resistance, tear resistance, flame resistance is good[5]. Its Rebound Rating in Cold as well hot is Good excellent. Its service temperature is from -20 to 600°F. It has Recommended Shelf Life of 20 years. Its resistance to weather, sunlight, ozone, water, is outstanding. Its resistance to steam, radiation and gas permeability is fair. It has high-performance applications[6]. Polytetrafluoroethylene(thermoplastic polymer) has excellent seal ability[7] . Its resistance to creep and cold flow is good. It is used in fluid sealing applications[8] . The compressive modulus of PTFE gaskets decreases rapidly when the temperature increases from room temperature to 200 _C[9]. It has temperature dependent properties. It has the density of 2200 kg/m^3. Its melting point is 600 K[10] . It has high strength, toughness, and self-lubrication at low temperatures down to 5 K, and good flexibility at temperatures above 194 K[11] . Its Thermal expansion is 112–125 · 10^{-6} K^{-1}, Thermal diffusivity is 0.124 mm^2/s, Young's modulus is 0.5 Gpa, yield strength is 23 Mpa and Coefficient of friction is 0.05-0.10. Pyrophyllite is easy to prepare and has the good isotropic characteristic[12] . The pyrophyllite cube is used as the gasket material for the cubic press. It has hardness of 1 to 1.5. It has the density of 2.65 - 2.85[13] . Polyethylene has a very good ductility, the heat resistance of Polyethylene is good and the tensile strength is also average[14] . It has commendable electrical insulating properties. Resistance to petroleum based products of polyethylene is adequate[15] . It is a good choice for moderate strength and elasticity applications. Its strength, hardness, and rigidity are low. Its ductility, impact strength is high and low friction. It feels waxy when touched. Its melting point is 80 °C (176 °F). It has a good electrical insulating property. Polypropylene is not expensive. The Electrical insulation of polypropylene is fair. It has good abrasion resistance too[16] . 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 utilized at many places and also used in lithium ion batteries as a gasket[17] . It has density of 0.895 - 0.92 g/cm^3. Its Young's modulus is 1300-1800 N/mm^2 and has good resistance to fatigue. Perfectly isotactic polypropylene melting point is 171 °C (340 °F), Commercial isotactic polypropylene melting point is 160 - 166 °C (320 - 331 °F) while Syndiotactic polypropylene melting point is 130 °C (266 °F). Below 0 °C, polypropylene becomes brittle. Polypropylene resistance to fats and the organic solvent is good but resistance to strong oxidants is poor. Chloroprene has a good weathering resistance property. Its Resistance to petroleum based fluids is moderate. Its Ozone resistance is outstanding. Its Applications include sound isolation on windows with fair results, also chloroprene gaskets are used in the marine industry. High-Density Polyurethane (PHU) behaves like a closed cell foam product when compressed[18] . It has lower compression set than typical closed cell foam gaskets. Its Density is 15 lb/ft^3, its working temperature is -45 - +212°F. Its Applications include gaskets and seals around equipment doors as well as mounting and protective pads. Styrene butadiene rubber has Low-Temperature Usage of -50°F | -45°C and High-Temperature Usage Up to 225°F | 107°C[19] . It has excellent adhesion to the metal characteristic and abrasion resistance[20] . It's Solvent Resistance and oil resistance is Poor. Its hardness is 30-100, its Tensile Range is 500-3000 P.S.I, its Elongation (Max %) is 600, its Compression Set is Good[21] . It is widely used in the Mining equipment, Synthetic Rubber Seals, Custom molded rubber components for plumbing applications. Silicone has hygienic applications[22] . It Max Temperature Range is -100°C - 250°C. Its temperature resistance, UV resistance, ozone resistance and weather resistance is excellent[23] . It has Very good dielectric properties. Its tensile strength, tear resistance, resistance to solvents, oils, and concentrated acids is poor.

Table 1: Metallic gaskets, their characteristics and applications

Sr no.	Material	Characteristics	Application
1.	Copolymeric resin	Elongation-400%. Relative density/g cm_3 -1.08. Tensile strength/Mpa – 9. Work temperature -40 to 316°c	Used for PEM fuel cell seal applications.
2.	Fluoroelastomer copolymer	Elongation-100% to 500%. Hardness Range is 60 to 90. Service Temperature is 20 -600°F.	Used in high-performance applications like in aerospace, automobiles etc.
3.	Polytetrafluoro ethylene	Its melting point is 600 K. Young's modulusis 0.5 Gpa. Coefficient of friction is 0.05-0.10.	Used in fluid sealing applications.
4.	Pyrophyllite	Hardness is 1 to 1.5. Specific gravity is 2.65 - 2.85.	Used as the gasket material for the cubic press.
5.	Polyethylene	Has high ductility and impact strength Has low friction. Melting point is 80 °C (176 °F).	It is used for packaging purpose.
6.	Polypropylene	Its Density is 0.895 - 0.92 g/cm³. Its Melting point is 171 °C. It becomes brittle below 0 °C.	Used in the making of flip-flop, chairs, piping materials.
7.	Chloroprene	Has a good weathering resistance property.	Chloroprene gasket is used in marine industry.
8.	High-Density Polyurethane	Its Density is 15 lb/ft³. Its Temperature Range is -45 to +212°F	Used in seal gaskets around equipment, doors and mounting.
9.	Styrene butadiene rubber	Its hardness is 30-100 Its Tensile Range is 500-3000 P.S.I Its Elongation is 600%	SBR rubber pads Synthetic Rubber Seals
10	Silicone	Its Temperature Range is -100- 250°C. Its temperature resistance is excellent.	Food and beverage applications.

III. Polymer with metal

Rubber mixed with stainless steel has a higher contact pressure which results in a better sealing performance[24]. Its Applications include head gaskets in diesel engines. It has High temperature and pressure applications. Its Thermal conductivity depends on the thermal conductivity of the filler particles, its shape, size, the volume fraction and spatial arrangement of the filler particles in the polymer matrix. The addition of the copper fiber increases the thermal conductivity of the composite. Copper fibre is the most enhancing agent on the thermal conductivity of the composite[25] . Ionic polymer–metal composites are used as soft biomimetic sensors and actuators[26] . They work very well in a liquid environment as well as in the air[27] . They have a force density of about 40 in a cantilever configuration. IPMCs in actuation, sensing, and energy harvesting have a very broad bandwidth to kilo HZ and higher.Nitrile Butadiene Rubber with stainless steel is certified for use with gas and drinking water[28] . There is no need for double storage also no danger of mixing parts up[29] . Its Working temperature ranges from (-30) to (100). EPDM with stainless steel is certified for use with drinking water supplies. Its Working temperature ranges from (-40) to (110).

Table 2: Metallic gaskets, their characteristics and applications

Sr no.	Material	Characteristic	Application
1.	stainless steel/rubber	High sealing performance.	Used as gaskets in diesel engines
2.	Copper Reinforced Polymer	High thermal conductivity.	Used in high-temperature areas.
3.	Ionic polymer–metal composites	Force density is 40 in the cantilever configuration.	Used as biomimetic sensors and actuators.
4.	Nitrile Butadiene Rubber with stainless steel	temperature ranges from -40 to 110°c	Used for drainage applications.
5.	EPDM with stainless steel	Temperature from -50 to +150 °C	used for drinking water supplies

IV. Polymer with non-metals

Rubber with asbestos Sealing capability is dependent on the thickness of the gasket used. Its Applications formerly included joints and pipes of pressure vessels subjected to variable pressures. Asbestos rubber sheet (paragonite) is designed as light duty gasket material. It's working temperature ranges from -60℃ to 450℃. Its density is 1.7 – 1.9g/cm3, its tensile strength in the cross section is 11.0MPa. Glass filled PTFE use, results in the increase in compressive strength. 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. Carbon/silicone elastomer has good mechanical properties[30] . It can withstand high clamping force in stack assembly. Its Young's modulus and tensile strengths are 39.9 Gpa and 161.3 Mpa[31] , respectively, at 20 _C. At 200 _C, Young's modulus and tensile strengths are 35.8GPA and 126.9 Mpa, respectively, which were 10.2% and 21.3% lower compared to the properties obtained at 20 _C, respectively[32] . Teflon/Nanodiamonds can be used in gaskets, bearings, and sealing for heavy duty applications as a substitute for bronze components. Nanodiamond/ Polytetrafluoroethylene Has got more abrasion resistance in practice and could replace conventional materials[33] . In Graphite / Epoxy resin and unsaturated polyester, Polystyrene of expanded graphite filled composites occurred at ∼1.0 wt. % EG loading in the epoxy and polyester matrices. Expanded graphite and milled expanded graphite are used as Nanofillers[34] . Polystyrene of epoxy/milled expanded graphite composite is at ∼5 wt.% filler and that of polyester/milled expanded graphite composite is at ∼2 wt.% filler loading. It is used in capacitors, sealing gaskets, etc.

Table 3: Metallic gaskets, their characteristics and applications

Sr no	Material	Characteristics	Application
1.	Rubber/asbestos	Temperature ranges from -60℃ to 450℃.	Used in joints and pipes of pressure vessels.
2.	Glass filled PTFE	Temperature ranges from -60℃ to 450℃. Its density is 1.7 – 1.9g/cm3. Its tensile strength is 11.0MPa.	Used in the aircraft industry
3.	carbon/silicone elastomer	Tensile strength at 20_C:-161.3MPa Tensile strength at 200_C:-126.9MPa	Used where mechanical applications are needed.
4.	Nano diamond/ Teflon	It has lowest friction coefficient	Used to make gaskets and bearing for heavy-duty applications
5.	Nano diamond/ Polytetrafluoroethylene	High abrasion resistance.	Can be used in mechanical parts instead of bronze.
6.	Graphite / Epoxy resin and polyester	High tensile strength, High fatigue resistance	Used to make capacitors, sealing gaskets etc.

V. Hybrid polymers

Ethylene-propylene-dienetermonomer is used as sealing materials in segmental joints[35]. Tensile strength and elongation at break of the material decrease with increase in aging temperature and time. It is used for tunnel segment joints. Its Hardness is 30A to 95A, Tensile Strength is 7 to 21MPa and ultimate is 25MPa, elongation is 100-600%, its compression is 20-60% and its working Temperature is -50 - +160°C. Its resistance to tear, abrasion is good. Its electrical properties are excellent. Its Density is 0.90 to >2.00 g/cm^3. It has glass transition temperature of −54 °C. Copolymeric resin has elongation-400%, Relative density/g cm_3 is 1.08, Tear strength/PPI is 241, Tensile strength/Mpa is 9 and Work temperature/_C is (-40 to 316). It is also used for PEM fuel cell seal applications. Ethylene-propylene-dienetermonomer with rubber is used as sealing material in segmental joints[36] . EPDM resistance to heat, light, and ozone and UV exposure is excellent. It has elongation of (100-600) %, Relative density/g cm_3 is 0.90 to >2.0, Tear strength/PPI is 200, Tensile strength/Mpa is 25 and Work temperature/_C is (-20 to 250)[37] . It has no effect of either heat or solar radiation[38] . Tensile strength and elongation at break of the material decrease with increase in aging temperature and time. Liquid silicone rubber[39] has elongation of >=300 %, Relative density/g cm_3 is 1.43, Tear strength/PPI is 100, Tensile strength/Mpa is 8 and Work temperature/_C of (-60 to 220). It's also used for PEM fuel cell seal application. They can remain flexible at temperatures as low as -40˚C. Liquid silicone rubber parts are chemically inert, hypoallergenic and resistant to bacteria growth[40] . Its Density is 1.6 g/cm^3 (100 lb/ft^3), Elongation at Break is 290 %, and Strength to Weight Ratio is 3.9 kN-m/kg[41] . Its working Temperature Range is – 85 to450 ° F. Its Hardness is 35 – 80 Shore A f, Tensile Strength Range is 200 – 1,500 PSI. Its resistance to high temperature is excellent. Silicone rubber is highly inert and does not react with most chemicals. It is used to make pistons, gaskets, flow regulators, respiratory masks, cosmetics and optics

products[42] . Nitrile butadiene rubber working Temperature is -54- 121°C. It resistance to oils, solvents, fuels, abrasion, and tear is good[43]. It is Preferred for applications with Nitrogen or Helium. Its resistance to UV, ozone, ketones and hydrocarbons is poor. It also is used in Aerospace & Automotive Fuel Handling Applications. Vinyl Nitrile (PVN) is a Vinyl/Nitrile/Neoprene closed cell foam designed for use as a gasket or seal in a variety of environments. Its resistance to gasoline and other aliphatic hydrocarbons is excellent. Its Density is 7-9 lb/ft³, its Temperature is -20 to +200°F. Its Compression deflection (25% deflection) in psi is 9-13 (KN/m2),, its minimum Tensile strength (min) in psi is 100 (KN/m2) and Elongation (min) in % is 100 . It's used to make gaskets and seal for engine enclosure and equipment. Neoprene Blend Foam (PNB) is a Neoprene/EPDM closed cell blend foam. Its resistance to weather, oxidation, and ozone is good. It has Temperature Range of -40°F to +250°F. Its Compression deflection in (25% Deflection) psi is 17-25(kN/m2), Tensile strength (typical) in Psi is 150, and Elongation (min) in % is 125.

Table 4: Metallic gaskets, their characteristics and applications

SR NO.	Material	Characteristics	Application
1	Ethylene-propylene-dienetermonomer	Hardness is 30A to 95A. Tensile Strength is 7 to 25MPa. Elongation 100 to 600%, Temperature Range is -50°C to +160°C.	Used as sealing materials in segmental joints.
2	Ethylene-propylene-dienetermonomer rubber	Good resistance to heat, light, and ozone. Elongation 100 to 600 percentage. Working temperature from -20 to 250oc.	Used as sealing material in segmental joints.
3.	Fluorosilicone rubber	Relative density 3-1.43 g/cm. Tear strength/PPI -100. Tensile strength/Mpa- 8. Work temperature/_C (-60 to 220).	Used for PEM fuel cell seal application
4	Liquid silicone rubber	Density is 1.6 g/cm3 (100 lb/ft3). Elongation at Break is 290 %. Temperature Range is (- 85º to + 450º F), Hardness Range 35 – 80 Shore A. Tensile Strength Range 200 – 1,500 PSI.	Used in medical applications such as medical implants.
5	Nitrile butadiene rubber	Temperature Range is 54- 121°C. Resistance to solvents, fuels, and oil. Good abrasion and tear resistance.	Used in Aerospace & Automotive Fuel Handling
.6.	Polyvinylchoride/Nitrile/Neoprene	Typical Density: 7-9 lb/ft³. Temperature Range: -20°F to +200°F. Tensile strength (min) psi: 100 (KN/m2). Elongation (min), %: 100. Water absorption, Max weight change, %: 5.	Used to make gaskets and seal for engine enclosure and equipment.
7	Neoprene/EPDM	Tensile strength (typical) Psi: 150. Elongation (min) %: 125. Typical Density: 10-14 lb/ft³. Water absorption, maximum weight, %: 5 Temperature Range: -40°F to +250°F	automotive and industrial products

VI. Conclusion

Gaskets can be made from metals, rubbers, plastics, corks, foams, and composite substances. Combination of gasket material and design depends on the gasket's specific uses and the cost parameters of the project. Selection of gaskets for an application depends upon the various parameters such as operating conditions, cost, gasket properties, etc. Polymeric gaskets have good pressure transmitting efficiency and good thermal stability making it feasible to be used in moderate pressure applications. There are devices that are better-suited for certain tasks, While gaskets serve an important function as sealing joints. Gasket is used as a seal, that forms a barrier between external and internal elements such as to prevent water leakage. While to fill small assembly gaps between components, spacer, or "shim," which is a narrow wedge are used by manufacturer for packing or levelling purposes. O-rings, which are similar to gaskets, has different use. O-rings are made of synthetic rubber

or plastic polymers with elastomeric properties. They are durable and reliable . They seal components by creating a barrier around an area with leakage potential.

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