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Introduction – Background and Reasons for Using Rubber as a Construction Material

1.1 Background

Prior to 1929, chemical process industries faced perplexing and growing problems. As more and more corrosive chemicals and compounds came into use, the need for a reliable and durable method of protecting mild steel and concrete storage tanks, process vessels, pickling lines, mixers, reactors, agitators, pipelines, tank trucks, railroad tank cars, ship tankers, and exhaust gas scrubbers against corrosion became imperative and the use of rubber as a construction material began to be recognized universally. The rubber industry, which was hitherto engaged in the technology development of consumer rubber products starting from erasers, raincoats, footwear play balls etc; to engineering products such as rubber tyres, and multifarious rubber components for all engineering applications, became alert to these problems of the chemical industry and introduced the first rubber lining in 1929 [1].

Since the advent of the first rubber lining, research and development work continued and today's rubber technology took a different shape from eraser-to-tyre technology to a more sophisticated high technology discipline known as anticorrosive rubber or acid resistant rubber technology, which is eminently and reliably depended upon by the process industries. Rubber as a material of construction was viewed with more seriousness than ever before by the chemical engineers and well recognized by the chlor-alkali, fertilizer and mining industries and the chemical processes in the oil well and nuclear industries. Today with higher temperature operations and with more complex and critical duty conditions such as nuclear radiation and high degree of thermal abuse as ablation in the rocket industry and mechanical abuse in ore mining industries, and other severe environmental conditions prevailing in the oil well industries, the rubber technologist is faced with challenges in the art of developing newer rubber compositions, compounding and processing technologies which are quite different from practices adopted for conventional products. The chief characteristics which make rubber of great importance to the mechanical or structural and chemical engineers are its strength, the adhesion and strength of its bonding to metals and other substrates, its all-round deformability which enables it to be used in extension, compression, shear, torsion or combinations of these, its resilience, its resistance to fatigue, its resistance to attack by corrosive chemicals, its resistance to abrasion, its good electrical properties, its wide latitude of properties by compounding and its ease of molding or forming to any shape and size. Rubber however has some limitations such as swelling in oils, ageing, ozone attack, and attack by flame, although most of them can be overcome to a great extent by compounding techniques and with the use of specialty synthetic rubbers. Acrylonitrile rubber can be used for oil resistance,, and the use of neoprene rubber and antioxidants in liberal doses greatly improves resistance to ageing and weathering, ozone attack and attack by flame.

Among the many reasons why rubbers are widely used in the process industries, three are considered as important. Firstly, rubber operates in a variety of environments and has usable ranges of deformity and durability and can be exploited through appropriate and more or less conventional equipment design principles. Secondly, rubber is an eminently suitable construction material for protection against corrosion in the chemical plant and equipment against various corrosive chemicals, acids and alkalies with minimum maintenance lower down time, negligible scale formation and a preferred choice for aggressive corroding and eroding environment. Thirdly, rubber can readily and rapidly, and at a relatively lower cost, be converted into usable products, having complicated shapes and dimensions.

Rubber is also used for protection of other materials against fire, heat and wearing. Rubber gives excellent performance as a construction material, in vibration and shock dampening, in elimination of structural noise and is the ultimate material for sealing systems. All basic properties are more or less present in all types of products. For each application individual functional properties are optimized to meet specific requirements.

Before going further into the various functional characteristics of rubber it is worthwhile to know the meanings of the terms "elastomer" and "polymer" which are synonymous with the term, "rubber" which means a material that when rubbed erases a pencil or pen mark. Michael L. Berins [2] describes the above terms in the following manner.

1.2 Elastomer

A material which at room temperature stretches under low stress to at least twice its length and snaps back to the original length upon release of the stress.

1.3 Polymer

A high molecular weight organic compound, natural or synthetic, whose structure can be represented by a repeated small unit, the monomer (e.g., polyethylene, isoprene and cellulose). Synthetic polymers are formed by the addition or condensation polymerization of monomers. If two or more different monomers are involved, a copolymer is obtained. Some polymers can be rubbers and some can be plastics. Plastics which are also high polymers can include both natural, or synthetic products but exclude rubber whether natural or synthetic. At some stage in its manufacture every plastic is capable of flowing under heat and pressure into the desired final shape.

1.4 Rubber

Any elastomer capable of rapid elastic recovery after being stretched to at least twice its length at room temperature from 0°F to 150°F at any humidity. Hevea or natural rubber can be considered as an elastomer.

Since the terms rubber, polymer and elastomer are synonyms, throughout this book these terms are used interchangeably.

Hishfeld and Pison [3] were quoted by W.J.S. Naunton as stating that rubber will never attain the position it deserves in the field of engineering until it has been investigated comprehensively and its behaviour can be calculated and measured in the same way as that of steel. However, the prediction of Hishfeld and Pison has not been proved to be true, since rubber is extensively used in mechanical, chemical and various other engineering fields including today in the nuclear industry, and it is used so, because it can do something which steel cannot do, namely combine softness and hardness in the same material due to its ease of deformation and more credibly can resist corrosion of acids and erosion of ores. It was not intended to be used as a construction material during the early times of its discovery, but at later stages it offered numerous possibilities with its specialty characteristics in developing various applications in the chemical process industries, and during the past several decades it has been an accepted and recognized material of construction world wide for many industries facing corrosion. Today rubber is indispensable.

1.5 Rubber Dampens

Rubber dampens by transforming kinetic energy into static energy. This basic rubber property is utilized in protection against explosion and impact and effectively reduces or eliminates noise, vibration and water hammer in pipelines and reaction tanks with agitators.

1.6 Rubber Seals

Rubber has very good sealing properties due to its pliable and elastic behaviour and is the best choice to make oil, water and gas tight seals in the most demanding environments in the chemical and other engineering industries.

1.7 Rubber Protects Corrosion Effects

Rubber is chemically resistant to most corrosive liquids, gases, salt water, ozone and UV light. These corrosive agents are commonly encountered in process industries, shipping and the offshore sector. Where steel is exposed to corrosion, it is protected with a rubber lining, or a total rubber or rubber inflatable structure itself is used. Rubber has very good wear resistant properties. It provides excellent protection for steel and other materials against abrasion and protects against solids and suspended particles.

1.8 Rubber Gives Thermal Insulation

To prevent clogging of subsea oil and gas piping by wax and hydrate formation it is necessary to insulate subsea equipment with material with very good thermal properties, low k-value (The k-value, or heat transfer coefficient, is the measured value of the heat flow which is transferred through an area of 1 m^2 at a temperature difference of 1 K - thermal conductivity; the time of rate of heat flow through unit area of a homogeneous material in a direction perpendicular to isothermal) [3] also known as lambda the thermal conductance; it is the physical property of a material expressing its ability to conduct heat [4], and high heat capacity. It is tough, impact resistant and has a very long service life.

1.9 Rubber Gives Passive Fire Protection

Certain types of synthetic rubbers such as neoprenes and hypalons when suitably compounded with asbestos fillers are flame resistant and give passive fire protection. This safety aspect is a key priority in many chemical and engineering industries as well. These fire protection technologies are used to protect structures and equipment against all types of fires including the extreme conditions of a jet fire.

1.10 Rubber is Ablative

Ablation means removal of material from the surface of an object by vaporization, chipping, or other erosive processes. The term occurs in Space Physics [5]. In space vehicle design, ablation is used to both cool and protect mechanical parts and/or payloads that would otherwise be damaged by extremely high temperatures. A low-density EPDM rubber is a fire stopping and fire proofing product that can be ablative in nature.

1.11 Rubber Wears

Rubber wear products for the mineral processing, fertilizer and materials handling industries, such as scrubber linings, rubber screening panels, wear resistant sheets, etc. are well recognized and eminently suitable materials of construction.

1.12 Rubber Bonds with Metal

Rubber bonds well with metallic surfaces with suitable adhesives and this property is well utilized in many applications in the chemical industry, such as lining, metal rubber bonded anti corrosive molded components, diaphragms etc.

1.13 Rubber is Impermeable

Rubbers like butyl, EPDM and neoprenes are unreactive to air and corrosive gases and are impermeable to them.

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