The use of Performance Enhancing Engineering Polymers within the Subsea Environment



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Abstract

When considering the arduous characteristics of the subsea environment, the use of engineering polymers are proven to greatly enhance the performance, efficiency, maintenance and health and safety of many applications from subsea pipelines and tiebacks through to Christmas trees, bend restrictors and buoyancy elements, to name but a few.

Often used in the development of new applications and technology, engineering polymers are also widely utilized to replace traditional engineering materials used within the industry, such as steel, iron and bronze. The use of engineering polymers allows for highly advantages qualities including high dimensional stability in addition to being very lightweight, almost 1/7th the weight of steel. Engineering polymers are also highly resistant to wear and abrasion, in addition to having a high chemical and corrosion resistance, something which is very commonly found within the subsea environment. Furthermore, Engineering Polymers offer the quality of self lubrication and a very low co-efficient of friction, resulting in both smoother, longer running components and applications along with reduced or eliminated maintenance needs and costs.

Engineering polymers range in capabilities depending on loadings, bearings and operating temperatures, resulting in the need for material specification and selection advice to be a key attribute when it comes to engineering design and production of subsea equipment. In a region which still uses metals and traditional materials for many applications which can easily be outperformed by engineering polymers it is key to understand the capabilities and performance qualities of polymers or “Plastics” which can add and create high levels of value and innovation across the subsea environment.

Holistically understanding the full needs and requirements of the subsea application, coupled with in depth material selection is key to the enhancement in the performance of the subsea environment through the use of Engineering Polymers.

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In an industry fuelled by innovation and new technologies, there are still some areas lacking in the adoption of technology which is proven to deliver increased performance, efficiency and value in a variety of formats. In the case of the subsea environment the lack of technology adoption stems from materials technology, which is often the cause of inadequate materials selection for a wide span of applications and components.

The word "Polymer" has conflicting perceptions in different areas and industries of the world. In some regions it is perceived as being a pioneering material used within safety critical and value adding applications, in other regions it is stereotyped as a plastic; mechanically inferior materials used for high volume, low grade items. In fact both perceptions are correct due to the fact that the words Polymer or Plastic are very generic; there are thousands of different grades and types of polymers which fall under different groups, from semi-crystalline commodity thermoplastics through to amorphous high performance thermoplastics. The value a material can bring is dependent on what you require it to do. Many of the polymers widely available today regularly exceed the traditional boundaries and connotations of the word Plastic; from anti-bacterial polymers used in the healthcare industry to eliminate harmful viruses and the spread of disease, to metal detectable plastics used for commercial food production.

More specifically related to the subsea environment there is a considerable number of applications and components traditionally manufactured from metals such as steel, which are now manufactured from engineered polymers. This stretches from subsea pipe centralizers and bundle spacers through to flexible riser protectors and J Tube seals. Polymers are proven to add value through many methods, ranging from their lightweight and noise dampening qualities, through to having corrosion and chemical resistance and being available in high visibility colours. However there are areas of this environment still using traditional materials, which may meet basic application requirements, but lack in adding significant performance and efficiency advantages at the same time.

How do we deliver increased performance and efficiency within the subsea environment through the use of engineering polymers? The answer is found at the design stage of subsea equipment and applications through detailed material selection. Material selection is a key factor to any engineering application, whether it's a small, simple application, a safety critical component saving lives or even a pioneering, engineering breakthrough.

A key element of correct material selection lies within understanding the full requirements and demands of the application from cradle to grave, taking into consideration a number of essential factors which can easily be missed or disregarded. The loading and operating temperature are all fundamental points of consideration when selecting a material, however a holistic approach must be taken in reference to the application or component properties and the function they will undertake within the subsea environment.

Some of the fundamental factors of consideration for material selection in order to aid the enhancement of performance and efficiencies within the subsea environment are explained further.

Environment: In the case of this paper, the environment would be Subsea, however there are still further considerations which must take place, these being; the depth of the application and the pressure it will experience. Will the application be prone to corrosion? What other chemicals and substances will be in contact with the material?

Speed: If the component being designed will be in movement, what will be the speeds and load it will face?

Material contact: Is the respected component or application going to be interfacing with another? If so, what is the other material and its properties? Will they conflict or work harmoniously?

Shipping/Storage: How long will the component be in storage or shipping for before being installed within the subsea environment? Will this create any expansion or changes in material properties?

Temperature: If applicable, what will the continuous or static operating temperature be for the component?

Once these points have been considered the wide array of polymers available can then be narrowed down to the range which can meet and accommodate the relevant criteria and requirements. Once this narrowed down list of polymers has been generated, an often neglected point of consideration in relation to the material is its availability. Not simply can it be sourced within the supply chain, more importantly is it available in the correct size for the required application.

For example, if after due consideration of materials selection a design engineer comes to the conclusion that a specific material will prove to add significant

value to the subsea environment through the application of a sheave with a diameter of 2 metres, the question needs to be asked if this material is available in a size large enough, or is that specific material, due to its properties, only available in smaller sizes. The machine-ability of the polymer also needs to be considered, is it able to be machined, and are there engineering firms experienced in this material, especially if it is a new material on the market.

Another vital point of polymer consideration is the production process. Polymers are unlike metals, as they can be processed and manufactured in a number of manors; Injection moulded, extruded, cast. Each manufacturing process results in a significant difference in material properties, cast or extruded polymers are often dimensionally and structurally more stable and tougher than injection moulded polymers. Which material process best suits your application? This will ultimately hold a strong influence into how much the performance and efficiency of the subsea environment can be enhanced through the use of engineering polymers for your application.

One way to greatly enhance the performance and efficiency of the subsea environment is not only through the use of engineering polymers, but through investigating and implementing material integration. This has proven over many decades to harvest and nurture outstanding levels of value to many applications within the subsea environment. This is delivered through using the best qualities and advantages of two different materials. Many engineers often relate to the opinion that “Metals weaknesses are plastics strengths” and vice versa. However, there are many proven combinations of ferrous and non ferrous materials which work outstandingly well together by combining their advantages and ultimately eliminating weaknesses in the application at hand.

If we look at an automotive, consumer market as an example, a vehicle manufacturer and tyre manufacturer collaborate on a product, in this case the wheels. The vehicle manufacturer, for arguments sake Ford, holds renowned experience in the production of cars, whilst a tyre manufacturer, for example Pirelli holds the same respected experience within the tyre industry. Both brands are providing high levels of value in their respected areas, the result of this relationship is a significantly higher level of value created and offered to the consumer through the product quality and overall performance.

Another essential factor which can prove to strongly enhance the performance of the subsea environment through engineering polymers is the use of custom formulated materials. Again, relating this to a consumer market, it is similar to the selection process of a vehicle. From the thousands of motor vehicles available you have narrowed down your choice to one particular model. The next step is to customise it according to your needs, the engine choice, the interior, the gadgets and optional extras. The end product being a vehicle which meets all your necessary needs and requirements. This is no different to engineering polymers. Once you have selected the best suited polymer for your application needs, by working with the right level of experienced manufacturers there are options to custom formulate materials and polymers to deliver the highest possible value and performance from the selected polymeric material. Again this stems from the holistic understanding of the applications needs and requirements.

A proven case of the above three mentioned points (production process, material integration and custom formulation) can be understood when looking closely at a commodity product within the subsea environment, pipe centralisers. This application is utilised within a subsea pipeline or tieback, used globally the application stretches across hundreds of thousands of miles of pipelines, transporting oil from well to onshore production, or tiebacks between wells. Traditionally manufactured from steel, this application was converted to a performance enhancing polymeric material in order to add value to the subsea environment.

Many subsea pipe centralisers and spacers are today manufactured using a custom formulated material manufactured by Nylacast. Known as CF110, this is a formulated material based on an oil filled, cast, polyamide 6. Upon fully understanding the application needs and requirements, the standard polymeric material grade has been specifically customised and formulated to fully meet the applications objectives. The application also uses material integration, using the coating of a ferrous material on the underside. The result of this custom formulated engineering polymer coupled with the integration of a metal results in the proven enhancement of the applications value. The use of the ferrous material means the centraliser strongly grips the inner pipe which it sits on, with no movement at all, this has been tested at 70 to 80 tonnes of force in the research and development lab, coupled with over 20 years of industry utilisation. The custom formulated material has been customised for ultimate creep resistance. Furthermore, the custom formulated material allows the outer pipe to easily slide over the top, eliminating any friction or damage to the pipeline, creating an insulation to keep the oil product in transportation at a specific flow temperature. This integration is a proven example of the outstanding

value which can be delivered in a number of formats. A very high friction property on the underside coupled with a very low friction property on the top side means the application is delivering optimum value, spacing the pipes, clamping them, creating insulation and eliminating any damage or bundling of the centralisers at one end after the outer pipe slides over. This case exemplifies the different manors in which a commodity product within the subsea environment adds significant value.

In conclusion, fully understanding material selection is a key step to enhancing the performance of the subsea environment through the use of engineering polymers.

The secret to utilising engineering polymers to deliver increased performance and efficiencies is to manipulate the best qualities of materials according to the application needs. For example, if an application is needed to run at an operating temperature of 200°C you may consider Polyether ether ketone (PEEK) as in most circumstances it can reach 450°C. However, if the application will continuously be running at 300°C then a para-aramid may be a better material choice as PEEK shows signs of degradation between the temperatures of 450°C and 500°C, as the application itself will never reach these higher temperatures. There is therefore no requirement for the selection of a material which in this instance would be over engineered for the application.

The second step to this success is selecting the most advantageous production process and formulation of material for the application, not missing out the consideration of material integration and the value which can be offered through two materials working harmoniously together. Testing is also a key attribute to success, knowing that the application will work and meet its required objectives when utilised within the subsea environment. Quality should also be considered and come second to none, partnering with a manufacturer or solutions provider established and experienced in materials science and technology can prove to provide a wealth of benefits and advantages for numerous projects.