Thermal and Shear Properties of Particle Filled Polymer Grout for PIP Application

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Abstract: As oil and gas field production shifts into deeper water, seawater temperature at the wellhead decreases nearly to freezing point and hence pipe-in-pipe application is becoming more popular. In this study, polymer and polymer-aggregate composite were used to investigate the bonding shear strength with steel and thermal conductivity. Addition of solid coarse aggregates increased the shear bonding strength with steel and thermal conductivity.

Introduction: Flow assurance and associated thermal insulation of pipelines is an important part of exploitation of deepwater reservoirs. Insulated pipelines and bundles offer a reliable and cost effective solution for deepwater flow assurance. Flexibility of Pipe-in-pipe (PIP) configuration in selection of geometrical parameters, pipe materials and insulation materials allows optimizing thermal and structural properties of pipelines for specific water depth and operation requirement. A cased insulated flowline consists of a single production flowline concentrically located inside a protective casing pipe. The annuals filled with insulation material. There are various materials available as the insulation layers such as polyurethane foam, synthetic foam or ceramic microsphere cement. The optimal design of a cased insulated flowline requires a balance among the cost of the insulation and casing as well as synergy between the structural performance and the thermal insulation performance of the pipeline.

Objectives: The objective of this study was to investigate the effect of fillers such as aggregates on the shear bonding strength with steel and thermal conductivity of a polymer based grout.

Testing Program: The overall testing program was to determine the thermal conductivity and bonding shear strength of the polymer material with and without aggregates. Coarse aggregate size was less than 0.752 inch (19.1 mm). The aggregate loading was about 60% (by weight).

***Thermal Conductivity*:** Hot wire method was used to estimate the transient thermal conductivity of pure polymer and polymer with filler. The thermal conductivity coefficient k was determined using the following relationship (ASTM D 5930).

$$k = \frac{q / 4p}{(dT / d \ln t)}$$

Single lap joint shear tests: Single lap test was performed with the pipe materials (outer and inner pipes) and grout. In this test, grout was considered as an adhesive and one inch thick metal strips were used as shown in Figure1.

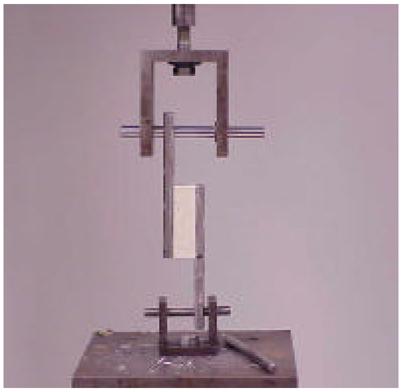

Figure 1. Single lap shear test

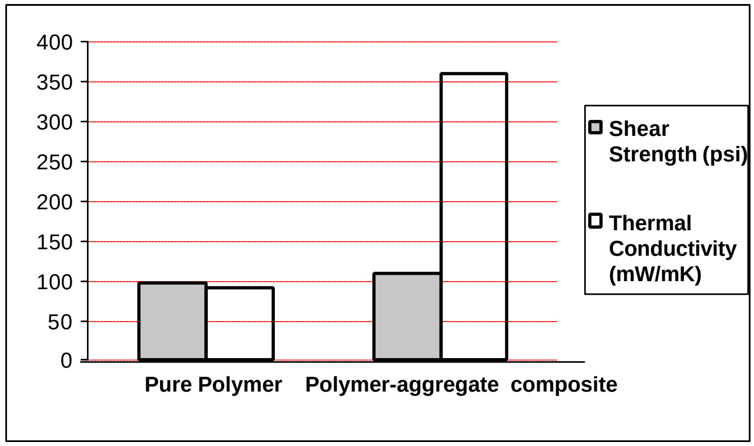

Figure 2. Average shear strength and thermal conductivity

Results and discussion: Figure 2 summarizes the results of the bonding shear strength and thermal conductivity of the material tested. As the thermal conductivity is function of the volume fractions of the constituent phases and thermal conductivity of aggregates is higher than thermal conductivity of pure polymer, polymer-aggregate composite resulted in higher thermal conductivity than pure polymer.

Conclusion:

Addition of 60% of aggregates to the polymer resulted in 12% higher shear bonding strength with 75% higher thermal conductivity as compared to the pure polymer.

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References:

1 Chin, Y.D., Bomba, J.G., Kvaerner, R.J., "Structural and Thermal Optimization of Cased Insulated Flowlines" Proceedings of offshore Technology Conference, May 1999, pp. 727-734.

2. Tucker, R. N., Hays, P. R. and Antani J. K., the preceedings of Offshore Technology Conference, 1996, 861.

3. Gustafsson, S.E.,"Transient Hot Strip Technique for Measuring Thermal Conductivity and Thermal Diffusivity" The Rigaku Journal, Vol. 4, No. 1/2, 1987, pp. 16-28

4. ASTM D5930-01 Standard Test Method for Thermal Conductivity of Plastics by Means of a Transient Line-Source Technique.