Heat Shrinking of Hexoloy® Silicon Carbide

CARBORUNDUM

Saint-Gobain Ceramics
Structural Ceramics

Introduction

The properties of sintered alpha silicon carbide have made it an ideal material for seal face and pump bearing applications. A means of integrating silicon carbide components into the mechanical seal or pump assembly is a key question for the design engineer. A common method of joining silicon carbide seal faces and bearings to metals is shrink fitting. The heat shrink method of assembly depends on the coefficient of thermal expansion differential between the metal and the silicon carbide components. Unfortunately, due to the large thermal expansion mismatch between silicon carbide and metals, the use of heat shrinking for joining components even at relatively low temperatures, 300-500°F., is often complicated. The mismatch necessitates an exaggerated amount of interference at room temperature to compensate for the expansion differentials created at operating temperatures.

Heat Shrinking Mechanisms

The stresses produced by heat shrinking are such that the outer metal sleeve experiences tensile stress while the SiC is in compression. The maximum tensile stress is located at the inner diameter of the metal sleeve. In addition, there is also a shear stress produced in the metal sleeve. Therefore, interferences must be selected such that the metal will not fail due to yielding either in tension or shear. Since the compressive strength of SiC is extremely high, the risk of failure due to compression is usually negligible. See the table for an example showing stresses produced and temperature differentials required when shrink fitting stainless steel onto SiC.

Recommendations

The following recommendations can be made when heat shrinking metals to silicon carbide materials:

- Minimize the shrink temperature, which in turn minimizes the tensile stresses. The recommended shrink temperature is dependent upon the desired interference between the SiC and metal components.
- Heat both the metal and silicon carbide isothermally; that is to the same temperature before joining and cooling so that thermal shock situations may be avoided. As previously stated, the shrink temperature is dependent upon the desired interference.
- Since stresses produced on both the metal and SiC are dependent on the interference used in shrink fitting, careful attention must be paid to the dimensional control of the SiC and metal components. The OD of the silicon carbide seal face or bearing needs to be finished ground with dimensional tolerance of no greater than 0.003" (0.076mm), a roundness specification of no greater than 0.004"(0.10mm) and a perpendicularity specification from either face to the OD of no greater than 0.002" (0.05mm).
- Flatness is a factor to consider when heat shrinking metals to silicon carbide seal faces and bearings. As a result of the stresses in shrink fitting, the silicon carbide seal face or the bearing face may become distorted and no longer flat with respect to the mating face. Lapping the SiC seal face after shrink fitting is highly recommended and will correct this problem. However, the distortion may reappear at operating conditions due to the change in stress state. By reducing the height of the seal face beyond the metal sleeve and reducing the face width, a positive influence on the deformation of the silicon carbide will be accomplished. An iterative Finite Element Analysis (FEA) for the shrink fit assembly is recommended for the optimum configuration.

Conclusion

Heat shrinking Hexoloy Silicon Carbide material to metal alloys is a viable option for the design engineer to consider. For further information regarding heat shrinking or other methods of assembly, please contact us for specific design assistance.

Saint-Gobain Ceramics
Structural Ceramics
Hexoloy® Products
23 Acheson Drive
Niagara Falls, New York 14303
Telephone: 716-278-6233
Fax: 716-278-2373
E-mail: scd.sales@saint-gobain.com
www.hexoloy.com

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Heat Shrinking Stainless Steel-to-SiC

ID SiC in	OD SiC in	ID Steel in	OD Steel in	e in/in	Delta T °C	Maximum Stress Steel ksi	Maximum Stress SiC ksi
0.5000	1.0000	0.9900	1.2500	0.0100	1260	241	-55
0.5000	1.0000	0.9950	1.2500	0.0050	625	121	-27
0.5000	1.0000	0.9960	1.2500	0.0040	499	97	-22
0.5000	1.0000	0.9970	1.2500	0.0030	374	73	-16
0.5000	1.0000	0.9980	1.2500	0.0020	249	48	-11
0.5000	1.0000	0.9990	1.2500	0.0010	124	24	-5
0.5000	1.0000	0.9995	1.2500	0.0005	62	12	-3
0.5000	1.0000	0.9998	1.2500	0.0002	25	5	-1
0.5000	1.0000	0.9900	1.5000	0.0100	1260	211	-83
0.5000	1.0000	0.9950	1.5000	0.0050	625	106	-41
0.5000	1.0000	0.9960	1.5000	0.0040	499	85	-33
0.5000	1.0000	0.9970	1.5000	0.0030	374	64	-25
0.5000	1.0000	0.9980	1.5000	0.0020	249	42	-16
0.5000	1.0000	0.9990	1.5000	0.0010	124	21	-8
0.5000	1.0000	0.9995	1.5000	0.0005	62	11	-4
0.5000	1.0000	0.9998	1.5000	0.0002	25	4	-2
1.0000	1.5000	1.4900	1.7500	0.0067	835	160	-26
1.0000	1.5000	1.4950	1.7500	0.0033	416	80	-13
1.0000	1.5000	1.4960	1.7500	0.0027	332	64	-10
1.0000	1.5000	1.4970	1.7500	0.0020	249	48	-7
1.0000	1.5000	1.4980	1.7500	0.0013	166	32	-5
1.0000	1.5000	1.4990	1.7500	0.0007	83	16	-2
1.0000	1.5000	1.4995	1.7500	0.0003	41	8	-1
1.0000	1.5000	1.4998	1.7500	0.0001	17	3	-0
1.0000	1.5000	1.4900	2.0000	0.0067	835	139	-40
1.0000	1.5000	1.4950	2.0000	0.0033	416	69	-20
1.0000	1.5000	1.4960	2.0000	0.0027	332	56	-16
1.0000	1.5000	1.4970	2.0000	0.0020	249	42	-12
1.0000	1.5000	1.4980	2.0000	0.0013	166	28	-8
1.0000	1.5000	1.4990	2.0000	0.0007	83	14	-4
1.0000	1.5000	1.4995	2.0000	0.0003	41	7	-2
1.0000	1.5000	1.4998	2.0000	0.0001	17	3	-1

e = Interference per inch of SiC OD

Delta T = Required temperature differential for desired interference

Maximum Stress = the maximum stress produced

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