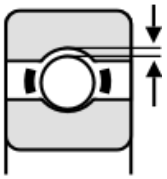
Issue 4A: Follow-up on the Article: Ceramic Ball Bearings & Induction Heating

I received a lot of feedback and questions on my article discussing the concern that induction heat could cause raceway surface damage when employing a bearing with ceramic (Si_3N_4) rolling elements. This article is a summary of a few of my discussions with expansions into other topics.

Does Clearance change the results?

Absolutely! One of the key factors is the initial internal clearance. Clearance is the gap that is taken up during heating. It could cause the rolling elements to press into the raceway surface. In electric motor/pump repair standard clearance is C3. Using a bearing with anything less than C3 I would suggest consulting with your authorized bearing distributor.

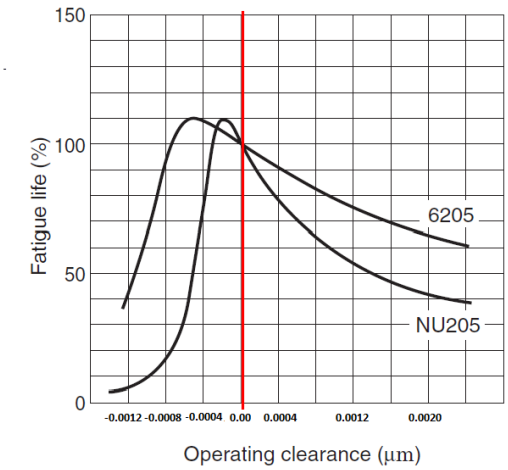


Pic 1: Radial Internal Clearance

Does Mounting Take Out All the Internal Clearance?

There is no way to just say yes or no. In theory, bearing life is maximized in preload (or negative clearance.) Certain bearings are designed to operate in preload. For example, tapered roller bearings run preloaded. In general, the recommended fitting practice will leave a residual amount of clearance. If the bearing is designed to operate in preload the application set-up will create ideal conditions.

In electric motor and pump repair the recommended fitting normally results in a clearance. Due to uncontrollable factors it is important that we stay in the clearance range. Picture 2 shows with preload life increases. When clearance is increased life crashes downward like a roller coaster. Missing your tolerance by thousandths or two on fitting, load a little higher than expected, belts a touch too tight; grease a little worn, etc... All contribute to premature bearing failure.



Pic 2: Fatigue vs. Operating Clearance

What is the contact stress on smaller steel and ceramic sizes?

For comparison, I added some smaller sizes in both steel and ceramic ball. Additional criteria; steel rings, steel or ceramic balls, C3 clearance with a heating temperature of 220 degrees F. To create worst case scenario we assumed zero expansion on the outer ring.

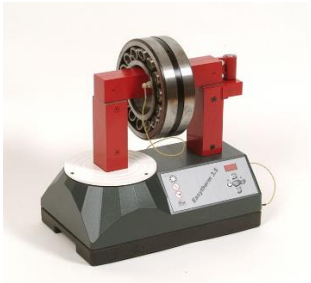
Base #	Ball Material	Initial Clearance (in) C3	Result contact stress (psi)	Allowable contact stress (psi)
6205	52100	0.0005-0.0011	205,500	609,000
6208	52100	0.0006-0.0013	205,100	609,000
6308	52100	0.0006-0.0013	233,100	609,000
6205	Si_3N_4	0.0005-0.0011	242,500	609,000
6208	Si_3N_4	0.0006-0.0013	242,000	609,000
6308	Si_3N_4	0.0006-0.0013	275,100	609,000
6313	Si_3N_4	0.0009-0.0017	252,800	609,000
6320	Si_3N_4	0.0012-0.0023	247,100	609,000
6324	Si_3N_4	0.0014-0.0026	258,000	609,000
6330	Si_3N_4	0.0018-0.0036	272,500	609,000

Table 1: Contact stress calculated results

Are you implying the only acceptable method for mounting is using an induction heater?

My statement in my introduction was: *Bearing manufacturers consider induction heating the safest method to heat bearings for installation.*

There are plenty of acceptable methods, with positives and negatives to all. My opinion is that using an induction heater is the best, most repeatable practice. I also believe all methods require proper training to insure all technicians are following the same practices.



Pic 2: Induction Heater (TM Easytherm 3.5)

Great follow-up questions!

How does Induction Heating Affect Ceramic Coated Bearings?

At this point I do not have an answer! I have asked for this to be studied and hope to have results in the near future.

Clarification:

Where did you get the contact stress numbers?

In my bearing engineering years we called it the Bearing Bible: *Essential Concepts of Bearing Technology* by Tedric Harris.

TABLE 9.1
Contact Stress That Causes 0.0001*D* Permanent Deformation

	Contact Stress	
Bearing Type	**MPa**	**psi**
Self-aligning ball bearing	4,600	667,000
Other ball bearings	4,200	609,000
Roller bearings	4,000	580,000

Table 9.1 from Mr. Harris' book.

How big is the dent?

The resultant dent of exceeding the maximum contract stress is 0.0001 times the ball diameter. For example if the ball diameter is 3/4 inch the dent will be: 0.75 in * 0.0001 = 0.000075 in.

Final Thought:

I want to thank those who read my articles for the questions and comments! It's a great feeling knowing that time spent in my bearing cave studying topics to discuss is read! I also need to thank our supplier's engineering team for providing the contact stress calculations.