Member Joel Ventura on where you measure CHTs 8-19

I want to return to the subject of CHT measurement. This is normally done with thermocouples under the spark plugs, which I will call STs, or with bayonet thermocouples (BT's), which are screwed into recesses in the cylinder head that are designed to receive them and designed by the manufacturer to measure the cylinder head temperature.   
  
Gary and Terry point out that temperatures measured by STs will be significantly higher than those measured by BT's in the same engine. I have seen that reported several times, though I cannot cite chapter and verse. They also point out that STs will indicate significantly higher temperatures on the hot side of the cylinders than on the cooler side of the cylinder (the cooling air intake side). And I have seen that reported by several sources. What I have not seen are differences in the temperatures reported by BT's depending on which way the air flows over the cylinders.  
  
When I was at Oshkosh about ten years ago, I asked a Lycoming engineer about this. He told me that the measured temperature difference was not significant for BT's, though of course he had no data to show me.  He wouldn't even talk to me about STs. Lycoming considers them totally unreliable, and recommends that we only use BT's for CHT measurements.  
  
BT's do give us a stable reliable reference for CHT, but STs are significantly affected by several additional variables that do not affect BT's. We already mentioned the direction of airflow across the cylinder. In addition STs do not actually measure the CHT. They measure a combination of the CHT, and the temperature of the spark plug metal base, and this is affected by several variables. The temperature of the center electrode of the spark plug is controlled by adjusting the length of the heat path from the center electrode to the outside metal shell. And then a significant amount of that heat will pass through the base of the spark plug, into the ST, and then into the cylinder head. Hotter spark plugs have hotter center electrodes, because they have longer heat paths to the outside metal shell. As I recall this longer heat path results in a cooler spark plug base, and therefore a lower indicated CHT. I did these tests on my motorcycle about fifty years ago so I'm not positive about the direction, but I do remember the indicated CHT was affected by the heat range of the spark plug, and that is not something that affects BT's (unless you use such a hot plug that it causes preignition, then of course the CHT will take off).  
  
The bottom line is an ST will not give an accurate measure of the CHT unless it is calibrated against a more accurate source, like a BT, and this calibration will only be good for the ST at one power setting, on one side of the engine, and with one heat range spark plug, at one tightening torque value.  I don't know how significant any of these variables are to the accuracy of ST temperature measurements, but these variables do not significantly affect BT measurements, so one can see the reasons behind Lycoming's preference for BTs..

I think ST measurements should be considered as relative temperature indicators, and as such they are useful for noting changes in CHT in tasks like adjusting the cylinder baffling, or balancing the cooling airflow through the cylinders.  But in most cases they should not be considered as an accurate source for absolute CHT temperature unless calibrated with a more accurate source in specific conditions.  
  
Reluctance to use BT's is probably at least partially due to their higher cost. However it is not difficult to make your own BT's for less than five dollars each. There are several articles available on the internet that describe how to make a BT from a modified bolt or plug.  The most readily available and detailed description of the whole process is in Chapter 14 of Bob Nuckolls excellent book The AeroElectric Connection.  Every home builder should have this book in paper or electronic form or both:

<http://www.aeroelectric.com/Book/AEC_R12A.pdf>

There are several tricks to the thermocouple trade, including cold junction temperature compensation, that Bob covers very well.  However, he is a much bigger fan of STs than I am.  
-- Joel