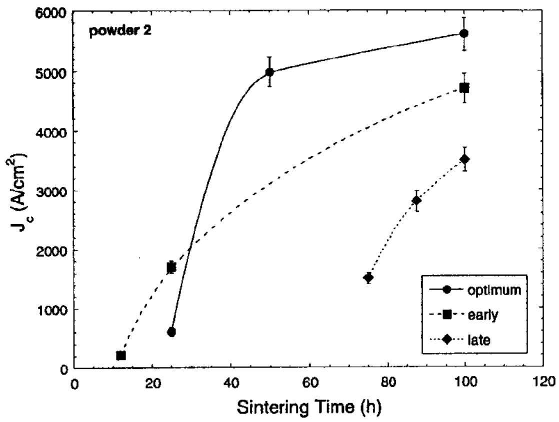

Figure 4. Variation in J_c with accumulated sintering time for PIT tapes containing powder 2 and subjected to treatments listed in experimental set A.

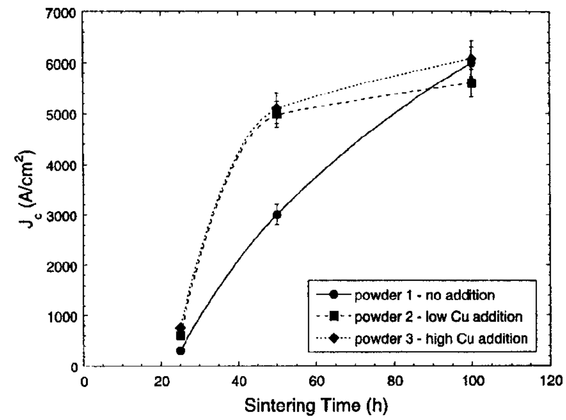

Figure 6. Variation in J_c with accumulated sintering time for PIT tapes containing all three precursor powders and subjected to the optimum treatment.

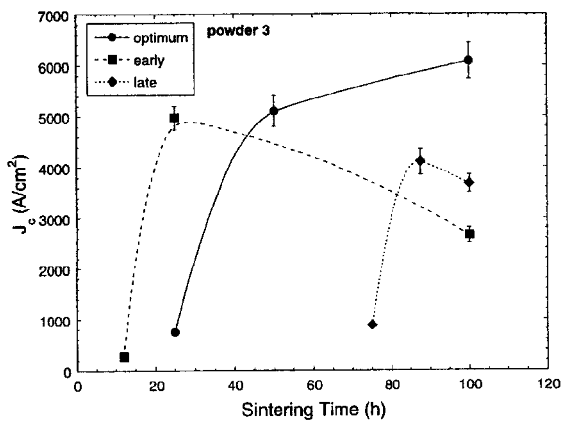

Figure 5. Variation in J_c with accumulated sintering time for PIT tapes containing powder 3 and subjected to treatments listed in experimental set A.

J_c values of at least five companion samples, are shown in figures 4 and 5 for powders 2 and 3, respectively. It can be seen from these figures that one of the optimum treatments obtained for powder 1 (25–25–50) [13] also resulted in the highest J_c for the other two precursors. This indicates that Cu addition does not significantly affect the %Bi-2223/pressing schedule in obtaining good tape performance. It is, however, observed from these figures that the J_c behaviour of the two powders differs when initial pressings were performed either at early stages or late in the heat treatment schedule, i.e. sequences 1 and 2. When pressings were performed at early stages of thermomechanical treatment, J_c of PIT tapes containing powder 3 decrease after the second pressing (24 h total sintering) whereas those of powder 2 continue to increase. Similar difference in J_c behaviours, although with lower J_c values, is seen for the two powders when the initial pressing step was carried out late in the thermomechanical treatment, i.e. after 76 h of sintering. One reason for these differences may be the faster reaction kinetics of powder 3 as seen in figure 1. That is, after the powder has been brought into intimate contact following first pressing, less time is required for the precursor to react thereby leaving insufficient liquid phase to heal the cracks that were produced during the second pressing.

Figure 6 shows a comparison of J_c as functions of accumulated sintering time using the optimum pressing schedule for all three precursor powders. It can be seen from this figure that J_c of the powders reach the same value after the final stage of sintering. While PIT tapes of the three precursors produced using the optimum schedule possess the same final J_c, it should be noted that J_c of the two precursors with different amount of Cu additions increase more rapidly than the base powder during the beginning of thermomechanical treatment. This lends additional support to the argument that precursors with excess Cu can result in faster reaction. It is clear that even though the same optimum treatment can be used to obtain good J_c in these powders, subtle differences remain such that the optimum treatment may be modified to account for the possible fast reaction rate when a precursor is rich in Cu. If the sintering intervals are correlated with the amount of Bi-2223 phase, it can be suggested that a 20–20–40 hours treatment would be sufficient for the tapes containing the highest Cu addition. In general, the effect of Cu addition on J_c, within the small amount considered in this study, is not significant compared to the influences of other processing parameters such as cooling rate.

3.2. Cooling rate

Variations in J_c with accumulated sintering time for precursor powders 2 and 3 using heat treatment sequences of experimental sets B and C (table 1) are shown in figures 7 to 10. In figure 7, the J_c of powder 2 samples produced by treatment sequences in set B are shown as functions of sintering time. It can be seen from this figure that samples produced by slow cooling resulted in two to three times higher J_c than those fabricated using only fast-cooling steps. A slow cooling rate of 0.1 °C min^{-1} represents an additional 4 h of heat treatment above 800 °C for each sintering interval, a temperature above which precursor conversion to Bi-2223 is possible. This additional time,