B. Development of a Modified Cast-Pin Tear Test

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A modified cast-pin tear (CPT) test has been developed to quantify the solidification cracking susceptibility of a range of Ni-base alloys, including both solid-solution strengthened alloys and superalloys. This modified CPT test is faster and more economical than other widely used solidification cracking susceptibility tests. A few grams of material were melted on a water-cooled copper hearth using an arc generated by a tungsten electrode. The material was then rapidly solidified by delivering the molten charge into a copper mold to create a cast pin. The mold geometry was varied to generate a range of strains in the solidifying pins.

The two objectives of this work were to develop a molten metal delivery system that could replace the levitation melting system used in the original CPT test, and to demonstrate that the modified CPT test could be successfully applied to extremely susceptible Ni-base superalloys. The factors that influenced successful delivery of the molten charge to the mold were systematically investigated and then incorporated into the design of the modified CPT apparatus. The test was then applied to a series of alloys that had been previously tested using the Varestraint test and a series of alloys that had previously been untested.

Successful delivery of the molten charge to the mold was dependent upon the temperature of the charge during the casting process and upon the design of the molten metal delivery system. The temperature of the charge was controlled by varying the melting current and melting technique. The basic design of the delivery system consisted of a recessed water-cooled hearth with a hole at the center to allow the delivery of the molten charge to the mold below. A copper rod which blocked the hole during the melting process was retracted to allow the molten material to pass through.

The pin geometry consisted of a cylindrical body with a foot at the base and a flare at the head of the pin for restraint. The length of the pin was varied to control the amount of strain as the pin solidified. The amount of surface cracking was quantified and used as a cracking susceptibility indicator. Cracking in the alloys studied increased with an increase in mold length, and the data was used to rank the alloys in order of cracking susceptibility. The cracking results correlated with previously developed cracking susceptibility data. Metallography and fractography confirmed that the cracking was solidification cracking.

The results of this work have demonstrated that a simplified molten metal delivery system using GTAW button melting can successfully take the place of levitation melting when using the CPT test. Also the modified CPT test was used to rank a series of Ni-base superalloy filler metals which had previously been difficult to evaluate using conventional weldability test techniques. The test showed clear differentiation among these materials and will allow selection/development of crack resistant filler metals. The modified CPT test also has the advantage of being faster and more economical than many other weldability tests.