Fig. 3. Control panel - large touch screen operator interface

completion of the safety and pumping sequences. Once the heating circuit is enabled, algorithms are used to guarantee that temperatures are ramped appropriately to ensure the rate of heating doesn't produce a significant amount of stress on the load. The process controllers are also used to verify the temperature of the workpieces during the heating and cooling cycle. Load sensors used during vacuum heat treating verify a uniform part temperature, ensuring the desired metallurgical properties. More sophisticated controllers can manage load-sensor offsets, which provide a higher degree of accuracy when determining uniform part temperature. The ramping and cooling temperatures, when properly controlled, reduce the stress and distortion on the parts. Controllers can also manage out-of-tolerance issues or outgassing due to contaminated parts. With real-time visibility of vacuum levels, an automated programmable controller can be set up to guarantee correct vacuum levels.

Most vacuum furnaces are versatile when it comes to partial pressure and cooling. Gas-pressure quenches usually consist of nitrogen or argon and are used in conjunction with a cooling fan. Pressure gauges and contactors are monitored to ensure that these events are ready and have been turned on/off depending on the desired step in the process. With the sensors and verifications built into the processes, proper vacuum levels can be maintained, and the quality of the gas-quench media can be assured.

Electronic Data and Record Keeping

As a definition, automation replaces manual operations with mechanical or electronic equipment. As industry standards and customer requirements increase, the requirement of traceability and proof of processing is common. Companies are looking for an efficient method to generate the required paperwork. Computer systems are being installed to provide data and other load characteristics. SCADA systems (Supervisory Control and Data Acquisition) are known for providing quick access to information and a foundation for plant automation.

The goal of these systems is to provide a user-friendly environment to enter data associated with the load and to make the process of gathering this information quick and easy. With the use of scanning technology, computers and recipe programmers, the loading systems provide a method of automating this process. The off-the-shelf relational database tools that run on standard personal computers enable end-user requirements specific to data capture and reporting to be incorporated into the load-tracking system. SCADA systems can be used to initiate programs running on each piece of equipment and then constantly monitor the equipment for an "end of cycle" notification. At the end of the cycle, the load is marked as complete, and a record of the process is

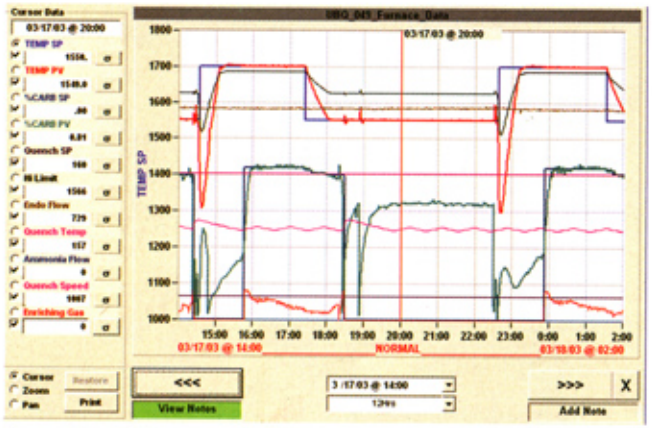

Fig. 4. Electronic data recorder - "Paperless" chart recording (real time and historical data)

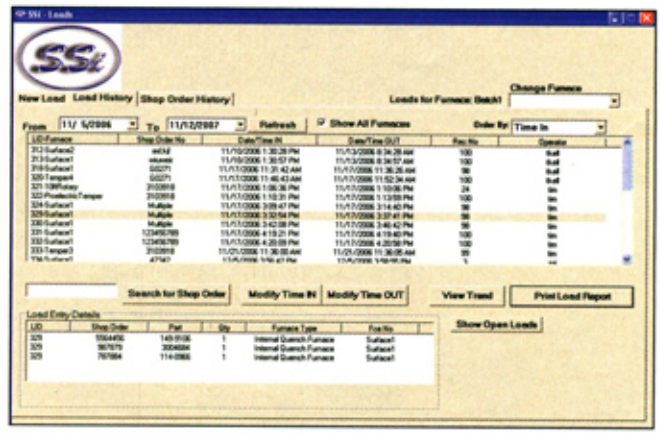

Fig. 5. Load tracking database