(e.g., hard disk, floppy disk, magnetic strips), optical disks (e.g., compact disc (CD), digital versatile disc (DVD)), smart cards, flash memory devices, etc.

Processor 2008 executes instructions (e.g., stored at the computer-readable medium 2010). The instructions can be carried out by a special purpose computer, logic circuits, or hardware circuits. In one or more embodiments, processor 2008 is implemented in hardware and/or firmware. Processor 2008 executes an instruction, meaning it performs or controls the operations called for by that instruction. The term “execution” is the process of running an application or the carrying out of the operation called for by an instruction. The instructions can be written using one or more programming language, scripting language, assembly language, etc. Processor 2008 in one or more embodiments can retrieve a set of instructions from a permanent memory device and copy the instructions in an executable form to a temporary memory device that is generally some form of RAM, for example. Processor 2008 operably couples with components of computing device 2002 (e.g., input interface 2005, with output interface 2006 and with computer-readable medium 2010) to receive, to send, and to process information.

In one or more embodiments, computer-readable medium 2010 stores instructions for execution by processor 2008. For example, in one or more embodiments, the computer-readable medium 2010 comprises instructions for a process data application 2012 to select or derive process data 2034 and machine learning model application 2014 to derive a machine learning model 2050 as described herein.

In one or more embodiments, one or more applications stored on computer-readable medium 2010 are implemented in software (e.g., computer-readable and/or computer-executable instructions) stored in computer-readable medium 2010 and accessible by processor 2008 for execution of the instructions. The one or more applications can be integrated with other analytic tools such as that offered by SAS Institute Inc. of Cary, N.C., USA. Merely for illustration, the applications are implemented using or integrated with one or more SAS software tools such as JMP®, Base SAS, SAS® Enterprise Miner™, SAS/STAT®, SAS® Event Stream Processing, SAS® High Performance Analytics Server, SAS® Visual Data Mining and Machine Learning, SAS® LASR™ SAS® In-Database Products, SAS® Scalable Performance Data Engine, SAS® Cloud Analytic Services, SAS/OR®, SAS/ETS®, SAS® Inventory Optimization, SAS® Inventory Optimization Workbench, SAS® Visual Analytics, SAS® Viya™, SAS In-Memory Statistics for Hadoop®, SAS® Forecast Server, and SAS/IML® all of which are developed and provided by SAS Institute Inc. of Cary, N.C., USA.

In one or more embodiments, fewer, different, and additional components can be incorporated into computing device 2002 or a system comprising computing device 2002. For instance, in one or more embodiments, there are multiple input devices 2004 (e.g., keyboard 2022, mouse 2026 and computing system 2024). In the same or different embodiments, there are multiple output devices 2096. As another example, the same interface supports both input

In one or more embodiments, the process data can be used to predict information about a quality predictor for a bonding operation. For instance, the measurements in the first and second operation can comprise measurements associated with a process of forming stitch bonds and/or a process of forming ball bonds.

Figure 25 is a graph 2500 illustrating the correspondence between the predicted ball shear values modeled according to the present embodiments to actual ball shear values obtained as a result of destructive testing.

Specification limits are used for final acceptance or rejection of a product. In this example, divider 2510 represents a lower bound and divider 2512 represents an upper bound for specification limits for ball shear test measurements (e.g., in grams). Control limits may be used that are stricter than specification limits. Control limits are used for process control purposes to ensure that products result within specification limits. In this example, divider 2520 represents a lower bound and divider 2522 represents an upper bound for control limits for ball shear test measurements. Dividers have corresponding values on the predicted ball shear axis 2530 (e.g., the lower specification limit can be at A, the lower control limit can be at B, the upper control limit can be at C, and the upper specification limit can be at D on both axes of graph 2500). Test results for each of the destructive tests for ball shear were plotted against plotted predicted values for ball shear for different objective targets identified by the key including different normal conditions and abnormal conditions (Material Contamination (MC), Old Cap (OC), and Floating Conditions (FC)).

The accuracy of the model was evaluated. TP stand for true positives and represents bad quality bonds identified by model as Bad. TN stands for true negative and represents good quality bonds identified by model as Good. As shown in the table 2550 the graph shows most predictions where correct (291 TP and 11,922 TN). FN stands for false negative and represents bad quality bonds identified by model as Good. FP stands for false positive and represents good quality bonds identified by model as Bad. There were only a handful of false predictions (27FP and 40 FN)

Some metrics are more important for different industries. For instance, false negatives may be important in integrated circuit construction because these types of bonds can lead to increase in field returns and warranty claims. According, Benign False Negatives (B_FN) were also considered. These represent bonds with bond strength between lower (upper) spec limit and lower (upper) control limit. These False Negatives do not have poor quality with respect to specification limits. Most of the false negatives were benign false negatives (32 of 40). The models can be evaluated using statistical tools like precision, recall, and f1. For instance, precision can be computed as the number of true positives divided by the sum of the number of true positives and the number of false positives: