

REPRESENTATIVE VALUE CALCULATING APPARATUS AND METHOD

BACKGROUND

1. Field

The present invention relates to an apparatus and a method for calculating representative values, in which the representative values are calculated through values which have been measured for a process condition in process systems, and the calculated representative values are displayed in a display unit.

2. Description of the Related Art

In general, enormous investment costs are required in high-tech industries such as a semiconductor industry and an LCD industry. In particular, most of the costs correspond to equipment costs. Accordingly, manufacturing companies in the high-tech industries are essentially making an effort to improve a using rate of the equipment.

Technologies by which malfunctions are detected through monitoring data for process condition such as a temperature, a pressure, and a time are illustrated as one of the methods for improving the using rate of the equipment.

In the process systems, sensors may be installed to measure data for process conditions depending on a time variation. Users can grasp a variation of values for the process conditions depending on the time variation on the basis of the data which has been measured through the sensors. This helps the users apprehend a current state of the equipment.

However, since the values for the process conditions are continuously measured at a time interval of several seconds, and there are more than tens or hundreds of process conditions in the process systems, an amount of data for the process conditions become enormous. Accordingly, a technology, by which a large amount of data for the process conditions is analyzed and displayed through a statistic technique so

that the users can conveniently view accurate data, is needed. Such a technology as described above pertains to fields of Fault Detection and Classification (FDC).

Contents related to a technology by which measurement data through sensors for operation processes is displayed in a display unit are disclosed in Korean Patent Publication No. 2001-0079426, the title of which is "A Control Management System of Injection Molding Process".

Moreover, in order to reduce a large amount of data for the process conditions, instead of a method in which data obtained in times is stored as it is, a method in which process conditions are separated for samples, a representative value capable of representing data obtained in times with one value is calculated, and the calculated representative value is used for storage and analysis is being used. Accordingly, not only storage capacity can be reduced, but also a variation tendency of data can be easily apprehended based on the representative value.

SUMMARY

In one aspect, there is provided a representative value calculating apparatus capable of calculating representative values of process condition values by using values of the process condition which have been measured in process systems.

In one general aspect, there is provided a representative value calculating apparatus. The representative value calculating apparatus includes: a first calculation unit which calculates a median value and a median absolute deviation (MAD), or a mean value and a standard deviation of process condition values for each sampling point, by using the process condition values which have been measured through a sensor for the each sampling point for each sample; a second calculation unit which calculates standardized values by using the process condition values, the median value, and the median absolute deviation (MAD), or calculates standardized values by using the process condition values, the mean value, and the standard deviation; and a third calculation unit which calculates a representative value of the process condition values for the each sample based on the calculated standardized values.

The representative value calculating apparatus may further include an extraction unit which extracts only the process condition values corresponding to sampling points which have been set by a user among the measured process condition values.

The third calculation unit may calculate a representative value of the process condition values based on any one of a mean value, a median value, a mode, a minimum value, a maximum value, and a standard deviation of the calculated standardized values.

The representative value calculating apparatus may further include a controller which displays at least one of the standardized values for the each sampling point, the calculated representative value for the each sample, and an accumulated sum of the calculated representative value for the each sample in a display unit.

In another general aspect, there is provided a representative value calculating method. The representative value calculating method includes: calculating a median value and a median absolute deviation (MAD), or a mean value and a standard deviation of process condition values for each sampling point, by using the process condition values which have been measured through a sensor for the each sampling point for each sample; calculating standardized values by using the process condition values, the median value, and the median absolute deviation (MAD), or calculating standardized values by using the process condition values, the mean value, and the standard deviation; and calculating a representative value of the process condition values for the each sample based on the calculated standardized values.

The representative value calculating method may further include extracting only the process condition values corresponding to sampling points which have been set by a user among the measured process condition values.

The calculating the representative value may include calculating the representative value of the process condition values based on any one of a mean value, a median value, a mode, a minimum value, a maximum value, and a standard deviation of the calculated standardized values.

The representative value calculating method may further include displaying at least one of the standardized values for the each sampling point, the calculated representative value for the each sample, and an accumulated sum of the calculated representative value for the each sample in a display unit.

According to embodiments of the present invention, through a standardization process, since the values for the process condition between which there are large magnitude differences are changed to the standardized values between which there are small magnitude differences, the magnitude differences between the standardized values can be reduced. In addition, since the representative values of the values for the process condition are calculated through the standardized values with the reduced magnitude differences, correctness of the representative values can be enhanced.

Moreover, since the magnitude differences between the standardized values are reduced so that the correctness of the representative values is enhanced, it is not necessary to intentionally remove the values corresponding to the portion of deteriorating the correctness of the representative values ('the portion of generating a transient phenomenon') among the values for the measured process condition.

Furthermore, since the magnitude differences between the standardized values are reduced through the standardization process, several variables with considerably different scales can be displayed all together on one chart, whereby the values corresponding to the variables can be easily compared.

Other features will become apparent to those skilled in the art from the following detailed description, which, taken in conjunction with the attached drawings, discloses exemplary embodiments of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a block diagram showing a representative value calculating apparatus according to an embodiment of the present invention.

FIG. 2 is a graph depicting standardized values versus sampling points for some samples.

FIGS. 3A and 3B are graphs depicting measured process condition values and standardized values for sampling points.

FIG. 4 is a graph depicting calculated representative values versus sampling points.

FIG. 5 is a graph depicting accumulated sum values versus sampling points.

5 FIG. 6 is a flowchart showing a method, through which a representative value calculating apparatus calculates representative values, according to an embodiment of the present invention.

FIG. 7 is a flowchart showing a method, through which a representative value calculating apparatus calculates representative values, according to another embodiment of the present invention.

10 Elements, features, and structures are denoted by the same reference numerals throughout the drawings and the detailed description, and the size and proportions of some elements may be exaggerated in the drawings for clarity and convenience.

DETAILED DESCRIPTION

15 Hereinafter, detailed description for carrying out the present invention will be given with reference to the accompanying drawings.

FIG. 1 is a block diagram showing a representative value calculating apparatus according to an embodiment of the present invention.

Referring to FIG. 1, the representative value calculating apparatus 100 includes a sensor 110, an extraction unit 120, a first calculation unit 130, a second calculation unit 140, a third calculation unit 150, 20 a controller 160, and a display unit 170.

The representative value calculating apparatus 100 may be installed in a process apparatus or a process system.

The sensor 110 may be installed in the process apparatus or the process system, and may measure values for a process condition for each sample according to a preset measuring period. The process

condition includes various conditions, which are necessary for processes, such as a temperature, a pressure, a time and a location of a product.

A plurality of sampling points may exist in one step. The sampling points imply locations at which the sensor 110 has measured the process condition. For example, when it takes a time of 26
5 seconds to perform one step and a measuring period is 2 seconds, the sensor 110 measures the values for the process condition every 2 seconds so that a total of 13 sampling points are generated until the one step is completed.

The predetermined measuring period may be set by users or manufacturers.

The samples may correspond to respective products. For example, in a case of a process for
10 producing 40 semiconductor wafers, the samples may correspond to the semiconductor wafers, respectively.

A recipe includes information such as an operating method and a facility manipulating method for producing the products. The operating method and the facility manipulating method include several steps, and process conditions required for each step are different from each other. The process conditions
15 imply various conditions, which are necessary for the processes, such as a temperature, a pressure, a time and a location of a product. For example, in 'A' step, a process condition where a process should be performed at a temperature of 100 degrees Celsius for one minute may be required, and in 'B' step, a process condition where a process should be performed at a temperature of 50 degrees Celsius and a pressure of 1 atmosphere for twenty seconds may be required.

20 Giving an example of the sensor 110, in-situ sensors may be installed in a semiconductor device apparatus, and may measure various pieces of information such that a process progress state in an interior of a chamber may be monitored in real time.

The information acquired through the sensor 110 may be expressed as shown in Table 1 and Table 2. Table 1 and Table 2 show values which the sensor 110 has measured for process condition 1
25 (for example, a temperature). First row corresponds to sampling points, and first column corresponds to

the number of samples. In Table 1 and Table 2, a total number of the sampling points are eleven, and a total number of the samples are forty. However, the number of the sampling points and the samples corresponds to mere one embodiment, and may be variously varied.

TABLE 1

	1	2	3	4	5	6
#1	3.08278	4.7734	3.3364	3.0865	5.0858	7.9599
#2	10.3342	3.6488	3.0865	3.3989	6.3354	8.8347
#3	6.8353	3.2739	2.9615	4.6485	7.0852	9.397
#4	11.3964	3.5863	3.0865	3.3989	6.023	8.4598
#5	22.8303	4.2111	3.0865	2.9615	5.8981	8.0849
#6	6.273	3.2739	3.024	4.6485	7.0227	9.6469
#7	9.5844	3.3989	2.9615	3.5863	6.5854	8.8971
#8	8.3348	3.5238	2.9615	3.7737	6.3354	9.3345
#9	6.6478	3.2739	3.0865	4.6485	7.0227	9.5844
#10	12.8334	3.6488	3.024	3.2739	6.0855	8.6472
#11	12.5835	3.9612	3.024	3.2739	5.9606	8.4598
#12	9.8343	3.3989	3.0865	3.5238	6.7103	9.0221
#13	3.50077	5.3358	3.3364	2.9615	5.0233	7.8975
#14	7.1852	3.4989	3.4989	5.4982	8.8722	12.1212
#15	7.4351	3.5613	3.6863	4.8734	8.8722	12.0587
#16	6.7478	3.8737	3.7488	5.4982	8.4973	12.1212
#17	9.8094	3.4989	3.3739	4.3736	7.8725	11.1215
#18	11.4339	3.9987	3.124	4.3736	7.3726	10.934
#19	5.4358	3.5613	3.4989	6.1855	9.497	12.746
#20	7.4976	3.8113	3.4989	4.9359	8.4973	11.1215
#21	4.561	2.1868	0.8747	1.0621	1.437	1.4995
#22	7.5601	2.4367	1.437	1.1871	1.4995	1.437
#23	8.0599	2.999	1.4995	1.0621	1.1871	1.1871
#24	9.1846	2.999	1.562	0.9996	1.1871	1.4995
#25	6.7478	2.5616	1.4995	1.1871	1.3745	1.4995
#26	4.3736	2.2492	0.8747	1.4995	1.1871	1.1871

#27	4.1237	1.562	0.9372	1.1871	1.4995	1.4995
#28	6.1855	2.3742	1.2496	1.1871	1.1871	1.437
#29	6.0606	2.4992	1.1246	1.312	1.1246	1.437
#30	6.373	2.3117	1.1871	1.4995	1.4995	1.4995
#31	3.7488	1.9368	1.1871	1.1246	1.3745	1.4995
#32	4.3111	1.6869	1.1246	1.1871	1.437	1.437
#33	4.2486	1.9368	1.1871	1.3745	1.437	1.562
#34	6.7478	2.4367	1.1246	1.0621	1.4995	1.312
#35	7.935	2.999	1.4995	1.0621	1.4995	1.4995
#36	3.4333	3.6238	1.4995	1.1871	1.1871	1.4995
#37	7.3726	2.4367	1.6244	0.9996	1.1871	1.1246
#38	7.1852	2.4367	1.562	1.1871	1.4995	1.4995
#39	4.3736	1.8744	1.1871	1.1871	1.1871	1.437
#40	5.4358	2.3742	1.1871	1.1246	1.4995	1.6244

TABLE 2

7	8	9	10	11
10.3342	3.024	0.6497	0.5872	0.3998
8.0849	0.5872	0.6497	0.4623	0.6497
11.0215	0.8996	0.5872	0.5872	
10.7716	1.462	0.5872	0.5872	0.7122
9.4595	0.6497	0.5872	0.5872	0.5872
11.3964	0.6497	0.6497	0.4623	0.5872
11.8962	0.6497	0.6497	0.3373	0.6497
9.7719	0.5872	0.5872	0.6497	0.5248
11.084	1.0871	0.5872	0.3998	
11.2714	1.3995	0.5872	0.6497	0.6497
11.5213	0.7747	0.4623	0.7122	0.6497
10.3967	0.40237	0.7122	0.5872	0.5872
7.4351	0.8122	0.9372	0.8122	
14.1205	0.9996			
11.3714	0.7497	0.9996	0.7497	0.9372

14.3705	0.9996	0.8747	0.9372	0.6872
14.0581	1.1246	0.6872	0.9996	
4.686	0.9372	0.6872	0.9372	0.6872
13.9956	0.8122	0.8122	0.7497	0.9372
0.3748	0.0624	0.1874	0.0624	0.2499
0.9372	0	0	0.1249	
1.562	0	0		
1.437	0.1249	0.1874	0.0624	0.0624
1.2496	0.1249	0.0624	0	0
0.1874	0.0624	0.0624	0	0.1249
0	0.1874	0.1874	0.1249	0.2499
0.8747	0.0624	0.0624	0.1874	0.2499
0.8747	0.1249	0.0624	0.1249	0.1874
1.0621	0.1249	0	0.0624	0.1874
0.1874	0	0	0	0.1249
0.1874	0.1874	0	0.0624	0.0624
0.2499	0.0624	0.0624	0.1249	0.0624
1.4995	0	0.1249	0	0.1874
1.4995	0.4998	0.1249	0	0.2499
1.4995	0.1249	0.1249	0.3748	0.0624
1.562	0.2499	0.3124	0.1249	0.0624
1.3745	0.1874	0.1249	0	0
0.3748	0	0	0.1874	0.1249
0.6872	0.1874	0	0	0.1249

The information acquired through the sensor 110 may be expressed as shown in Table 3 and Table 4. Table 3 and Table 4 show values which the sensor 110 has measured for process condition 2 (for example, a pressure). First row corresponds to sampling points, and first column corresponds to the number of samples. In Table 3 and Table 4, a total number of the sampling points is eleven, and a total number of the samples is forty. However, the number of the sampling points and the samples corresponds to mere one embodiment, and may be variously varied.

TABLE 3

샘플#	1	2	3	4	5	6
#1	330.4628331	100.160885	30.51358818	9.217116614	10.50585539	11.13922152
#2	380.3805479	130.9025424	40.57750649	11.64172347	9.86411062	10.83165185
#3	380.6711252	150.2400937	40.50504315	8.195122056	9.589144058	10.61850909
#4	290.3585188	180.2847009	50.95184537	10.54503009	11.09992197	9.973616597
#5	361.1753884	120.1006175	40.38202722	8.057241696	9.179803066	10.16535673
#6	340.3453545	100.4984354	30.68580461	10.23413853	8.612669057	9.356521876
#7	300.8805121	150.7433733	50.3624409	10.96957042	10.01249957	10.04030151
#8	250.9415543	60.64695349	20.16570977	8.902652926	10.4982885	8.431349859
#9	250.105224	60.06057366	20.70347717	10.27212017	10.82741684	10.04293006
#10	380.1773277	270.3236907	80.46615542	10.42269166	8.523593459	9.060005322
#11	400.7508207	370.1826229	130.268707	15.01487195	12.57884162	11.4477515
#12	350.7886084	270.5880844	160.1901412	11.25323071	12.84238284	10.18232675
#13	370.1231865	130.4211294	30.39733325	12.01315406	10.35747906	9.74433827
#14	230.1449774	70.61897298	20.79222153	10.73735678	10.31916567	10.05682801
#15	290.5958573	150.1140805	50.87474827	8.335267633	11.0782124	11.89622919
#16	280.7515674	280.8480338	70.03325901	11.88889338	10.41122875	10.0636595
#17	330.3037076	250.8835243	60.75070484	12.97378468	9.813538586	9.756297955
#18	360.1628536	230.4689901	60.72703978	12.0477055	10.71487999	10.01563013
#19	330.9746554	180.8046801	170.1326335	10.43609829	8.595277952	9.840890332
#20	320.1368842	310.3697104	100.3819528	9.544157481	10.13342153	8.196713379
#21	300.7546607	150.0667491	40.02625552	10.97920934	12.85345361	11.99253051
#22	230.4089898	170.152245	50.02697698	10.04264491	13.75397936	11.65691301
#23	300.7607774	100.9447663	30.99213252	10.9015152	10.22591286	10.88616379
#24	370.8957567	290.2954571	90.14989147	12.62050082	12.15308107	9.933096605
#25	370.6306886	130.0887302	40.01801012	10.43741031	10.10530761	10.08440016
#26	360.3191875	210.3718672	50.87518181	9.573328974	13.70200204	11.0060575
#27	370.938481	150.7187381	40.24524055	10.39191874	8.057649994	9.932068661
#28	290.8273522	210.7975375	50.25044152	10.68496478	10.61281678	10.53287868
#29	270.6909429	80.88743301	20.75294533	10.01716135	10.17165318	10.99785769
#30	310.3842332	210.2170016	50.80063188	11.48392112	12.84953392	8.950375543

#31	300.2222245	230.0132381	60.75244903	23.60518696	10.62818388	11.15033264
#32	340.5597385	100.1820943	30.30821411	13.7917826	11.39726916	9.094713974
#33	370.8534497	110.3134754	30.19774994	10.92831549	10.43699389	9.288588297
#34	340.6289641	100.7220668	30.17162313	12.94053154	10.04793088	8.110155443
#35	280.4092177	70.09756622	20.51215622	9.541625174	10.51800533	10.28197808
#36	290.4992302	180.4813449	50.28849099	12.43825243	10.3775814	10.78629124
#37	380.3503839	300.9097993	80.178668	11.7642773	9.94446115	9.24057969
#38	340.7743314	110.164399	30.7757818	12.42119585	10.85461866	8.745305294
#39	330.3911756	170.272292	50.95276051	10.52405472	9.980991012	9.93531918
#40	400.8593387	380.9031308	40.9760403	11.23783369	10.8307735	10.20564295

TABLE 4

7	8	9	10	11
9.119430597	8.446991967	9.663602043	10.79711356	11.15819018
11.24787773	10.25710585	10.55748353	9.355803498	11.31199923
8.472432776	9.84423797	10.44289104	10.90054287	
10.80398677	11.28129444	10.09969147	9.459717785	10.00236721
11.74036709	10.89140913	10.48372672	9.13708099	9.720183867
10.08785551	10.48252485	10.55373905	10.17995544	10.63944289
9.969373793	10.78767519	10.10330683	11.6345476	10.99831211
10.70907561	10.89608978	10.73797829	10.80618335	10.55611392
9.229492789	9.339580304	9.896153982	10.0215543	
11.34561006	9.254570236	9.219533983	9.601568904	9.654250101
9.340390082	9.375534982	8.280130761	10.70482322	11.82980282
9.597549436	9.428101642	8.245923712	10.03431775	
10.29374254	10.12555569			
10.15494195	10.87271598	9.64419727	9.006764369	8.476712701
9.953553847	9.429868876	9.615641843	9.956155617	10.94356428
9.566392931	10.64263874	10.90015592	10.2366041	10.15385656
10.5572553	10.80117564	10.0231738	10.3017831	
9.812812296	12.84824371	12.34768729	10.29438309	11.33581947
8.11821458	8.496783106	9.785590618	9.898643139	10.73410929

11.05852573	9.089995642	9.098755592	10.51358186	10.90034643
10.46659664	10.92773193	9.945699664	9.805797207	
10.31816259	10.52164819	10.99972613		
8.167266243	8.647587409	9.514655968	9.002780097	10.20403131
10.96322911	10.9971237	10.50206555	10.60007033	10.55507471
9.6462473	9.367114848	8.241437307	9.008454344	11.03327534
9.246789608	9.916203591	11.41988646	11.08239574	12.48109877
10.47320248	10.02161306	10.70520418	10.63145239	10.09066491
8.733202987	10.57769289	10.4716797	9.257637751	10.13868713
8.691959989	8.618926854	8.328623114	9.849721749	9.26215644
12.1539496	8.444348093	9.977928217	9.745521495	9.430254984
8.091424843	8.895517778	9.107696181	10.56306856	11.34480722
9.918957057	8.15708254	8.81976843	10.74815278	11.69682688
8.278881868	8.075457444	9.729748919	9.528817679	9.612088127
10.67274928	10.5950984	10.7323474	11.81595775	10.01044747
8.56894155	9.628587477	8.574729382	9.664938744	10.19880395
9.862644257	8.317141973	11.92985499	11.93215747	10.31847275
8.757716524	9.986004113	9.266039576	9.521337411	9.566979942
9.723014356	9.455199235	9.128015871	9.787385876	9.776761639
10.31259488	8.008257944	8.669055792	10.07987555	10.22460733

The extraction unit 120 may extract only the process condition values corresponding to the user set sampling points among the measured process condition values. For example, the sampling points may be variously set in the same way as second to tenth sampling points, sampling points with a sampling point number fewer than or equal to an average number of the sampling points, and sampling points with a sampling point number fewer than or equal to 90% of a total number of the sampling points are excluded.

The extraction unit 120 may set the process condition values of cells in which there is no process condition value as a null.

For example, the extraction unit 120 may extract only the process condition values corresponding to the sampling points which the user has set in Table 1 and Table 2. For example, the extracted results may correspond to those shown in Table 5 and Table 6.

TABLE 5

샘플#	1	2	3	4	5	6
#3	6.8353	3.2739	2.9615	4.6485	7.0852	9.397
#4	11.3964	3.5863	3.0865	3.3989	6.023	8.4598
#5	22.8303	4.2111	3.0865	2.9615	5.8981	8.0849
#6	6.273	3.2739	3.024	4.6485	7.0227	9.6469
#7	9.5844	3.3989	2.9615	3.5863	6.5854	8.8971
#8	8.3348	3.5238	2.9615	3.7737	6.3354	9.3345
#9	6.6478	3.2739	3.0865	4.6485	7.0227	9.5844
#10	12.8334	3.6488	3.024	3.2739	6.0855	8.6472
#21	4.561	2.1868	0.8747	1.0621	1.437	1.4995
#22	7.5601	2.4367	1.437	1.1871	1.4995	1.437
#23	8.0599	2.999	1.4995	1.0621	1.1871	1.1871
#24	9.1846	2.999	1.562	0.9996	1.1871	1.4995
#25	6.7478	2.5616	1.4995	1.1871	1.3745	1.4995
#26	4.3736	2.2492	0.8747	1.4995	1.1871	1.1871
#27	4.1237	1.562	0.9372	1.1871	1.4995	1.4995
#28	6.1855	2.3742	1.2496	1.1871	1.1871	1.437

5

TABLE 6

7	8	9	10	11
8.0849	0.5872	0.6497	0.4623	0.6497
11.0215	0.8996	0.5872	0.5872	0
10.7716	1.462	0.5872	0.5872	0.7122
9.4595	0.6497	0.5872	0.5872	0.5872
11.3964	0.6497	0.6497	0.4623	0.5872
11.8962	0.6497	0.6497	0.3373	0.6497
9.7719	0.5872	0.5872	0.6497	0.5248

11.084	1.0871	0.5872	0.3998	0
0.3748	0.0624	0.1874	0.0624	0.2499
0.9372	0.00000	0.00000	0.1249	0
1.562	0.00000	0.00000	0	0
1.437	0.1249	0.1874	0.0624	0.0624
1.2496	0.1249	0.0624	0.00000	0
0.1874	0.0624	0.0624	0.00000	0.1249
0.00000	0.1874	0.1874	0.1249	0.2499
0.8747	0.0624	0.0624	0.1874	0.2499

The extraction unit 120 may extract only the process condition values corresponding to the sampling points which the user has set in Table 3 and Table 4. For example, the extracted results may correspond to those shown in Table 7 and Table 8.

TABLE 7

샘플#	1	2	3	4	5	6
#3	380.6711252	150.2400937	40.50504315	8.195122056	9.589144058	10.61850909
#4	290.3585188	180.2847009	50.95184537	10.54503009	11.09992197	9.973616597
#5	361.1753884	120.1006175	40.38202722	8.057241696	9.179803066	10.16535673
#6	340.3453545	100.4984354	30.68580461	10.23413853	8.612669057	9.356521876
#7	300.8805121	150.7433733	50.3624409	10.96957042	10.01249957	10.04030151
#8	250.9415543	60.64695349	20.16570977	8.902652926	10.4982885	8.431349859
#9	250.105224	60.06057366	20.70347717	10.27212017	10.82741684	10.04293006
#10	380.1773277	270.3236907	80.46615542	10.42269166	8.523593459	9.060005322
#21	300.7546607	150.0667491	40.02625552	10.97920934	12.85345361	11.99253051
#22	230.4089898	170.152245	50.02697698	10.04264491	13.75397936	11.65691301
#23	300.7607774	100.9447663	30.99213252	10.9015152	10.22591286	10.88616379
#24	370.8957567	290.2954571	90.14989147	12.62050082	12.15308107	9.933096605
#25	370.6306886	130.0887302	40.01801012	10.43741031	10.10530761	10.08440016
#26	360.3191875	210.3718672	50.87518181	9.573328974	13.70200204	11.0060575
#27	370.938481	150.7187381	40.24524055	10.39191874	8.057649994	9.932068661
#28	290.8273522	210.7975375	50.25044152	10.68496478	10.61281678	10.53287868

TABLE 8

샘플#	7	8	9	10	11
#3	11.24787773	10.25710585	10.55748353	9.355803498	11.31199923
#4	8.472432776	9.84423797	10.44289104	10.90054287	0
#5	10.80398677	11.28129444	10.09969147	9.459717785	10.00236721
#6	11.74036709	10.89140913	10.48372672	9.13708099	9.720183867
#7	10.08785551	10.48252485	10.55373905	10.17995544	10.63944289
#8	9.969373793	10.78767519	10.10330683	11.6345476	10.99831211
#9	10.70907561	10.89608978	10.73797829	10.80618335	10.55611392
#10	9.229492789	9.339580304	9.896153982	10.0215543	0
#21	11.05852573	9.089995642	9.098755592	10.51358186	10.90034643
#22	10.46659664	10.92773193	9.945699664	9.805797207	0
#23	10.31816259	10.52164819	10.99972613	0	0
#24	8.167266243	8.647587409	9.514655968	9.002780097	10.20403131
#25	10.96322911	10.9971237	10.50206555	10.60007033	10.55507471
#26	9.6462473	9.367114848	8.241437307	9.008454344	11.03327534
#27	9.246789608	9.916203591	11.41988646	11.08239574	12.48109877
#28	10.47320248	10.02161306	10.70520418	10.63145239	10.09066491

The first calculation unit 130 may calculate a median value and a median absolute deviation (MAD) of the process condition values for each sampling point, by using the process condition values which have been measured for sampling points for each sample through the sensor 110. The median value, which is a middle value, represents the middle number in a set of numbers, and when the number of the numbers in the set of numbers is an even number, corresponds to a mean value of two numbers in the center of the set.

The first calculation unit 130 may calculate a mean value and a standard deviation of the process condition values for each sampling point, by using the process condition values which have been measured for sampling points for each sample through the sensor 110.

The first calculation unit 130 may calculate a median absolute deviation (MAD) value by using Equation 1.

Equation 1

$$MAD = a * \text{Median}(|X_i - \text{Median}(X_j)|)$$

here, a is a correction factor making the MAD identical with a standard deviation for a normal distribution, X_i is a process condition value, X_j is a median value, and $\text{Median}(X)$ is a function calculating a median value among X variables.

5 The first calculation unit 130 assumes that the value of a is 1.4826, and may calculate a median value and a median absolute deviation (MAD) for each sampling point by using Table 5, Table 6, and Equation 1. The calculated results may correspond to those shown in Table 9 and Table 10.

TABLE 9

구분	1	2	3	4	5
Median	7.1977	3.1365	2.2618	2.2305	3.6988
MAD	2.3158	0.7133	1.1764	1.7323	3.7238

TABLE 10

6	7	8	9	10	11
4.7922	4.8235	0.3873	0.3873	0.2624	0.2499
5.3449	6.8734	0.4354	0.3427	0.2964	0.3705

10 The first calculation unit 130 assumes that the value of a is 1.4826, and may calculate a median value and a median absolute deviation (MAD) for each sampling point by using Table 7, Table 8, and Equation 1. The calculated results may correspond to those shown in Table 11 and Table 12.

TABLE 11

구분	1	2	3	4	5
Median	320.6129333	150.4794159	40.44353518	10.4073052	10.36210068
MAD	67.1471	59.2398	14.5033	0.6367	1.4494

TABLE 12

6	7	8	9	10	11
10.06366511	10.39237962	10.36981535	10.46330888	10.10075487	10.37955301
0.7591	0.9170	0.7797	0.5364	1.0752	0.9433

Although only the results of the median values and the median absolute deviations (MADs), which the first calculation unit 130 has calculated, are described above, the first calculation unit 130 may also calculate mean values and standard deviations.

The second calculation unit 140 may calculate standardized values by using the process condition values, the median value, and the median absolute deviation (MADs).

For example, the second calculation unit 140 may calculate a standardized value by using Equation 2.

Equation 2

$$\text{Standardized value} = (X_i - X_j) / \text{Median Absolute Deviation (MAD)}$$

here, X_i is a process condition value, and X_j is a median value.

The second calculation unit 140 may calculate standardized values for process condition 1 by using Table 1, Table 2, the median value and the median absolute deviation (MADs). The calculated results may correspond to those shown in Table 13 and Table 14.

TABLE 13

샘플#	1	2	3	4	5
#1	-1.7769	2.2950	0.9135	0.4941	0.3725
#2	1.3544	0.7183	0.7011	0.6745	0.7080
#3	-0.1565	0.1927	0.5948	1.3959	0.9094
#4	1.8131	0.6307	0.7011	0.6745	0.6241
#5	6.7503	1.5066	0.7011	0.4220	0.5906
#6	-0.3993	0.1927	0.6479	1.3959	0.8926
#7	1.0306	0.3679	0.5948	0.7827	0.7752
#8	0.4910	0.5431	0.5948	0.8909	0.7080
#9	-0.2375	0.1927	0.7011	1.3959	0.8926
#10	2.4336	0.7183	0.6479	0.6023	0.6409
#11	2.3257	1.1563	0.6479	0.6023	0.6074

#12	1.1385	0.3679	0.7011	0.7466	0.8087
#13	-1.5964	3.0834	0.9135	0.4220	0.3557
#14	-0.0054	0.5081	1.0516	1.8864	1.3893
#15	0.1025	0.5956	1.2109	1.5257	1.3893
#16	-0.1943	1.0336	1.2640	1.8864	1.2886
#17	1.1278	0.5081	0.9453	1.2372	1.1208
#18	1.8292	1.2089	0.7329	1.2372	0.9866
#19	-0.7608	0.5956	1.0516	2.2831	1.5570
#20	0.1295	0.9461	1.0516	1.5618	1.2886
#21	-1.1386	-1.3314	-1.1790	-0.6745	-0.6074
#22	0.1565	-0.9810	-0.7011	-0.6023	-0.5906
#23	0.3723	-0.1927	-0.6479	-0.6745	-0.6745
#24	0.8580	-0.1927	-0.5948	-0.7106	-0.6745
#25	-0.1943	-0.8059	-0.6479	-0.6023	-0.6242
#26	-1.2195	-1.2439	-1.1790	-0.4220	-0.6745
#27	-1.3274	-2.2073	-1.1259	-0.6023	-0.5906
#28	-0.4371	-1.0687	-0.8603	-0.6023	-0.6745
#29	-0.4910	-0.8934	-0.9666	-0.5302	-0.6913
#30	-0.3561	-1.1563	-0.9135	-0.4220	-0.5906
#31	-1.4893	-1.6819	-0.9135	-0.6384	-0.6242
#32	-1.2465	-2.0322	-0.9666	-0.6023	-0.6074
#33	-1.2735	-1.6819	-0.9135	-0.4941	-0.6074
#34	-0.1943	-0.9810	-0.9666	-0.6745	-0.5906
#35	0.3184	-0.1927	-0.6479	-0.6745	-0.5906
#36	-1.6255	0.6833	-0.6479	-0.6023	-0.6745
#37	0.0755	-0.9810	-0.5418	-0.7106	-0.6745
#38	-0.0054	-0.9810	-0.5948	-0.6023	-0.5906
#39	-1.2195	-1.7694	-0.9135	-0.6023	-0.6745
#40	-0.7608	-1.0687	-0.9135	-0.6384	-0.5906

TABLE 14

6	7	8	9	10	11
0.5927	0.8017	6.0563	0.7657	1.0958	0.4046

0.7563	-0.7018	-0.8896	-1.1301	-0.8850	-0.6745
0.8615	0.4745	0.4592	0.7657	0.6745	1.0791
0.6862	0.9017	1.1767	0.5833	1.0958	-0.6745
0.6160	0.8654	2.4685	0.5833	1.0958	1.2478
0.9083	0.6745	0.6027	0.5833	1.0958	0.9104
0.7680	0.9563	0.6027	0.7657	0.6745	0.9104
0.8498	1.0290	0.6027	0.7657	0.2528	1.0791
0.8966	0.7199	0.4592	0.5833	1.3066	0.7420
0.7212	0.9108	1.6074	0.5833	0.4637	-0.6745
0.6862	0.9381	2.3249	0.5833	1.3066	1.0791
0.7914	0.9745	0.8898	0.2188	1.5175	1.0791
0.5810	0.8108	0.0346	0.9481	1.0958	0.9104
1.3712	0.3800	0.9760	1.6046	1.8548	-0.6745
1.3595	1.3526	1.4064	-1.1301	-0.8850	-0.6745
1.3712	0.9526	0.8324	1.7867	1.6440	1.8551
1.1842	1.3890	1.4064	1.4222	2.2765	1.1803
1.1491	1.3435	1.6935	0.8751	2.4870	-0.6745
1.4881	-0.0200	1.2631	0.8751	2.2765	1.1803
1.1842	1.3344	0.9760	1.2398	1.6440	1.8551
-0.6160	-0.6472	-0.7463	-0.5833	-0.6745	0.0000
-0.6277	-0.5654	-0.8896	-1.1301	-0.4637	-0.6745
-0.6745	-0.4745	-0.8896	-1.1301	-0.8850	-0.6745
-0.6160	-0.4927	-0.6027	-0.5833	-0.6745	-0.5061
-0.6160	-0.5200	-0.6027	-0.9481	-0.8850	-0.6745
-0.6745	-0.6745	-0.7463	-0.9481	-0.8850	-0.3374
-0.6160	-0.7018	-0.4592	-0.5833	-0.4637	0.0000
-0.6277	-0.5745	-0.7463	-0.9481	-0.2528	0.0000
-0.6277	-0.5745	-0.6027	-0.9481	-0.4637	-0.1687
-0.6160	-0.5472	-0.6027	-1.1301	-0.6745	-0.1687
-0.6160	-0.6745	-0.8896	-1.1301	-0.8850	-0.3374
-0.6277	-0.6745	-0.4592	-1.1301	-0.6745	-0.5061
-0.6043	-0.6654	-0.7463	-0.9481	-0.4637	-0.5061

-0.6511	-0.4836	-0.8896	-0.7657	-0.8850	-0.1687
-0.6160	-0.4836	0.2584	-0.7657	-0.8850	0.0000
-0.6160	-0.4836	-0.6027	-0.7657	0.3793	-0.5061
-0.6862	-0.4745	-0.3156	-0.2186	-0.4637	-0.5061
-0.6160	-0.5018	-0.4592	-0.7657	-0.8850	-0.6745
-0.6277	-0.6472	-0.8896	-1.1301	-0.2528	-0.3374
-0.5927	-0.6018	-0.4592	-1.1301	-0.8850	-0.3374

The second calculation unit 140 may calculate standardized values for process condition 2 by using Table 3, Table 4, the median value and the median absolute deviation (MADs). The calculated results may correspond to those shown in Table 15 and Table 16.

TABLE 15

샘플#	1	2	3	4	5
#1	0.1467	-0.8494	-0.6847	-1.8694	0.0992
#2	0.8901	-0.3305	0.0092	1.9388	-0.3436
#3	0.8944	-0.0040	0.0042	-3.4746	-0.5333
#4	-0.4506	0.5031	0.7245	0.2163	0.5090
#5	0.6041	-0.5128	-0.0042	-3.6911	-0.8157
#6	0.2939	-0.8437	-0.6728	-0.2720	-1.2070
#7	-0.2939	0.0045	0.6839	0.8831	-0.2412
#8	-1.0376	-1.5164	-1.3982	-2.3633	0.0940
#9	-1.0500	-1.5263	-1.3611	-0.2123	0.3210
#10	0.8871	2.0230	2.7596	0.0242	-1.2684
#11	1.1935	3.7087	6.1934	7.2369	1.5294
#12	0.4494	2.0275	8.2565	1.3286	1.7112
#13	0.7373	-0.3386	-0.6927	2.5222	-0.0032
#14	-1.3473	-1.3481	-1.3550	0.5184	-0.0296
#15	-0.4470	-0.0062	0.7192	-3.2544	0.4941
#16	-0.5936	2.2007	2.0402	2.3271	0.0339
#17	0.1443	1.6949	1.4002	4.0310	-0.3785
#18	0.5890	1.3503	1.3985	2.5765	0.2434
#19	0.1543	0.5119	8.9421	0.0452	-1.2190

#20	-0.0071	2.6990	4.1328	-1.3557	-0.1578
#21	-0.2957	-0.0070	-0.0288	0.8983	1.7189
#22	-1.3434	0.3321	0.6608	-0.5728	2.3401
#23	-0.2957	-0.8362	-0.6517	0.7762	-0.0940
#24	0.7488	2.3602	3.4273	3.4761	1.2356
#25	0.7449	-0.3442	-0.0293	0.0473	-0.1772
#26	0.5913	1.0110	0.7193	-1.3099	2.3043
#27	0.7495	0.0040	-0.0137	-0.0242	-1.5899
#28	-0.4436	1.0182	0.6762	0.4361	0.1730
#29	-0.7435	-1.1747	-1.3577	-0.6128	-0.1314
#30	-0.1523	1.0084	0.7141	1.6910	1.7161
#31	-0.3037	1.3426	1.4003	20.7292	0.1836
#32	0.2971	-0.8490	-0.6988	5.3158	0.7142
#33	0.7482	-0.6780	-0.7064	0.8183	0.0517
#34	0.2981	-0.8399	-0.7082	3.9788	-0.2168
#35	-0.5987	-1.3569	-1.3743	-1.3597	0.1076
#36	-0.4485	0.5064	0.6788	3.1899	0.0107
#37	0.8897	2.5393	2.7397	2.1313	-0.2881
#38	0.3003	-0.6805	-0.6666	3.1631	0.3398
#39	0.1456	0.3341	0.7246	0.1834	-0.2629
#40	1.1951	3.8897	0.0367	1.3045	0.3233

TABLE 16

6	7	8	9	10	11
1.4168	-1.3882	-2.4660	-1.4908	0.6477	0.8254
1.0117	-11.3332	-13.2991	-19.5058	-9.3946	-11.0036
0.7309	0.9329	-0.1445	0.1756	-0.6929	0.9885
-0.1186	-2.0938	-0.6740	-0.0381	0.7439	-11.0036
0.1340	0.4489	1.1690	-0.6779	-0.5962	-0.3999
-0.9315	1.4700	0.6689	0.0381	-0.8963	-0.6990
-0.0308	-0.3321	0.1445	0.1686	0.0737	0.2755
-2.1502	-0.4613	0.5359	-0.6711	1.4266	0.6560
-0.0273	0.3454	0.6749	0.5120	0.6561	0.1872

-1.3221	-1.2682	-1.3213	-1.0573	-0.0737	-11.0036
1.8232	1.0395	-1.4303	-2.3187	-0.4643	-0.7689
0.1563	-1.1472	-1.2751	-4.0699	0.5618	1.5374
-0.4206	-0.8668	-1.2077	-4.1337	-0.0618	-11.0036
-0.0090	-0.1076	-0.3133	-19.5058	-9.3946	-11.0036
2.4140	-0.2589	0.6450	-1.5270	-1.0175	-2.0172
0.0000	-0.4786	-1.2055	-1.5802	-0.1345	0.5979
-0.4049	-0.9008	0.3499	0.8144	0.1264	-0.2393
-0.0633	0.1798	0.5532	-0.8205	0.1870	-11.0036
-0.2935	-0.6320	3.1785	3.5129	0.1801	1.0138
-2.4593	-2.4800	-2.4021	-1.2634	-0.1880	0.3759
2.5409	0.7265	-1.6413	-2.5438	0.3840	0.5521
2.0988	0.0809	0.7155	-0.9649	-0.2743	-11.0036
1.0835	-0.0809	0.1947	1.0000	-9.3946	-11.0036
-0.1720	-2.4266	-2.2087	-1.7685	-1.0212	-0.1861
0.0273	0.6225	0.8045	0.0723	0.4644	0.1861
1.2414	-0.8137	-1.2859	-4.1420	-1.0159	0.6930
-0.1734	-1.2493	-0.5817	1.7833	0.9130	2.2279
0.6181	0.0881	-0.4466	0.4509	0.4936	-0.3063
1.2306	-1.8094	0.2666	0.0156	-0.7842	-0.2553
-1.4665	-1.8544	-2.2455	-3.9795	-0.2335	-1.1846
1.4315	1.9210	-2.4694	-0.9049	-0.3304	-1.0064
-1.2764	-2.5093	-1.8908	-2.5272	0.4300	1.0233
-1.0210	-0.5163	-2.8378	-3.0639	0.6021	1.3965
-2.5733	-2.3048	-2.9425	-1.3675	-0.5320	-0.8136
0.2876	0.3058	0.2889	0.5015	1.5953	-0.3913
0.9519	-1.9885	-0.9506	-3.5207	-0.4053	-0.1916
-1.0842	-0.5777	-2.6325	2.7340	1.7034	-0.0648
-1.7367	-1.7827	-0.4922	-2.2320	-0.5389	-0.8614
-0.1691	-0.7300	-1.1730	-2.4893	-0.2915	-0.6390
0.1870	-0.0870	-3.0287	-3.3449	-0.0194	-0.1643

The second calculation unit 140 may calculate standardized values by using the process condition values, the median value, and the standard deviation.

For example, the second calculation unit 140 may calculate a standardized value by using Equation 3.

Equation 3

$$\text{Standardized value} = (X_i - \text{Mean value}) / \text{Standard Deviation}$$

here, X_i is a process condition value.

FIG. 2 is a graph depicting standardized values versus sampling points for some samples.

Referring to FIG. 2, the controller 160 may graph the standardized values for sampling points for samples of #6, #9, #26, and #40 among the samples, and display the graph in the display unit 170. A horizontal axis corresponds to sampling points, and a vertical axis corresponds to standardized values. For example, when the controller 160 displays a graph of standardized values versus sampling points for samples, which a user selects or presets, in the display unit 170, the user may easily determine similarity between the samples. For example, the user may easily determine that the samples of #6 and #9 have a similar characteristic, and the samples of #26 and #40 have a similar characteristic.

FIGS. 3A and 3B are graphs depicting measured process condition values and standardized values for sampling points.

FIG. 3A is a graph depicting process condition values of Table 1 and Table 2 versus sampling points. A horizontal axis corresponds to sampling points, and a vertical axis corresponds to process condition values.

FIG. 3B is a graph depicting standardized values of Table 13 and Table 14 versus sampling points. A horizontal axis corresponds to sampling points, and a vertical axis corresponds to standardized values.

Referring to FIG. 3A based on first sampling point, there is a difference of about 20 between maximum value and minimum value of the process condition values. Moreover, the process condition

values do not gather at a specific location but scatter everywhere. Accordingly, a variance value of the process condition values grows larger, and a difference between the variance values also grows larger.

On the other hand, referring to FIG. 3B based on first sampling point, there is a difference of about 10, which is smaller than the difference between the process condition values of FIG. 3A, between maximum value and minimum value of the standardized values. Moreover, the standardized values uniformly gather at a specific location ('a magnitude of -2 to 3'). Accordingly, a variance value of the standardized values grows smaller, and a difference between the variance values also grows smaller. The representative value calculating apparatus calculates representative values of the values for the process condition by using the standardized values whose magnitude differences have been reduced, thus improving correctness of the representative value.

The third calculation unit 150 may calculate a representative value of the process condition values for each sample based on the calculated standardized values. The third calculation unit 150 may calculate the representative value of the process condition values based on any one of a mean value, a median value, a mode, a minimum value, a maximum value, and a standard deviation of the calculated standardized values.

If a case in which the third calculation unit 150 calculates the representative value for the process condition values based on the mean value of the calculated standardized values is illustrated, the third calculation unit 150 may calculate a mean value of the calculated standardized values for each sample based on Table 13 and Table 14. Accordingly, the third calculation unit 150 may calculate the representative value of the process condition values for process condition 1. Moreover, the third calculation unit 150 may calculate a mean value of the calculated standardized values for each sample based on Table 15 and Table 16. Accordingly, the third calculation unit 150 may calculate the representative value of the process condition values for process condition 2. For example, the calculated results may correspond to those shown in Table 17.

The controller 160 may allow the calculated representative values to be displayed for each sample.

FIG. 4 is a graph depicting calculated representative values versus sampling points. A horizontal axis corresponds to sampling points, and a vertical axis corresponds to representative values.

Referring to FIG. 4, the user can see that among representative values for process condition 1, representative values corresponding to samples of #1 to #20 are positive, and representative values corresponding to samples of #21 to #40 are negative. When determining based on that, the user can see that a state of process condition 1 has been considerably varied in the samples of #20 and #21. For example, it can be seen that when the process condition 1 corresponds to a temperature, the temperature in the samples of #1 to #20 is 110 degrees Celsius, and the temperature in the samples of #21 to #40 is 90 degrees Celsius. At this time, a portion at which the representative value is null corresponds to a temperature of 100 degrees Celsius.

Moreover, the user can see that there is no special pattern of the representative values for process condition 2 in the sample of #1 to #40. When determining based on that, the user can see that a state of process condition 2 has not been varied in a special pattern in the samples of #1 to #40.

In this way, the user can easily determine a degree of a change of the process condition based on the representative values shown for each sampling point.

TABLE 17

샘플#	공정 조건 1	공정 조건 2
#1	1.0923	-0.5102
#2	0.0574	-5.5782
#3	0.6592	-0.1021
#4	0.7466	-1.0620
#5	1.5316	-0.3947
#6	0.6823	-0.2774
#7	0.7481	0.1214
#8	0.7097	-0.6260
#9	0.6957	-0.1346
#10	0.7868	-1.0564

#11	1.1143	1.6130
#12	0.8394	0.8670
#13	0.6872	-1.4063
#14	0.9402	-3.9905
#15	0.5684	-0.3869
#16	1.2473	0.2916
#17	1.2543	0.6034
#18	1.1699	-0.4372
#19	1.0718	1.3995
#20	1.2010	-0.2823
#21	-0.7453	0.2094
#22	-0.6427	-0.7210
#23	-0.5950	-1.7547
#24	-0.4354	0.3150
#25	-0.6474	0.2199
#26	-0.8186	-0.1825
#27	-0.7889	0.1860
#28	-0.6175	0.2507
#29	-0.6325	-0.4869
#30	-0.6525	-0.5442
#31	-0.8982	1.9994
#32	-0.8661	-0.1792
#33	-0.8095	-0.4733
#34	-0.6592	-0.7293
#35	-0.3890	-0.1813
#36	-0.4965	-0.1970
#37	-0.4997	0.7355
#38	-0.6069	-0.4716
#39	-0.8240	-0.3970
#40	-0.7253	0.0266

In this way, the representative values which may be a representative among the standardized values are calculated so that the number of values which should be analyzed, and the number of values which should be stored are reduced, whereby an effect of data reduction can be achieved.

The third calculation unit 150 may accumulate and add up the calculated standardized values for
5 each sample.

The controller 160 may allow the accumulated and added up values to be displayed for each sampling point.

FIG. 5 is a graph depicting accumulated sum values versus sampling points. A vertical axis corresponds to sampling points, and a vertical axis corresponds to accumulated and added up values of
10 representative values.

Referring to FIG. 5, it can be seen that the accumulated and added up values for process condition 1 are varied on the basis of the sample of #20. Accordingly, the user can easily apprehend that process condition 1 is varied before and after the sample of #20.

On the other hand, it can be seen that there is no section in which the accumulated and added up
15 values are largely varied.

In this way, the user can easily determine a degree of a variation of the process condition based on the accumulated and added up values shown according to each sampling point.

The controller 160 may display the standardized values for each sampling point, the calculated representative values for each sample, and the accumulated sum of the calculated representative values
20 for each sample in the display unit 170. Accordingly, the user can see the degree of the variation of various values through the display unit 170, and can easily grasp a state of the apparatus based on the degree of the variation.

In this way, the user can easily determine the degree of the variation of the process condition based on the representative values shown according to each sampling point.

The display unit 170 may display various data generated in the representative value calculating apparatus 100.

The display unit 170 may include at least one of a liquid crystal display (LCD), a thin film transistor-liquid crystal display (TFT-LCD), an organic light emitting diode (OLED), a flexible display, and a three dimensional (3D) display.

Through a standardization process, the representative value calculating apparatus may change the values for the process condition, between which there are large magnitude differences, to the standardized values between which there are small magnitude differences, thus reducing the magnitude differences between the standardized values. The representative value calculating apparatus calculates the representative values of the values for the process condition by using the standardized values with the reduced magnitude differences, whereby correctness of the representative values is enhanced.

Moreover, since the representative values calculating apparatus reduces the magnitude differences between the standardized values so that the correctness of the representative values is enhanced, it is not necessary to intentionally remove, among the values for the measured process conditions, the values corresponding to the portion of deteriorating the correctness of the representative values ('the portion of generating a transient phenomenon').

Furthermore, the representative values calculating apparatus reduces the magnitude differences between the standardized values through a standardization process so that several variables with considerably different scales may be displayed all together on one chart, whereby the values corresponding to the variables can be easily compared.

FIG. 6 is a flowchart showing a method, through which a representative value calculating apparatus calculates representative values, according to an embodiment of the present invention.

Referring to FIG. 6, the representative value calculating apparatus may calculate a median value and a median absolute deviation (MAD), or a mean value and a standard deviation of the process

condition values for each sampling point, by using the process condition values which have been measured for sampling points for each sample through a sensor (610).

The representative value calculating apparatus may calculate a median absolute deviation (MAD) value by using Equation 1.

Equation 1

$$\text{MAD} = a * \text{Median}(|X_i - \text{Median}(X_j)|)$$

here, a is a correction factor making the MAD identical with a standard deviation for a normal distribution, X_i is a process condition value, X_j is a median value, and $\text{Median}(X)$ is a function calculating a median value among X variables.

The representative value calculating apparatus calculates a standardized value by using process condition values, a median value, and a median absolute deviation (MAD), or calculates a standardized value by using process condition values, a mean value, and a standard deviation.

The representative value calculating apparatus may calculate a standardized value by using Equation 2.

Equation 2

$$\text{Standardized value} = (X_i - X_j) / \text{Median Absolute Deviation (MAD)}$$

here, X_i is a process condition value, and X_j is a median value.

Moreover, the representative value calculating apparatus may calculate a standardized value by using Equation 3.

Equation 3

$$\text{Standardized value} = (X_i - \text{Mean value}) / \text{Standard Deviation}$$

here, X_i is a process condition value.

The representative value calculating apparatus calculates a representative value of the process condition values for each sample based on the calculated standardized values (620). For example, the representative value calculating apparatus may calculate the representative value of the process condition values based on any one of a mean value, a median value, a mode, a minimum value, a maximum value, and a standard deviation of the calculated standardized values.

The representative value calculating apparatus displays at least one of the standardized values for each sampling point, the calculated representative values for each sample, and the accumulated sum of the calculated representative values for each sample (630).

In the representative value calculating method, through a standardization process, the values for the process condition between which there are large magnitude differences is changed to the standardized values between which there are small magnitude differences so that the magnitude differences between the standardized values may be reduced. In the representative value calculating method, the representative values of the values for the process conditions are calculated by using the standardized values with the reduced magnitude differences, whereby correctness of the representative values is enhanced.

FIG. 7 is a flowchart showing a method, through which a representative value calculating apparatus calculates representative values, according to another embodiment of the present invention.

Referring to FIG. 7, the representative value calculating apparatus extracts only process condition values corresponding to a user set sampling points among the process condition values which have been measured for sampling points for each sample through a sensor (700).

The representative value calculating apparatus calculates a median value and a median absolute deviation (MAD), or a mean value and a standard deviation of values for process conditions which have been extracted for each sampling point (710).

The representative value calculating apparatus calculates a standardized value by using process condition values, a median value, and a median absolute deviation (MAD), or calculates a standardized value by using process condition values, a mean value, and a standard deviation (720).

5 The representative value calculating apparatus calculates a representative value of the process condition values for each sample based on the calculated standardized values (730).

The representative value calculating apparatus displays at least one of the standardized values for each sampling point, the calculated representative values for each sample, and the accumulated sum of the calculated representative values for each sample (740).

10 The embodiments which have been described may be configured through selected combinations of all or some of the embodiments such that various modifications thereof may be achieved.

Moreover, the above-described embodiments should be understood illustrative, and not restrictive in all aspects. Furthermore, it will be understood that various modifications and variations can be made by those skilled in the art to which the present invention pertains without departing from the spirit and scope of the present invention.

15 In addition, according to an embodiment of the present invention, the above-described method may be realized as a processor readable code in a program recorded medium. As an example of the processor readable medium, a ROM, a RAM, a magnetic tape, a floppy disk, and an optical data storage device are illustrated, and a medium realized in a form of a carrier wave (for example, transmission through the internet) is also included in the processor readable medium

WHAT IS CLAIMED IS:

1. A representative value calculating apparatus comprising:

a first calculation unit which calculates a median value and a median absolute deviation (MAD), or a mean value and a standard deviation of process condition values for each sampling point, by using the process condition values which have been measured through a sensor for the each sampling point for each sample;

a second calculation unit which calculates standardized values by using the process condition values, the median value, and the median absolute deviation (MAD), or calculates standardized values by using the process condition values, the mean value, and the standard deviation; and

a third calculation unit which calculates a representative value of the process condition values for the each sample based on the calculated standardized values.

2. The representative value calculating apparatus of claim 1, further comprising:

an extraction unit which extracts only the process condition values corresponding to sampling points which have been set by a user among the measured process condition values.

3. The representative value calculating apparatus of claim 1, wherein the first calculation

unit calculates the median absolute deviation (MAD) by using Equation 1:

Equation 1

$$MAD = a * \text{Median}(|X_i - \text{Median}(X_j)|)$$

here, a is a correction factor making the MAD identical with a standard deviation for a normal distribution, X_i is a process condition value, X_j is a median value, and $\text{Median}(X)$ is a function calculating a median value among X variables.

5 4. The representative value calculating apparatus of claim 1, wherein the second calculation unit calculates the standardized value by using Equation 2:

Equation 2

Standardized value = $(X_i - X_j) / \text{Median Absolute Deviation (MAD)}$

here, X_i is a process condition value, and X_j is a median value.

10 5. The representative value calculating apparatus of claim 1, wherein the second calculation unit calculates the standardized value by using Equation 3:

Equation 3

Standardized value = $(X_i - \text{Mean value}) / \text{Standard Deviation}$

15 here, X_i is a process condition value.

6. The representative value calculating apparatus of claim 1, wherein the third calculation unit calculates a representative value of the process condition values based on any one of a mean value, a median value, a mode, a minimum value, a maximum value, and a standard deviation of the calculated
20 standardized values.

7. The representative value calculating apparatus of claim 1, further comprising:

a controller which displays at least one of the standardized values for the each sampling point, the calculated representative value for the each sample, and an accumulated sum of the calculated representative value for the each sample in a display unit.

5 8. The representative value calculating apparatus of claim 1, wherein the process condition comprises at least one of a temperature, a pressure, a time, and a location of a product.

9. A representative value calculating method comprising:

calculating a median value and a median absolute deviation (MAD), or a mean value
10 and a standard deviation of process condition values for each sampling point, by using the process condition values which have been measured through a sensor for the each sampling point for each sample;

calculating standardized values by using the process condition values, the median value, and the median absolute deviation (MAD), or calculating standardized values by using the
15 process condition values, the mean value, and the standard deviation; and

calculating a representative value of the process condition values for the each sample based on the calculated standardized values.

10. The representative value calculating method of claim 9, further comprising:

20 extracting only the process condition values corresponding to sampling points which have been set by a user among the measured process condition values.

11. The representative value calculating method of claim 9, wherein calculating the median value and the median absolute deviation (MAD), or the mean value and the standard deviation comprises
25 calculating the median absolute deviation (MAD) by using Equation 1:

Equation 1

$$\text{MAD} = a * \text{Median}(|X_i - \text{Median}(X_j)|)$$

here, a is a correction factor making the MAD identical with a standard deviation for a normal distribution, X_i is a process condition value, X_j is a median value, and $\text{Median}(X)$ is a function calculating a median value among X variables.

12. The representative value calculating method of claim 9, wherein calculating the standardized values comprises calculating the standardized value by using Equation 2:

Equation 2

$$\text{Standardized value} = (X_i - X_j) / \text{Median Absolute Deviation (MAD)}$$

here, X_i is a process condition value, and X_j is a median value.

13. The representative value calculating method of claim 9, wherein calculating the standardized value comprises calculating the standardized value by using Equation 3:

Equation 3

$$\text{Standardized value} = (X_i - \text{Mean value}) / \text{Standard Deviation}$$

here, X_i is a process condition value.

14. The representative value calculating method of claim 9, wherein calculating the representative value comprises calculating the representative value of the process condition values based on any one of a mean value, a median value, a mode, a minimum value, a maximum value, and a standard deviation of the calculated standardized values.

15. The representative value calculating method of claim 9, further comprising:
- displaying at least one of the standardized values for the each sampling point, the calculated representative value for the each sample, and an accumulated sum of the calculated representative value for the each sample in a display unit.