

THE INVENTION CLAIMED IS

1. A computer-implemented method to optimize a manufacturing process, comprising:

receiving, with at least one processor, manufacturing data associated with a manufacturing process for manufacturing a product, the manufacturing data comprising data from a plurality of data sources associated with a plurality of stages of the manufacturing process, the manufacturing data comprising values for a plurality of parameters including at least one process parameter value and at least one quality parameter value;

generating, with at least one processor, a time-sequenced data structure comprising the manufacturing data, wherein each parameter of the plurality of parameters is associated with a time in the time-sequenced data structure;

transforming, with at least one processor, the time-sequenced data structure to a positionally-dimensioned data structure based on timing data associated with the plurality of stages, wherein each parameter of the plurality of parameters is associated with at least one position;

determining, with at least one processor, a new value for the at least one process parameter value based on the positionally-dimensioned data structure and at least one algorithm; and

optimizing the manufacturing process based on the new value.

2. The computer-implemented method of claim 1, wherein transforming the time-sequenced data structure to the positionally-dimensioned data structure comprises:

identifying, with at least one processor, a zone for each parameter of the plurality of parameters;

determining, for each parameter, a time delay factor based on a length of the zone for the parameter and a line speed of the zone; and

generating, with at least one processor, the positionally-dimensioned data structure using a data matrix transformation based on the time-sequenced data structure, the zone for each parameter, and the time delay factor for each parameter.

3. The computer-implemented method of claims 1 or 2, wherein the manufacturing process comprises a glass manufacturing process and the product comprises a coated glass product.

4. The computer-implemented method of claim 3, wherein the plurality of parameters comprises: temperature, event time, electrical arcing, gas flow, voltage, current, power, pressure, or any combination thereof.

5. The computer-implemented method of any of the claims 1-4, further comprising:

detecting, with at least one processor, at least one outlier parameter value in the time-sequenced data structure or the positionally-dimensioned data structure; and

removing, with at least one processor, the at least one outlier parameter value.

6. The computer-implemented method of any of the claims 1-5, wherein the at least one algorithm comprises a machine-learning algorithm configured to output the new value based on a model and at least one user input value.

7. The computer-implemented method of any of the claims 1-6, further comprising:

identifying, with at least one processor, a set of empty data entries in the time-sequenced data structure or the positionally-dimensioned data structure;

determining, with at least one processor, a proportion of missing data by comparing a size of the set of empty data entries to the size of the time-sequenced data structure or the positionally-dimensioned data structure; and

comparing, with at least one processor, the proportion of missing data to a predetermined tolerance threshold.

8. The computer-implemented method of claim 7, further comprising, in response to the proportion of missing data not satisfying the predetermined tolerance threshold, deleting the set of empty data entries from the time-sequenced data structure or the positionally-

dimensioned data structure.

9. The computer-implemented method of claim 7 or 8, further comprising, in response to the proportion of missing data satisfying the predetermined tolerance threshold, imputing data into the set of empty data entries.

10. A system for optimizing a manufacturing process, comprising:
at least one processor programmed or configured to:
receive manufacturing data associated with a manufacturing process for manufacturing a product, the manufacturing data comprising data from a plurality of data sources associated with a plurality of stages of the manufacturing process, the manufacturing data comprising values for a plurality of parameters including at least one process parameter value and at least one quality parameter value;
generate a time-sequenced data structure comprising the manufacturing data, wherein each parameter of the plurality of parameters is associated with a time in the time-sequenced data structure;
transform the time-sequenced data structure to a positionally-dimensioned data structure based on timing data associated with the plurality of stages, wherein each parameter of the plurality of parameters is associated with at least one position;
determine a new value for the at least one process parameter value based on the positionally-dimensioned data structure and at least one algorithm; and
optimize the manufacturing process based on the new value.

11. The system of claim 10, wherein transforming the time-sequenced data structure to the positionally-dimensioned data structure comprises:
identifying a zone for each parameter of the plurality of parameters;
determining, for each parameter, a time delay factor based on a length of the zone for the parameter and a line speed of the zone; and
generating the positionally-dimensioned data structure using a data matrix transformation based on the time-sequenced data structure, the zone for each parameter, and the time delay factor for each parameter.

12. The system of claim 10 or 11, wherein the plurality of parameters comprises: temperature, event time, electrical arcing, gas flow, voltage, current, power, pressure, or any combination thereof.

13. The system of any of the claims 10-12, wherein the at least one processor is further programmed or configured to:

detect at least one outlier parameter value in the time-sequenced data structure or the positionally-dimensioned data structure; and

remove the at least one outlier parameter value.

14. A computer program product for optimizing a manufacturing process, comprising at least one non-transitory computer-readable medium including program instructions that, when executed by at least one processor, cause the at least one processor to:

receive manufacturing data associated with a manufacturing process for manufacturing a product, the manufacturing data comprising data from a plurality of data sources associated with a plurality of stages of the manufacturing process, the manufacturing data comprising values for a plurality of parameters including at least one process parameter value and at least one quality parameter value;

generate a time-sequenced data structure comprising the manufacturing data, wherein each parameter of the plurality of parameters is associated with a time in the time-sequenced data structure;

transform the time-sequenced data structure to a positionally-dimensioned data structure based on timing data associated with the plurality of stages, wherein each parameter of the plurality of parameters is associated with at least one position;

determine a new value for the at least one process parameter value based on the positionally-dimensioned data structure and at least one algorithm; and

optimize the manufacturing process based on the new value.

15. The computer program product of claim 14, wherein transforming the time-sequenced data structure to the positionally-dimensioned data structure comprises:

identifying a zone for each parameter of the plurality of parameters;

determining, for each parameter, a time delay factor based on a length of the zone for the parameter and a line speed of the zone; and

generating the positionally-dimensioned data structure using a data matrix transformation based on the time-sequenced data structure, the zone for each parameter, and the time delay factor for each parameter.