SYSTEMS AND METHODS FOR AUTOMATED STARTUP OF AN AIR SEPARATION PLANT

TECHNICAL FIELD

The present application is generally related to the technical field of control systems for processing gases, and more particularly to the technical field of air separation plant control systems.

BACKGROUND OF THE INVENTION

Air separation plants operate to compress, liquefy, and distil air in order to separate its different components (e.g., oxygen, nitrogen, argon, etc.). Typically, an air separation unit is operated to produce one or more desired output gases and/or liquids (e.g., the components separated from air taken into the air separation plant) that may be used as an on-site source that provides the desired output gases and/or liquids to other equipment at the site. For example, an air separation plant may be located proximate to a methanol production facility, and may be used to generate oxygen that is consumed by the methanol production facility during the production of methanol. Additionally or alternatively, the air separation plant may be used as an off-site source that provides generated the output gases and/or liquids to equipment located remote to the air separation plant (e.g,. via a pipeline, via a truck, etc.). For example, an air separation plant may be used to generate oxygen that is bottled and delivered to businesses operating in various technical fields, such as healthcare facilities, oil and gas production facilities, and the like.

BRIEF SUMMARY OF THE DISCLOSURE

The present disclosure provides for systems, methods, and computer-readable storage media for automating startup of an air separation plant. The startup of the air separation plant may involve executing a sequence of actions which are traditionally performed sequentially by a plant operator in a manual fashion. The automated startup may be facilitated by defining a sequence of steps, where each step is associated with one or more actions and one or more permissives. The one or more permissives may specify criteria for initiating one or more of the actions for a particular step of the sequence of steps. During execution of the automated startup sequence, one or more of the actions may be initiated concurrently (e.g., at the same time or substantially the same time) or partially concurrently (e.g., both actions are being executed at the same time although they may not have been started at the same time). This may reduce the total time required to complete the automated startup process relative to the

traditional manual startup process where every action is performed manually. Additionally, during execution of the steps of the automated startup process, various characteristics and conditions may be monitored to dynamically identify optimizations or modifications to the startup process. Such optimizations or modifications may further reduce the duration of the startup process, or may increase the lifespan of one or more components or equipment of the air separation plant.

The foregoing has outlined rather broadly the features and technical advantages of the present disclosure in order that the detailed description of the disclosure that follows may be better understood. Additional features and advantages of the embodiments will be described hereinafter which form the subject of the claims of the present disclosure. It should be appreciated by those skilled in the art that the conception and specific embodiment disclosed may be readily utilized as a basis for modifying or designing other structures for carrying out the same purposes of the present disclosure. It should also be realized by those skilled in the art that such equivalent constructions do not depart from the scope of the present disclosure as set forth in the appended claims. The novel features which are believed to be characteristic of the embodiments, both as to its organization and method of operation, together with further objects and advantages will be better understood from the following description when considered in connection with the accompanying figures. It is to be expressly understood, however, that each of the figures is provided for the purpose of illustration and description only and is not intended as a definition of the limits of the present disclosure.

In one aspect, there is provided a method for controlling startup of an air separation plant, the method comprising: receiving, by a processor, a request to initiate startup of an air separation plant; in response to receiving the request, retrieving, by the processor, startup information for the air separation plant, wherein the startup information includes information identifying a sequence of steps to be automatically executed to start up the air separation plant, wherein each step of the sequence of steps is associated with a component of the air separation plant, and wherein the startup information includes, for each step of the sequence of steps, an action to be automatically completed and a set of permissives corresponding to the action, the set of permissives for each action specifying one or more parameters for controlling the execution of the corresponding action; automatically initiating execution of the sequence of steps; monitoring execution of one or more of the steps; and determining, based on the monitoring, whether to modify one or more steps based on the monitoring.

In another aspect, there is provided an apparatus for controlling startup of an air separation plant, the apparatus comprising: at least one processor configured to: receive a request to initiate startup of an air separation plant; retrieve startup information for the air separation plant in response to receiving the request, wherein the startup information includes information identifying a sequence of steps to be automatically executed to start up the air separation plant and information indicating an order of execution for the sequence of steps, wherein each step of the sequence of steps is associated with a component of the air separation plant, and wherein the startup information includes, for each step of the sequence of steps, an action to be automatically completed and a set of permissives corresponding to the action, the set of permissives for each action specifying one or more parameters for controlling the execution of the corresponding action; automatically initiate execution of the sequence of steps; monitor execution of each of the steps; store performance information in a database, wherein the performance information is generated based at least in part on the monitoring and includes metrics representative of operational status of one or more components of the air separation plant during execution of each step of the sequence of steps; determine one or more optimizations for one or more steps of the sequence of steps based on the performance information; and store the optimizations in the database; and a memory coupled to the at least one processor.

In another aspect, there is provided a non-transitory computer-readable storage medium storing instructions that, when executed by a processor, cause the processor to perform operations for controlling startup of an air separation plant, the operations comprising: receiving a request to initiate startup of an air separation plant; in response to receiving the request: retrieving, by the processor, startup information for the air separation plant from a database, wherein the startup information includes information identifying a sequence of steps to be automatically executed to start up the air separation plant and information indicating an order of execution for the sequence of steps, wherein each step of the sequence of steps is associated with a component of the air separation plant, and wherein the startup information includes, for each step of the sequence of steps, at least an action to be automatically completed and a set of permissives corresponding to the action, the set of

permissives for each action specifying one or more parameters for controlling the execution of the corresponding action; determining current conditions associated with the air separation plant; identifying optimizations corresponding to a prior execution of the sequence of steps under conditions that match the current conditions to within a threshold tolerance; and optimizing the sequence of steps based on the identified optimizations; initiating automatic execution of the optimized sequence of steps; monitoring execution of each of the steps; storing performance information in the database, wherein the performance information is generated based at least in part on the monitoring and includes metrics representative of operational status of one or more components of the air separation plant during execution of each step of the sequence of steps; determining whether any of the one or more steps of the sequence of steps can be further optimized based on the performance information; and in response to a determination that one or more steps can be optimized, storing optimization information in the database.

BRIEF DESCRIPTION OF THE DRAWINGS

For a more complete understanding of the present invention, reference is now made to the following descriptions taken in conjunction with the accompanying drawings, in which:

FIG. 1 is a block diagram illustrating various aspects of an exemplary embodiment of an automated process for starting up an air separation plant;

FIG. 2 is a block diagram of illustrating aspects of an air separation plant and a process control sequencer in accordance with one or more embodiments of the present disclosure;

Fig. 3 includes block diagrams illustrating various aspects of exemplary embodiments for tuning an action performed during an automated process for starting up an air separation plant;