

CLAIMS

What is claimed is:

1. A power control system comprising:
 - a controller housing;
 - a power switch disposed within the controller housing and configured for selectively providing power from a power supply to a power load;
 - a limiter disposed within the controller housing configured for providing a limit switching function in response to a threshold limit; and
 - a controller disposed within the controller housing and configured for controlling one or more operations of the control system, the controller controlling the power switch to selectively provide the power from the power supply to a power load, the controller receiving a first temperature signal and a limiter receiving a second temperature signal, both of the first and second temperature signals being from temperature sensors associated with the power load, the first and second temperature signals being utilized by both the controller to ensure proper temperature control of the power load and the limiter to ensure the safety of the system.
2. The system of claim 1 wherein the controller housing includes a cavity for receiving the power switch, the limiter and the controller therein and defines external maximum dimensions defining a volume of less than or equal to about 24 cubic inches.
3. The system of claim 1 wherein the power switch and limiter are each configured to selectively provide power to the load independent of the controller.

4. The system of claim 1 wherein the limiter includes a plurality of user definable threshold limits and is configured for receiving one or more user definable threshold limits from among the plurality of user definable threshold limits.

5. The system of claim 1 wherein the limiter includes a plurality of threshold limit settings and is configured for providing a limit switching function in response to the two or more of the plurality of threshold limit settings.

6. The system of claim 1 wherein the limiter is configured for providing a limit switching function in response to a limiter control signal and wherein the controller is configured for generating the limiter control signal in response to the threshold limit.

7. The system of claim 1 wherein the limiter is a safety limit circuit.

8. The system of claim 1 wherein the limiter includes at least one of a high limit threshold and a low limit threshold.

9. The system of claim 1 wherein the power load is a heater, further comprising a first sensor input for receiving a first temperature signal from a first temperature sensor associated with the heater and a second sensor input for receiving a second temperature signal from a second temperature sensor associated with the

heater, wherein the controller and limiter each receive the first temperature signal and the second temperature signal and wherein the limiter provides the limit switching function in response to the first and second temperature signals and the controller controls the power switch in response to the first and second temperature signals.

10. The system of claim 1 wherein the power load is a heater, further including a sensor input for receiving a temperature signal from a temperature sensor associated with the heater, and an output for providing power to the heater, wherein the threshold limit is a temperature limit, and wherein the limiter provides a limit switching function in response to the temperature signal.

11. The system of claim 10 wherein the sensor input is a first sensor input for receiving a first temperature signal from a first temperature sensor associated with the heater, further comprising a second sensor input for receiving a second temperature signal from a second temperature sensor associated with the heater, wherein the limiter receives the first temperature signal and the second temperature signal and provides the limit switching function in response to the first and second temperature signals.

12. The system of claim 10 wherein the controller includes a low temperature alarm module configured for receiving a low temperature threshold, receiving a measured temperature from a temperature sensor, and generating an alarm

in response to the received measured temperature being less than the low temperature threshold.

13. The system of claim 1 wherein the limiter includes a mechanical relay configured to open in response to the limit threshold and to close in response to the limit threshold and upon a recycling of the limiter.

14. The system of claim 1 wherein the limit threshold is selected from the group consisting of a temperature, a pressure, a humidity, and a flow.

15. The system of claim 1 wherein the power switch is configured for selectively providing power in response to a switch control signal and the controller is configured for generating the switch control signal.

16. The system of claim 15 wherein the controller includes a processor and memory, and wherein the controller is configured for generating the switch control signal in response to a control function selected from the group consisting of a proportional, integral, derivative (PID) function, an adaptive PID function, a proportional function, a proportional/integral function, a proportional, integral, and two derivative control (PIDD) function, a feed forward function, and a feedback function.

17. The system of claim 1 wherein the power switch includes a switch device selected from the group consisting of a contactor, a relay, a solid state device, a knife switch, a mercury switch, and a cam switch.

18. The system of claim 1 wherein the power switch includes a relay, further including an arc reduction relay control circuit disposed within the controller housing for controlling arcing across contact points of the relay.

19. The system of claim 1, further comprising a user interface module having a user interface housing and a controller interface and being configured to provide a human machine interface to the controller for receiving user input including a value of the threshold limit, the user interface module, the controller housing and the controller being configured for releasable coupling of the user interface housing to the controller housing and the user interface module and the controller being configured for electrically and releasably coupling the user interface module to the controller for communicating between the user interface and the controller.

20. The system of claim 19 wherein the user input includes a display for displaying an operation of the system and a user input device for receiving manually entered user commands.

21. The system of claim 19 wherein the user interface module includes a data communication interface for communication with a secondary system.

22. The system of claim 21, further including a system identification module for generating a system identification over the data communication interface

23. The system of claim 21 wherein the user interface module includes at least one of a visual output device and an audio output device and wherein the at least one of a visual output device and an audio output device are being configured to generate a user notification output in response to the data communication interface receiving a power control system identification request signal from the secondary system.

24. The system of claim 19 wherein the user interface module includes a security module configured to provide secure access to the user interface module by a user.

25. The system of claim 1, further comprising a first interface having a first connector for coupling to an input connector for receiving power from a power source and a second interface having a second connector for coupling to an output connector for providing power to the power load, wherein the controller housing is configured to at least partially secure a portion of the input connector to the housing when the input connector is coupled with the first connector and is configured to at least partially secure a portion of the output connector to the housing when the output connector is coupled with the second connector.

26. The system of claim 25 wherein the controller housing includes a cam-like edge configured to provide a biasing force to a portion of at least one of the input connector and the output connector coupled to the control system.

27. The system of claim 1 wherein the controller housing includes a mounting coupler on an external surface, further comprising a mounting bracket configured for fixedly mounting to a surface in a power control operating environment, the mounting coupler and the mounting bracket being configured for releasable mutual engagement.

28. The system of claim 27 wherein the mounting coupler and the mounting bracket are configured for mounting the controller housing at a predefined distance from the operating environment surface for enabling ambient airflow about the controller housing and creating a thermal separation between the controller housing and the operating environment surface.

29. The system of claim 27 wherein the mounting bracket is configured for mounting to the operating environment surface by one or more different types of mounting fasteners selected from the group consisting of a cable tie, a screw, a bolt, and a DIN rail.

30. The system of claim 1, further including a plurality of visual status indicators each configured to provide a different operational status of the system.

31. The system of claim 30 wherein a first visual status indicator is indicative of an output of the controller, a second visual status indicator is indicative of an in-range system operation of the controller, and a third visual status indicator is indicative of an exceeded range of operation of the controller.

32. The system of claim 1 wherein the controller housing includes a plurality of thermal venting ports positioned about the peripheral of the controller housing and configured for enabling ambient airflow through the thermal venting ports and about the limiter and power switch within the controller housing.

33. A power control system for a thermal processing system, the system comprising:

- a controller housing;
- an input power interface for receiving power from a power source;
- an output power interface for providing power to a power load;
- a temperature sensor interface for receiving a temperature signal from a temperature sensor;
- a power switch disposed within the controller housing for selectively providing, at least a portion of, the received power to the power load in response to a power switch temperature limit based on the temperature signal;
- a safety limiter disposed within the controller housing including a plurality of threshold temperature limits, the limiter being configured for providing a safety limit

switching function in response to two or more of the threshold temperature limits and the received temperature signal; and

a controller disposed within the controller housing and configured for controlling the selective providing of power by the power switch.

34. The system of claim 33 wherein the controller is configured for controlling the selective providing of power by the power switch in response to the received temperature signal and wherein the two or more of the threshold temperature limits includes a high limit threshold and a low limit threshold.

35. The system of claim 33, further comprising a user interface module having a user interface housing and a controller interface and being configured to provide a human machine interface to the controller for receiving user input including a value of at least one of the plurality of threshold safety limits, the user interface module, the controller housing and the controller being configured for releasable coupling of the user interface housing to the controller housing and the user interface module and the controller being configured for electrically and releasably coupling the user interface module to the controller for communicating between the user interface and the controller.

36. The system of claim 33 wherein the input power interface includes a first connector for coupling to an input connector for receiving the power from the power source and a second connector for coupling to an output connector for

providing the power to the power load, wherein the controller housing is configured to at least partially secure a portion of the input connector to the housing when the input connector is coupled with the first connector and is configured to at least partially secure a portion of the output connector to the housing when the output connector is coupled with the second connector.

37. The system of claim 33 wherein the controller housing includes a mounting coupler on an external surface, further comprising a mounting bracket configured for fixedly mounting to a surface in a thermal power controller operating environment, the mounting coupler and the mounting bracket being configured for releasable mutual engagement.

38. A method of providing power to a heating element, the method comprising:

- receiving power from a power source;
- sensing a temperature associated with the heating element and generating a temperature signal;
- selectively providing, at least a portion of, the received power to the heating element in response to the temperature signal;
- comparing the temperature signal to a plurality of safety thresholds;

and

limiting the selective providing of the received power to the heating element in response to the comparing;

placing a power control system in proximity to the heating element, the power control system having a controller housing, a power switch disposed within the controller housing for selectively providing, at least a portion of, the received power to the heating element in response to the temperature signal, a limiter disposed within the controller housing, the limiter being configured for limiting the selective providing of the received power to the heating element in response to the comparing, and a controller disposed within the controller housing and configured for controlling an operation of the power switch.

39. The method of claim 38, further comprising receiving two or more user defined safety thresholds wherein the comparing includes the received two or more user defined safety thresholds.

40. The method of claim 38, further comprising fixedly mounting a mounting bracket to a surface in proximity with the heating element and releasably coupling a controller housing to the mounting bracket, the controller housing containing a power switch, a controller and a safety limit configured for providing the selective providing, comparing and limiting.

41. The system of claim 1, wherein the power switch and the limiter are in electrical series connection between the power supply and the power load.

42. The system of claim 33, wherein the power switch and the limiter are in electrical series connection between the power source and the power load.

43. The system of claim 38, wherein the power switch and the limiter are in electrical series connection between the power source and the heating element.

CLAIMS

What is claimed is:

1. A power control system comprising:

- a controller housing;

- a power switch disposed within the controller housing and configured for selectively providing power from a power supply to a power load in response to a first threshold limit based on a sensor signal;

- a limiter disposed within the controller housing and configured for providing a limit switching function in response to a second threshold limit based on the sensor signal; and

- a controller disposed within the controller housing and configured for controlling one or more operations of the control system;

wherein the power load is a heater, further comprising a first sensor input for receiving a first temperature signal from a first temperature sensor associated with the heater and a second sensor input for receiving a second temperature signal from a second temperature sensor associated with the heater, wherein the controller and limiter each receive the first temperature signal and the second temperature signal and wherein the limiter provides the limit switching function in response to the first and second temperature signals and the controller controls the power switch in response to the first and second temperature signals.

2. The system of claim 1 wherein the controller housing includes a cavity for receiving the power switch, the limiter and the controller therein and defines external maximum dimensions defining a volume of less than or equal to about 24 cubic inches.

3. The system of claim 1 wherein the power switch and limiter are each configured to selectively provide power to the load independent of the controller.

4. The system of claim 1 wherein the limiter includes a plurality of user definable threshold limits and is configured for receiving one or more user definable threshold limits from among the plurality of user definable threshold limits.

5. The system of claim 1 wherein the limiter includes a plurality of threshold limit settings and is configured for providing a limit switching function in response to the two or more of the plurality of threshold limit settings.

6. The system of claim 1 wherein the limiter is configured for providing a limit switching function in response to a limiter control signal and wherein the controller is configured for generating the limiter control signal in response to the threshold limit.

7. The system of claim 1 wherein the limiter is a safety limit circuit.

8. The system of claim 1 wherein the limiter includes at least one of a high limit threshold and a low limit threshold.

9. The system of claim 1 wherein the power load is a heater, further including a sensor input for receiving a temperature signal from a temperature sensor associated with the heater, and an output for providing power to the heater, wherein the threshold

limit is a temperature limit, and wherein the limiter provides a limit switching function in response to the temperature signal.

10. The system of claim 9 wherein the sensor input is a first sensor input for receiving a first temperature signal from a first temperature sensor associated with the heater, further comprising a second sensor input for receiving a second temperature signal from a second temperature sensor associated with the heater, wherein the limiter receives the first temperature signal and the second temperature signal and provides the limit switching function in response to the first and second temperature signals.

11. The system of claim 9 wherein the controller includes a low temperature alarm module configured for receiving a low temperature threshold, receiving a measured temperature from a temperature sensor, and generating an alarm in response to the received measured temperature being less than the low temperature threshold.

12. The system of claim 1 wherein the limiter includes a mechanical relay configured to open in response to the limit threshold and to close in response to the limit threshold and upon a recycling of the limiter.

13. The system of claim 1 wherein the limit threshold is selected from the group consisting of a temperature, a pressure, a humidity, and a flow.

14. The system of claim 1 wherein the power switch is configured for selectively providing power in response to a switch control signal and the controller is configured for generating the switch control signal.

15. The system of claim 14 wherein the controller includes a processor and memory, and wherein the controller is configured for generating the switch control signal in response to a control function selected from the group consisting of a proportional, integral, derivative (PID) function, an adaptive PID function, a proportional function, a proportional/integral function, a proportional, integral, and two derivative control (PIDDD) function, a feed forward function, and a feedback function.

16. The system of claim 1 wherein the power switch includes a switch device selected from the group consisting of a contactor, a relay, a solid state device, a knife switch, a mercury switch, and a cam switch.

17. The system of claim 1 wherein the power switch includes a relay, further including an arc reduction relay control circuit disposed within the controller housing for controlling arcing across contact points of the relay.

18. The system of claim 1, further comprising a user interface module having a user interface housing and a controller interface and being configured to provide a human machine interface to the controller for receiving user input including a value of the threshold limit, the user interface module, the controller housing and the controller

being configured for releasable coupling of the user interface housing to the controller housing and the user interface module and the controller being configured for electrically and releasably coupling the user interface module to the controller for communicating between the user interface and the controller.

19. The system of claim 18 wherein the user input includes a display for displaying an operation of the system and a user input device for receiving manually entered user commands.

20. The system of claim 18 wherein the user interface module includes a data communication interface for communication with a secondary system.

21. The system of claim 20, further including a system identification module for generating a system identification over the data communication interface.

22. The system of claim 20 wherein the user interface module includes at least one of a visual output device and an audio output device and wherein the at least one of a visual output device and an audio output device are being configured to generate a user notification output in response to the data communication interface receiving a power control system identification request signal from the secondary system.

23. The system of claim 18 wherein the user interface module includes a security module configured to provide secure access to the user interface module by a user.

24. The system of claim 1, further comprising a first interface having a first connector for coupling to an input connector for receiving power from a power source and a second interface having a second connector for coupling to an output connector for providing power to the power load, wherein the controller housing is configured to at least partially secure a portion of the input connector to the housing when the input connector is coupled with the first connector and is configured to at least partially secure a portion of the output connector to the housing when the output connector is coupled with the second connector.

25. The system of claim 24 wherein the controller housing includes a cam-like edge configured to provide a biasing force to a portion of at least one of the input connector and the output connector coupled to the control system.

26. The system of claim 1 wherein the controller housing includes a mounting coupler on an external surface, further comprising a mounting bracket configured for fixedly mounting to a surface in a power control operating environment, the mounting coupler and the mounting bracket being configured for releasable mutual engagement.

27. The system of claim 26 wherein the mounting coupler and the mounting bracket are configured for mounting the controller housing at a predefined distance from the operating environment surface for enabling ambient airflow about the controller housing and creating a thermal separation between the controller housing and the operating environment surface.

28. The system of claim 26 wherein the mounting bracket is configured for mounting to the operating environment surface by one or more different types of mounting fasteners selected from the group consisting of a cable tie, a screw, a bolt, and a DIN rail.

29. The system of claim 1, further including a plurality of visual status indicators each configured to provide a different operational status of the system.

30. The system of claim 1 wherein the controller housing includes a plurality of thermal venting ports positioned about the peripheral of the controller housing and configured for enabling ambient airflow through the thermal venting ports and about the limiter and power switch within the controller housing.

31. The system of claim 1, wherein the power switch and the limiter are in electrical series connection between the power supply and the power load.

32. A power control system comprising:

- a controller housing;
- a power switch disposed within the controller housing and configured for selectively providing power from a power supply to a power load;
- a limiter disposed within the controller housing configured for providing a limit switching function in response to a threshold limit; and
- a controller disposed within the controller housing and configured for controlling one or more operations of the control system;

wherein a first visual status indicator is indicative of an output of the controller, a second visual status indicator is indicative of an in-range system operation of the controller, and a third visual status indicator is indicative of an exceeded range of operation of the controller.

33. A power control system for a thermal processing system, the system comprising:

- a controller housing;
- an input power interface for receiving power from a power source;
- an output power interface for providing power to a power load;
- a ~~temperature sensor interface~~ first sensor input for receiving a first temperature signal from a first temperature sensor;
- a power switch disposed within the controller housing for selectively providing, at least a portion of, the received power to the power load in response to a power switch temperature limit based on the first temperature signal;

a safety limiter disposed within the controller housing including a plurality of threshold temperature limits, the limiter being configured for providing a safety limit switching function in response to two or more of the threshold temperature limits and the first received temperature signal; and

a controller disposed within the controller housing and configured for controlling the selective providing of power by the power switch;

wherein the power load is a heater, the first sensor input for receiving the first temperature signal from the first temperature sensor associated with the heater and a second sensor input for receiving a second temperature signal from a second temperature sensor associated with the heater, wherein the controller and safety limiter each receive the first temperature signal and the second temperature signal and wherein the safety limiter provides the limit switching function in response to the first and second temperature signals and the controller controls the power switch in response to the first and second temperature signals.

34. The system of claim 33 wherein the controller is configured for controlling the selective providing of power by the power switch in response to the received temperature signal and wherein the two or more of the threshold temperature limits includes a high limit threshold and a low limit threshold.

35. The system of claim 33, further comprising a user interface module having a user interface housing and a controller interface and being configured to provide a human machine interface to the controller for receiving user input including a value of at

least one of the plurality of threshold safety limits, the user interface module, the controller housing and the controller being configured for releasable coupling of the user interface housing to the controller housing and the user interface module and the controller being configured for electrically and releasably coupling the user interface module to the controller for communicating between the user interface and the controller.

36. The system of claim 33 wherein the input power interface includes a first connector for coupling to an input connector for receiving the power from the power source and a second connector for coupling to an output connector for providing the power to the power load, wherein the controller housing is configured to at least partially secure a portion of the input connector to the housing when the input connector is coupled with the first connector and is configured to at least partially secure a portion of the output connector to the housing when the output connector is coupled with the second connector.

37. The system of claim 33 wherein the controller housing includes a mounting coupler on an external surface, further comprising a mounting bracket configured for fixedly mounting to a surface in a thermal power controller operating environment, the mounting coupler and the mounting bracket being configured for releasable mutual engagement.

38. The system of claim 33, wherein the power switch and the limiter are in electrical series connection between the power source and the power load

40. A method of providing power to a heating element, the method comprising:

receiving power from a power source;

sensing a temperature associated with the heating element and generating a temperature signal;

selectively providing, at least a portion of, the received power to the heating element in response to the temperature signal;

comparing the temperature signal to a plurality of safety thresholds; and

limiting the selective providing of the received power to the heating element in response to the comparing;

placing a power control system in proximity to the heating element, the power control system having a controller housing, a power switch disposed within the controller housing for selectively providing, at least a portion of, the received power to the heating element in response to the temperature signal, a limiter disposed within the controller housing, the limiter being configured for limiting the selective providing of the received power to the heating element in response to the comparing of the temperature signal to a plurality safety threshold, and a controller disposed within the controller housing and configured for controlling an operation of the power switch;

wherein the power load is a heater, further comprising a first sensor input for receiving a first temperature signal from a first temperature sensor associated with

the heater and a second sensor input for receiving a second temperature signal from a second temperature sensor associated with the heater, wherein the controller and limiter each receive the first temperature signal and the second temperature signal and wherein the limiter provides the limit switching function in response to the first and second temperature signals and the controller controls the power switch in response to the first and second temperature signals.

40. The method of claim 39, further comprising receiving two or more user defined safety thresholds wherein the comparing includes the received two or more user defined safety thresholds.

41. The method of claim 39, further comprising fixedly mounting a mounting bracket to a surface in proximity with the heating element and releasably coupling a controller housing to the mounting bracket, the controller housing containing a power switch, a controller and a safety limit configured for providing the selective providing, comparing and limiting.

42. The system of claim 39, wherein the power switch and the limiter are in electrical series connection between the power source and the heating element.