OBJECTS AND SUMMARY OF THE INVENTION

[0005] It is an object of the present invention to provide an electrostatic spray drying apparatus and method for more effectively and efficiently spray drying heat sensitive powders.

[0006] Another object is to provide an electrostatic spray drying apparatus and method as characterized above that can be operated at substantially higher production rates than conventional spray drying systems.

[0007] A further object is to provide such an apparatus and method of the above kind that can be operated at higher temperatures for quicker and more efficient spray drying, even when producing heat sensitive powders.

[0008] Still another object is to provide an electrostatic spray drying apparatus and method of the foregoing type in which the dried powder is separated from the drying gas in a separation plenum without exposure to high temperature drying gases.

[0009] Yet another object is to provide such an electrostatic spray drying apparatus that is relatively simple in design and lends itself to economical manufacture.

[0010] Other objects and advantages of the invention will become apparent upon reading the following detailed description and upon reference to the drawings.

[0010a] According to an aspect of the present invention, there is provided an electrostatic spray drying system for drying liquid into powder form comprising:

an elongated structural body supported in upright position;

an upper end closure arrangement and a lower end closure arrangement at opposite upper and lower ends of the elongated body, respectively, for forming a drying chamber within said elongated body;

an electrostatic spray nozzle supported in said upper closure arrangement;

said electrostatic spray nozzle including a nozzle body having a discharge spray tip at a downstream end for directing liquid into said drying chamber;

said electrostatic spray nozzle having a liquid inlet for coupling to a supply of liquid to be discharged into the drying chamber and an electrode for coupling to an electrical source for electrically charging liquid passing through said spray nozzle for discharge from said discharge spray tip into said drying chamber as fine liquid particles;

said upper closure arrangement having a drying gas inlet for directing heated drying gas into said drying chamber for drying the discharged liquid particles into powder;

said lower closure arrangement including a powder direction plenum for receiving drying gas and entrained powder from said drying chamber;

a powder separation plenum downstream of said powder direction plenum; a connecting conduit between said powder direction plenum and said powder separation plenum for directing dried powder and gas exiting the powder direction plenum to said powder separation plenum; said powder separation plenum including at least one filter element for separating dried powder from the drying gas and directing separated gas to a gas outlet of the powder separation plenum while directing separated dried powder to a powder collection container; characterized by:

said powder direction plenum including an outer water jacket heat exchanger disposed in surrounding relation to said powder direction plenum for cooling the drying gas and entrained powder during passage through said powder direction plenum upon discharge from said drying chamber for reducing exposure of the powder to damaging temperatures; said powder direction plenum water jacket heat exchanger including a cooling water inlet adjacent one end coupled to a cooling water supply and a cooling water outlet adjacent an opposite end of the powder direction plenum water jacket heat exchanger such that the cooling water from said cooling water supply continuously flows through the powder direction plenum water jacket heat exchanger;

a connecting conduit water jacket heat exchanger defining an annular cooling water passage in surrounding relation to said connecting conduit; a cooling water inlet adjacent one end of the connecting conduit water jacket heat exchanger annular cooling water passage and a cooling water outlet adjacent an opposite end of said connecting conduit water jacket heat exchanger annular cooling water passage such that cooling water supplied to said connecting conduit water jacket heat exchanger cooling water inlet is continuously directed through said

annular cooling water passage of said connecting conduit water jacket heat exchanger for further cooling drying gas and powder exiting the powder direction plenum prior to entering the powder separation plenum and direction to the powder collection container.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] Figure 1 is a front elevational view of an illustrative spray drying system in accordance with the invention;

[0012] Fig. 2 is a diagrammatic depiction of the spray drying system shown in Fig. 1;

[0013] Fig. 3 is an enlarged vertical section of the water jacketed cone shaped powder direction plenum of the illustrated spray drying system;

[0014] Fig. 4 is an enlarged front elevational view of the water jacketed connecting pipe for coupling between the powder direction plenum and the powder separation plenum of the illustrated embodiment;

[0015] Fig. 5 is an enlarged vertical section of the electrostatic spray nozzle assembly of the illustrated spray drying system; and

[0016] Fig. 6 is an enlarged partial vertical section of the powder separation plenum of the illustrated spray dryer system.

What is claimed:

1. An electrostatic spray drying system for drying liquid into powder form comprising:

an elongated structural body supported in upright position;

an upper end closure arrangement and a lower end closure arrangement at opposite upper and lower ends of the elongated body, respectively, for forming a drying chamber within said elongated body;

an electrostatic spray nozzle supported in said upper closure arrangement;

said electrostatic spray nozzle including a nozzle body having a discharge spray tip at a downstream end for directing liquid into said drying chamber;

said electrostatic spray nozzle having a liquid inlet for coupling to a supply of liquid to be discharged into the drying chamber and an electrode for coupling to an electrical source for electrically charging liquid passing through said spray nozzle for discharge from said discharge spray tip into said drying chamber as fine liquid particles;

said upper closure arrangement having a drying gas inlet for directing heated drying gas into said drying chamber for drying the discharged liquid particles into powder;

said lower closure arrangement including a powder direction plenum for receiving drying gas and entrained powder from said drying chamber ~~and directing the powder to a powder collection container~~;

a powder separation plenum downstream of said powder direction plenum; a connecting conduit between said powder direction plenum and said powder separation plenum for directing dried powder and gas exiting the powder direction plenum to said powder separation plenum; said powder separation plenum including at least one filter element for separating dried powder from the drying gas and directing separated gas to a gas outlet of the powder separation plenum while directing separated dried powder to a powder collection container; characterized by:

said powder direction plenum including an outer water jacket heat exchanger disposed in surrounding relation to said powder direction plenum for cooling the drying gas and entrained powder during passage through said powder direction plenum upon discharge from said drying chamber for reducing exposure of the powder to damaging temperatures; said powder direction plenum water jacket heat exchanger including a cooling water inlet adjacent one end coupled to a cooling water supply~~,~~ and a cooling water outlet adjacent an opposite end of the powder direction plenum water jacket heat exchanger such that the cooling water from said cooling water supply continuously flows through the powder direction plenum water jacket heat exchanger~~.~~;

a connecting conduit water jacket heat exchanger defining an annular cooling water passage in surrounding relation to said connecting conduit; a cooling water inlet adjacent one end of the connecting conduit water jacket heat exchanger annular cooling water passage and a cooling water outlet adjacent an opposite end of said connecting conduit water jacket heat exchanger annular cooling water passage such that cooling water supplied to said connecting conduit water jacket heat exchanger cooling water inlet is continuously directed through said annular cooling water passage of said connecting conduit water jacket heat exchanger for further cooling drying gas and powder exiting the powder direction plenum prior to entering the powder separation plenum and direction to the powder collection container.

2. The electrostatic spray drying system of claim 1 in which said powder direction plenum and surrounding water jacket heat exchanger are conically tapered inwardly in a downstream direction.

3. The electrostatic spray drying system of claim 2 in which said powder direction plenum outlet water jacket heat exchanger comprises inner and outer conical walls that define a conical cooling flow passage.

4. The electrostatic spray drying system of claim 2 in which said powder direction plenum heat exchanger cooling water inlet is adjacent an upper end of said powder direction plenum heat exchanger and said powder direction plenum heat exchanger cooling water outlet is adjacent a lower end of said powder direction plenum heat exchanger.

5. The electrostatic spray drying system of claim 1 in which said cooling water supply ~~is a supply of the water~~to said powder directing plenum heat exchanger is chilled to a temperature of between 4.5°C and 12.8°C.

~~6. The electrostatic spray drying system of claim 1 including a powder separation plenum downstream of said powder direction plenum; a connecting conduit between said powder direction plenum and said powder separation plenum for directing dried powder and gas exiting the powder direction plenum to said powder separation plenum; said powder separation plenum including at least one filter element for separating dried powder from the drying gas and directing separated gas to a gas outlet of the powder separation plenum while directing separated dried powder to said powder collection container; a connecting conduit water jacket heat exchanger defining an annular cooling water passage in surrounding relation to said connecting conduit; a cooling water inlet adjacent one end of the annular cooling water passage and a cooling water outlet adjacent an opposite end of said annular cooling water passage such that cooling water supplied to said cooling water inlet of said water jacket heat exchanger is continuously directed through said annular cooling water passage for further cooling drying gas and powder exiting the powder direction plenum prior to entering the powder separation plenum and direction to the powder collection container.~~

~~7.~~6. The electrostatic spray drying system of claim 1~~6~~ in which said cooling water outlet of said powder direction plenum water jacket heat exchanger is coupled to the cooling water inlet of said connecting conduit water jacket heat exchanger for directing cooling water exiting said powder direction plenum water jacket heat exchanger through said connecting conduit water jacket heat exchanger.

~~8.~~7. The electrostatic spray drying system of claim ~~6~~1 in which ~~said~~a connecting conduit communicates between a lower end of said powder direction plenum water jacket heat exchanger and an upper end of said powder separation plenum water jacket heat exchanger.

~~9.~~8. The electrostatic spray drying system of claim ~~6~~1 in which said cooling water supply ~~is a supply of water chilled to a temperature of between 4.5°C and 12.8°C, and~~to said powder direction plenum ~~and powder separation plenum water jacket heat exchangers are operable such that~~heat exchanger is effective for cooling heated gas and powder discharging

from said drying chamber ~~at~~to temperatures of between 60°C and 90°C ~~are cooled~~and for cooling the drying gas and dried powder to temperatures of between 25°C and 50°C prior to direction to said powder separation plenum.

~~10.~~9. The electrostatic spray drying system of claim ~~6~~1 including a gas return line coupled between said powder separation plenum gas outlet and said drying chamber gas inlet for redirecting ~~heating~~drying gas into said heating chamber, and a heater disposed within said gas return line for reheating gas prior to redirection of the gas into the heating chamber.

~~11.~~10. The electrostatic spray drying system of claim 9~~10~~ in which said gas return line includes a condenser upstream of said heater for removing liquid vapor from said gas prior to direction to said heater.

~~12.~~11. The electrostatic spray drying system of claim 10~~1~~ in which said condenser has a water outlet line for directing condensed water to the cooling water inlet of said powder direction plenum water jacket heat exchanger.

~~13.~~12. The electrostatic spray drying system of claim 11~~2~~ including a selectively operable valve in said condenser water outlet line for selectively directing condensed water to said cooling water supply or said cooling water inlet of said powder direction plenum water jacket heat exchanger.

~~14.~~13. The electrostatic spray drying system of claim 12~~3~~ including a temperature sensor in said powder separation plenum for sensing the temperature in said powder separation plenum, and a control for operating said valve in response to temperatures sensed by said temperature sensor.

~~15. An electrostatic spray drying system for drying liquid into powder form comprising:~~

~~an elongated structural body supported in upright position;~~

~~an upper end closure arrangement and a lower end closure arrangement at opposite upper and lower ends of the elongated body, respectively, for forming a drying chamber within said elongated body;~~

an electrostatic spray nozzle supported in said upper closure arrangement;

said electrostatic spray nozzle including a nozzle body having a discharge spray tip at a downstream end thereof for directing liquid into said drying chamber;

said electrostatic spray nozzle having a liquid inlet for coupling to a supply of liquid to be discharged into the drying chamber and an electrode for coupling to an electrical source for electrically charging liquid passing through said spray nozzle for discharge from said discharge spray tip into said drying chamber as fine liquid particles;

said upper closure arrangement having a drying gas inlet for directing heated drying gas into said drying chamber for drying the discharged liquid particles into powder;

said lower closure arrangement including a powder direction plenum for receiving drying gas and entrained powder from said drying chamber and directing the drying gas and powder to a powder separation plenum;

said powder separation plenum including at least one filter element for separating dried powder from the drying gas and directing separated gas to a gas outlet of the powder separation plenum while directing separated dried powder to a powder collection chamber;

a connecting conduit between said powder direction plenum and said powder separation plenum for directing dried powder and gas exiting the powder direction plenum to said powder separation plenum;

a connecting conduit water jacket heat exchanger defining an annular cooling water passage in surrounding relation to said connecting conduit; said connecting conduit water jacket heat exchanger having a cooling water inlet adjacent one end connected to a cooling water supply and a cooling water outlet adjacent an opposite end such that cooling water from the cooling water supply may be continuously directed through the connecting conduit water jacket heat exchanger to the outlet thereof for cooling drying gas and powder as it is directed from said powder direction plenum to said powder separation plenum.

16. The electrostatic spray drying system of claim 15 in which said cooling water inlet is adjacent an upstream end of said connecting conduit water jacket heat exchanger and said

~~cooling water outlet is adjacent a downstream end of said connecting conduit water jacket heat exchanger.~~

~~17. The electrostatic spray drying system of claim 16 in which said connecting conduit communicates between a lower end of said powder direction plenum and an upper end of said powder separation plenum.~~

~~18. The electrostatic spray drying system of claim 16 in which said cooling water supply is a supply of water chilled to a temperature of between 4.5°C and 12.8°C.~~

~~19. The electrostatic spray drying system of claim 15 including a gas return line coupled between said powder separation plenum gas outlet and said drying chamber gas inlet for redirecting gas from the return line into said heating chamber, and a heater disposed within said gas return line for reheating gas prior to redirection of the gas into the heating chamber.~~

~~20. The electrostatic spray drying system of claim 19 in which said gas return line includes a condenser upstream of said heater for removing liquid vapor from said gas prior to direction to said heater, and said condenser has a water outlet line for directing condensed water to said cooling water supply.~~