AN INDUSTRIAL DISHWASHER

TECHNICAL FIELD

This invention relates generally to an industrial dishwasher for washing tableware, and relates more particularly, though not exclusively, to an industrial dishwasher suitable for washing aviation tableware.

BACKGROUND

Due to the high volume involved with inflight catering, commercial airlines use industrial dishwashers to wash used tableware and associated catering items such as oven racks, containers and carts after each flight. As shown in FIGS. 1 and 2, current industrial dishwashers 500 use pressure sprays 1000 to continuously direct a washing liquid 1010 comprising heated water and detergent at a conveyor belt 510 continuously moving through the dishwasher 500. Tableware 1200 and/or associated catering items placed on the conveyor belt 510 are therefore sprayed by the washing liquid 1010 when they pass under the pressure sprays 1000. Depending on how each item 1200 is placed on the conveyor belt 510 and oriented with respect to the pressure sprays 1000, food debris 1210 at certain locations on the item 1200 may not be reached by the washing liquid 1010 from the pressure sprays 1000. Furthermore, depending on the design of the item 1200, a particular type of item 1200 may have systematically unreachable "blind" spots that are never effectively cleaned by the washing liquid 1010 from the pressure sprays 1000. Existing industrial dishwashers 500 therefore have inherent inefficiencies that give rise to an estimated 10% of rejects arising from washing the tableware and/or associated catering items of each flight.

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A meal-set of aviation tableware typically includes a number of items such as a tray, a main dish commonly referred to as the casserole, side dishes, a glass, a cup, and flatware and cutlery. Currently, these items are separately machine-washed in dedicated industrial dishwashers as described above but configured specially to handle a specific type of tableware each. For example, one dishwasher is used for washing breakable and minimally soiled glasses, one dishwasher for washing moderately soiled cups, flatware, cutlery and side dishes, and another dishwasher for washing the main dish or casserole that is usually a most heavily soiled item. The main dish or casserole needs to be separately washed from the other tableware because a significantly higher pressure spray is required to properly clean the heavily soiled casserole, and such a higher pressure spray would blow off lighter items such as cups, plates and side dishes from the conveyor belt if these lighter items were washed in the same dishwasher as the casserole. Another dishwasher is normally used for washing associated bulky items such as oven racks and containers, and a separate cart washer is used to wash carts for transporting the tableware.

At a typical inflight catering washing centre, each meal-set of tableware together with the associated bulky items and carts are manually sorted and individual items are then brought to their respective dedicated industrial dishwasher for washing. Space currently required to industrially wash the aviation tableware and associated items used in each flight is therefore substantial since each industrial dishwasher already has a large footprint, and an even larger space is required to accommodate the five different dishwashers currently used to wash all the different types of tableware and associated items for each flight.

SUMMARY

According to a first exemplary aspect, there is provided an industrial dishwasher comprising a tableware washing lane comprising an ultrasonic washing station for ultrasonically washing differently soiled tableware; a tray washing lane; and an auxiliary washing lane for washing glassware. The industrial dishwasher may further comprise a cart washing lane for washing carts used to transport the tableware.

According to a second exemplary aspect, there is provided an industrial dishwasher suitable for washing tableware. The industrial dishwasher comprises a jig loading station for loading a plurality of types of tableware into jigs, each jig comprising a plurality of compartments for containing therein the plurality of types of tableware for immersing the tableware in a washing liquid; a first ultrasonic washing station containing the washing liquid for ultrasonically washing the tableware in the jig, a final rinsing station for a final rinsing of the tableware in the jig after ultrasonic washing; a drying station for drying the tableware in the jig after the final rinsing; and an unloading station for unloading the tableware from the jigs.

The industrial dishwasher may further comprise an initial rinsing station for an initial rinsing of the plurality of types of tableware contained in the jig before ultrasonically washing the tableware. Used water discharged from the final rinsing station is preferably recycled for use at the initial rinsing station.

The industrial dishwasher may also comprise a sanitizing station for sanitizing the tableware in the jig after the final rinsing and before drying the tableware.

Each jig preferably comprises a plurality of locking levers, each locking lever comprising a lever rotatably connected to the jig such that upon immersion of the jig in the washing liquid, the locking lever rotates due to natural buoyancy and contacts a tableware item adjacent the locking lever to block the tableware item against upward movement, thereby preventing flotation of the tableware item in the washing liquid.

The industrial dishwasher may further comprise a tray washing lane having a tray flipping conveyor configured to use gravity for removing food debris from trays among the tableware. The tray flipping conveyor may comprise a first conveying portion for loading the trays thereon and an overturning conveying portion in connection with the first conveying portion for overturning the trays such that food debris falls away from the overturned trays. The overturning conveying portion may comprise a twisted conveying portion; or a recirculating belt passing over a roller, the roller having a horizontal axis of rotation; or a curved chute.

The industrial dishwasher may further comprise an auxiliary washing lane for washing glassware among the tableware, and may also comprise a solid waste disposal chute in connection with the jig loading station, the chute comprising a top-opening vacuum compactor for collecting food debris removed from the tableware.

The industrial dishwasher may be provided with a jig return conveyor for returning jigs from the unloading station to the jig loading station.

A self-cleaning heating coil may be provided in the ultrasonic washing station for heating the washing liquid. A heat recovery system configured for recovering heat generated at the drying station to heat the washing liquid in the ultrasonic washing station may also be provided.

The industrial dishwasher may further comprise an intermediate rinsing station for an intermediate rinsing of the tableware in the jig after ultrasonic washing in the ultrasonic washing station, and further comprising a second ultrasonic washing station for a second simultaneous ultrasonic washing of the tableware in the jig after the intermediate rinsing and before the final rinsing. Used water discharged from the final rinsing station is preferably recycled for use at the intermediate rinsing station and used water discharged from the intermediate rinsing station is preferably recycled for use at the initial rinsing station. Used washing liquid from the second ultrasonic washing station is preferably recycled for use at the first ultrasonic washing station.

The industrial dishwasher may further comprise a cart washing lane for washing carts used to transport the tableware.

According to a third exemplary aspect, there is provided a jig for use with an industrial dishwasher for washing tableware. The jig comprises a plurality of compartments for containing therein a plurality of types of tableware for immersing the tableware in a washing liquid; and a plurality of locking levers, each locking lever comprising a lever rotatably connected to the jig such that upon immersion of the jig in the washing liquid, the locking lever rotates due to natural buoyancy and contacts a tableware item adjacent

the locking lever to block the tableware item against upward movement, thereby preventing flotation of the tableware item in the washing liquid.

According to a fourth exemplary aspect, there is provided a tray flipping conveyor for use with an industrial dishwasher for washing tableware. The tray flipping conveyor comprises a first conveying portion for loading trays from among the tableware thereon; and an overturning conveying portion in connection with the first conveying portion for overturning the trays such that food debris falls away from the overturned trays under gravity. The overturning conveying portion may comprise a twisted conveying portion; or a recirculating belt passing over a roller, the roller having a horizontal axis of rotation; or a curved chute.

According to a fifth exemplary aspect, there is provided a solid waste disposal chute for use with an industrial dishwasher for washing tableware. The chute comprises a top-opening vacuum compactor for collecting food debris removed from the tableware.

According to a sixth exemplary aspect, there is provided a method of washing tableware using an industrial dishwasher. The method comprises loading a plurality of types of tableware into a jig at a jig loading station of the industrial dishwasher; immersing the tableware in the jig in a first washing liquid and ultrasonically washing the tableware in the jig at a first ultrasonic washing station of the industrial dishwasher; performing a final rinsing of the tableware in the jig at a final rinsing station of the industrial dishwasher; drying the tableware in the jig at a drying station of the industrial

dishwasher; and unloading the tableware from the jig at an unloading station of the industrial dishwasher.

The method may further comprise performing an initial rinsing of the tableware in the jig at an initial rinsing station of the industrial dishwasher before immersing the tableware in the jig in the first washing liquid. Used water from the final rinsing is preferably recycled for the initial rinsing.

The method may also comprise sanitizing the tableware in the jig after the final rinsing and before the drying.

The method may further include performing an intermediate rinsing of the tableware in the jig at an intermediate rinsing station of the industrial dishwasher after the ultrasonic washing; and immersing the tableware in the jig in a second washing liquid and ultrasonically washing the tableware in the jig a second time at a second ultrasonic washing station of the industrial dishwasher before the final rinsing. Used water from the final rinsing is preferably recycled for the intermediate rinsing and used water from the intermediate rinsing is preferably recycled for the initial rinsing. Used second washing liquid from the second ultrasonic station is preferably recycled for use as the first washing liquid in the first ultrasonic station.

The method may further comprise using a tray flipping conveyor to overturn a tray from among the tableware to remove food debris from the tray by gravity; and washing glassware in an auxiliary washing lane of the industrial dishwasher.

The method may also comprise collecting food debris removed from the tableware using a solid waste disposal chute comprising a top-opening vacuum compactor.

The method may include returning jigs from the unloading station to the jig loading station using a jig return conveyor of the industrial dishwasher.

The method may further comprise recovering heat generated at the drying station to heat the washing liquid in the ultrasonic washing station using a heat recovery system.

BRIEF DESCRIPTION OF THE DRAWINGS

In order that the invention may be fully understood and readily put into practical effect there shall now be described by way of non-limitative example only exemplary embodiments, the description being with reference to the accompanying illustrative drawings.

In the drawings:

FIG. 1 (prior art) is a schematic side view of a conventional industrial dishwasher;

FIG. 2 (prior art) is a close-up side view of the dishwasher of FIG. 1;

FIG. 3 is a schematic perspective view of an exemplary embodiment of an industrial dishwasher according to the present invention;

FIG. 4 is a schematic cross-sectional perspective view of the industrial dishwasher of FIG. 3;

FIG. 5 is a schematic perspective view of a jig loading station of the industrial dishwasher of FIG. 4;

FIG. 6 is a schematic perspective view together with orthogonal views of a side table of the jig loading station of FIG. 5;

FIG. 7 is a simplified schematic cross-sectional side view of the industrial dishwasher of FIG. 4;

FIG. 8 (a) is a schematic perspective view of an initial rinsing station of the industrial dishwasher of FIG. 4;

FIG. 8 (b) is a schematic perspective view of the initial rinsing station of FIG. 8(a) having a rotated jig therein;

FIG. 8 (c) is a schematic side view of a pressure spray nozzle;

FIG. 9 is a schematic cross-sectional side view of an ultrasonic washing station;

FIG. 10 is a close-up view of the ultrasonic washing station of FIG. 9;

FIG. 11 is a schematic perspective view of removal of tableware from a liquid sanitizing bath;

FIG. 12 (a) to (c) are schematic top and perspective views of a drying station of the industrial dishwasher of FIG. 4;

FIG. 13 is a schematic perspective view of the industrial dishwasher of FIG. 4 showing the conveyor and general direction of movement of jigs;

FIG. 14 is a schematic perspective view of a jig lift at an unloading station of the industrial dishwasher of FIG. 4;

FIG. 15 (a) is a schematic perspective view of a jig used in the industrial dishwasher of FIG. 4;

FIG. 15 (b) is a schematic perspective view of a plurality of jigs wherein only alternate jigs are provided with a cutlery and flatware holder;

FIG. 16 (a) is a schematic perspective view of an alternative embodiment of a jig used in the industrial dishwasher of FIG. 4;

FIG. 16 (b) is a schematic side view of tableware containment in the jig of FIG. 16 (a);

FIG. 17 is a schematic side view of two adjacent locking levers provided in the jig of FIG. 15 (a);

FIG. 18 (a) is a schematic side view of a locking lever of FIG. 17 and a corresponding tableware item in a jig before immersion in a washing liquid;

FIG. 18 (b) is the locking lever of FIG. 18 (b) and the corresponding tableware item in the jig when immersed in the washing liquid;

FIG. 19 (a) is a schematic perspective view of a first embodiment of a tray washing lane of the industrial dishwasher of FIG. 4;

FIG. 19 (b) is a schematic perspective view of a tray flipping conveyor of the tray washing lane of FIG. 19 (a);

FIG. 19 (c) is an alternative schematic perspective view of the tray flipping conveyor of FIG. 19 (b);

FIG. 20 is a schematic side view of a second embodiment of the tray flipping conveyor;

FIG. 21 is a schematic side view of a third embodiment of the tray flipping conveyor;

FIG. 22 (a) is a schematic perspective view of an entry to an auxiliary lane of the industrial dishwasher of FIG. 4;

FIG. 22 (b) is a schematic cross-sectional side view of the auxiliary lane of FIG. 22 (a);

FIGS. 23 (a), (b) and (c) are schematic views of a solid waste disposal chute of the industrial dishwasher of FIG. 4;

FIG. 24 is a schematic diagram of a heat recovery system;

FIG. 25 is a schematic diagram of a detergent dispensing device;

FIG. 26 is a flowchart of an exemplary method of industrial dishwashing according to the present invention;

FIG. 27 is a schematic side view of an alternative embodiment of conveying tableware into a tank;

FIG. 28 is a schematic side view of an alternative embodiment of conveying trays into a tank;

FIGS. 29 (a) and (b) are schematic side views of a first alternative embodiment of adjacent locking levers provided in the jig of FIG. 15 (a);

FIGS. 30 (a), (b) and (c) are schematic side views of a second alternative embodiment of adjacent locking levers and tableware compartments provided in the jig of FIG. 15 (a);

FIGS. 31 (a), (b) and (c) are schematic side views of a third alternative embodiment of adjacent locking levers and tableware compartments provided in the jig of FIG. 15 (a);

FIG. 31 (d) is a schematic perspective close-up view of a tableware compartment of FIG. 31 (a);

FIGS. 32 (a) and (b) are plan and perspective views of another alternative embodiment of a jig used in the industrial dishwasher of FIG. 4; and

FIGS. 33 (a) and (b) are schematic side views of an alternative embodiment of immersing tableware in an ultrasonic washing liquid.

DETAILED DESCRIPTION OF EXEMPLARY EMBODIMENTS

With reference to FIGS. 3, 4 and 7 and the other figures as indicated below, an exemplary embodiment of an industrial dishwasher 10 for washing tableware 1200 and associated inflight catering items is described below. An exemplary method 200 of washing tableware is also described below, with reference to FIG. 26.

The exemplary industrial dishwasher 10 comprises a jig loading station 12 as shown in FIG. 5 for loading a plurality of types of tableware 1200 into jigs 20, 202. The plurality of types of tableware 1200 to be loaded into the jigs 20 for washing are usually differently soiled, and may include cups, side dishes, cutlery, flatware that are moderately soiled, and also the most heavily soiled main dishes or casseroles used in aviation meal-sets.

The jig loading station 12 preferably comprises an elongate surface 16 for supporting a plurality of jigs 20 thereon during loading of each jig 20. A conveyor 22 runs throughout the industrial dishwasher 10 for conveying jigs 20 from the jig loading station 12 through to various other stations 30, 40, 50, 60, 70, 80, 90, 100 in the industrial dishwasher 10. The conveyor 22 preferably includes a plurality of robotic arms 24 for lifting, lowering and laterally moving the jigs 20 from one station to the next station where appropriate, as shown in FIG. 13.

The jig loading station 12 preferably also includes a number of side tables 14 shown in FIG. 6 for placing used tableware 1200 thereon before loading of the tableware into the jigs 20. Each side table 14 is preferably provided with a plurality of holes 14-1 for drainage of liquid from the used tableware 1200 onto a base plate 14-2 of the side table 14. The base plate 14-2 is preferably sloped for channelling the drained liquid into a waste drainage system (not shown).

From the jig loading station 12, each jig 20 loaded with tableware 1200 is preferably conveyed into an adjacent initial rinsing station 30 where an initial rinsing of the

tableware 1200 in the jig 20 is performed 204. As shown in FIG. 8 (a), the tableware 1200 in the jig 20 is sprayed with rinsing water from a pressure spray as the jig 20 enters the initial rinsing station 30 in the direction indicated by the arrow. Preferably, a plurality of pressure spray nozzles 32 are provided on different sides of the jig 20 for effective pressure spray initial rinsing of the tableware 1200 contained in the jig 20 to remove bulk food debris from the tableware 1200. Each pressure spray nozzle 32 is preferably configured for reciprocating rotation during spraying as shown in FIG. 8 (c) in order to achieve a wave-like spraying effect for improved rinsing of the tableware 1200. The jig 20 is then preferably rotated 90 degrees at the initial rinsing station 30 as shown in FIG. 8 (b) before being conveyed into an adjacent first ultrasonic washing station 40 of the industrial dishwasher 10.

At the first ultrasonic washing station 40, the jig 20 containing the tableware 40 is lowered by a robotic arm 24 into a tank 41 containing a first washing liquid 42 such that the tableware 1200 are fully immersed in the first washing liquid 42, 206 as shown in FIGS. 9 and 10.

An ultrasonic generator 43 comprising a number of ultrasonic transducers 44 generates cavitation bubbles 45 in the first washing liquid 42. The cavitation bubbles 45 burst against food debris 1210 adhering to the tableware 1200, thereby effectively removing the food debris 1210 and thoroughly washing the tableware 1200, 206 regardless of orientation of the tableware 1200 in the first washing liquid 42. Because the tableware 1200 are fully immersed in the first washing liquid 42, all areas of the tableware 1200 are therefore reached by the cavitation bubbles 45 so that there are no "blind" spots in

the tableware 1200 that are left not cleaned. In this way, heavily soiled main dishes or casseroles can be washed simultaneously with other lighter tableware items such as the cups and side dishes in the industrial dishwasher 10 without requiring a separate dedicated dishwasher just for washing the casseroles alone.

In an alternative embodiment of the industrial dishwasher 10, instead of using a robotic arm 24 to lower the jig 20 into the ultrasonic washing tank 41, a continuous conveyor 160 may be provided as shown in FIGS. 27 and 28 to move items into and out of the ultrasonic washing tank 41.

The continuous conveyor 160 preferably comprises a sloped slide-down portion 161 for gradually sliding a jig 20 or tray 1202 into the washing liquid 42 at an angle instead of lowering them perpendicularly into the washing liquid 42 using the robotic arm 24. In this way, openings of the tableware 1200 in the jig 20 or trays 1202 are momentarily kept above the waterline 43 of the cleaning liquid 42 as the jig 20 or trays 1202 are lowered into the washing liquid 42, enabling the washing liquid 42 to totally fill the tableware 1200 or trays 1202, thereby achieving thorough ultrasonic washing by preventing entrapment of air in the tableware 1200 or trays 1202 when they are immersed in the washing liquid 42. Similarly, a sloped slide-up portion 163 is preferably provided in the continuous conveyor 160 for removing washed tableware 1200 or trays 1202 from the tank 41.

Angled removal of the washed items 1200, 1202 allows for slow pulling of the items 1200, 1202 from the surface 43 of the liquid 42 such that surface tension of the liquid

surface 43 removes the liquid 42 from the washed items 1200, 1202 with up to 85 to 90 % dryness. A slide-up 163 exit from the washing liquid 42 also prevents washing liquid 42 from being inadvertently and unnecessarily scooped out of the tank 41 by the tableware 1200 or trays 1202. For the washing of trays 1202, as shown in FIG. 28, high pressure sprays 32 may further be provided for removing stubborn debris from the trays 1202. In addition, a corresponding press-down conveyor 162 may be provided to hold the trays 1202 down against the continuous conveyor 160 when in the tank 41, so as to prevent flotation of the trays 1202 in the washing liquid 42 and to prevent the trays 1202 from being "blown off" the conveyor 160 by the high pressure sprays 32.

In an alternative embodiment of the ultrasonic washing station 40, as shown in FIGS. 33 (a) and (b), the ultrasonic transducers 44 are configured to engage a conveyor portion 165 in the ultrasonic station 40. The conveyor portion 165 is preferably configured to convey the jig 20 containing the tableware 1200 into the ultrasonic station 40 and also to support the jig 20 during ultrasonic cleaning. In this embodiment, instead of lowering the jig 20 into the tank 41 containing washing liquid 42, tank walls 41W are lowered around the jig 20 onto the conveyor portion 165 by arms 41A, as shown by the downward arrows in FIG. 33 (a). In this way, the jig 20 becomes fully surrounded by the tank walls 41W and is contained in a volume 41V defined by the tank walls 41W and the conveyor portion 165. Washing liquid 42 is then channelled into the volume 41V via appropriately configured pipes 42P until the tableware 1200 in the jig 20 become fully immersed in the washing liquid 42. The ultrasonic transducers 44 are then activated to ultrasonically wash all the tableware 1200 in the jig 20 via the cavitation bubbles 45 generated.

A detergent dispensing device 150 comprising a proportional dosing pump 151 as shown in FIG. 25 may be provided for adding detergent from a detergent storage container 152 to the washing liquid 42 in the ultrasonic washing station 40. The detergent dispensing device 150 is preferably triggered by a pH sensor 154 provided in the tank 41 or on a tank wall 41W of the ultrasonic washing station 40. In this way, only an essential amount of detergent is used, while excessive use of detergent is avoided, thereby allowing the industrial dishwasher 10 to be more ecologically friendly.

One or more heating coils (not shown) may be provided in the tank 41or on a tank wall 41W of the ultrasonic washing station 40 so that the washing liquid 42 is heated for more efficient washing of the tableware 1200. As a result of the action of the cavitation bubbles 45 generated in the washing liquid 42 for washing the tableware 1200, the heating coil is also simultaneously cleaned by the cavitation bubbles 45. In this way, the heating coil is effectively self-cleaning such that descaling of the heating coil during routine maintenance of the industrial dishwasher 10 can therefore eliminated.

The industrial dishwasher 10 may be provided with an intermediate rinsing station 50 adjacent the first ultrasonic washing station 40 for intermediate rinsing of the tableware 1200 after ultrasonic washing at the first ultrasonic washing station 40. The intermediate rinsing station 50 is similarly provided with pressure spray nozzles 32 for directing intermediate rinsing sprays onto the tableware 1200 in the jig 20. Used water discharged from the intermediate rinsing station 50 (if provided) is preferably recycled for re-use at the initial rinsing station 30, thereby significantly reducing water consumption by the industrial dishwasher 10.

A second ultrasonic washing station 60 similar to or identical with the first ultrasonic washing station 40 may further be provided adjacent the intermediate rinsing station 50 for a second ultrasonic washing of the tableware 1200 in the jig 20.

The industrial dishwasher 10 comprises a final rinsing station 70 for performing a final rinsing 208 of the tableware 1200 in the jig 20 after ultrasonic washing. At the final rinsing station 70, clean water is sprayed onto the ultrasonically cleaned tableware 1200 from similar or identical pressure spray nozzles 32. Used water from the final rinsing station 70 is preferably recycled for re-use at the initial rinsing station 30, or to the intermediate rinsing station 50 if an intermediate rinsing station 50 is provided, again significantly reducing water consumption by the industrial dishwasher 10.

A sanitizing station 80 comprising a liquid sanitizing bath 82 may be provided adjacent the final rinsing station 70 for sanitizing the tableware 1200 in the jig 20 after the final rinsing 208. As shown in FIG. 11, the tableware 1200 are preferably removed from the liquid in the sanitizing bath by slowing pulling 85 the tableware 1200 in the jig 20 (hidden in FIG. 11) out of the liquid surface 83 such that surface tension 86 of the liquid surface 83 removes the liquid from the tableware 1200 with up to 85 to 90 % dryness. In this way, there is no longer any need to apply a chemical drying aid to speed up drying of the tableware 1200 in a drying station 90 of the industrial dishwasher 10.

Alternatively or in addition to the liquid sanitizing bath 82, the sanitizing station 80 may also employ a UV sterilization/curing chamber for sterilizing the tableware 1200 after the final rinsing 208 and before drying 210.

At the drying station 90 provided adjacent the sanitizing station 80, the jig 20 containing the tableware 1200 is first conveyed into an oven as shown in FIG. 12 (a) while being blown by hot air emanating horizontally from a side air knife 92. The jig 20 is then preferably rotated 90 degrees as shown in FIG. 12 (b) and conveyed under a top air knife 94 as shown in FIG. 12 (c) such that the tableware 1200 undergoes further drying 210 by hot air emanating downwards from the top air knife 94.

A heat recovery system 96 as shown in FIG. 24 is preferably provided for recovering heat generated at the drying station 90 to heat the washing liquid 42 used in the ultrasonic washing station 40 or stations 40, 60. The heat recovery system may comprise a heat exchanger 98 that uses heat channelled from the drying station 90 (as indicated by double arrows) to heat water that is provided to the ultrasonic washing stations 40, 60 (direction of water travel indicated by single arrows). Energy consumption by the industrial dishwasher 10 is therefore reduced.

From the drying station 90, the jig 20 is conveyed to an adjacent unloading station 100 of the industrial dishwasher 10 for unloading the cleaned and dried tableware 1200 from the jig 20, 212. Emptied jigs 20 from which the tableware 1200 have been unloaded are preferably returned from the unloading station 100 to the jig loading station 12 via a jig return conveyor comprising a portion of the conveyor 22 (hidden) that runs beneath the other stations 90, 80, 70, 60, 50, 40, 30 of the industrial dishwasher 10. Arrows shown in FIG. 13 indicate the general direction of movement of the jigs 20 in the industrial dishwasher 10 as conveyed by the conveyor 22.

The unloading station 100 preferably includes a jig lift 102 having a tableware 1200 detection sensor 104 for detecting any tableware 1200 that has not been removed from a jig 20 as the jig 20 is conveyed for return to the jig loading station 12. Upon detection of the presence of a tableware 1200 item in a jig 20, the sensor 104 triggers the conveyor 22 to stop moving so that an operator may remove the tableware 1200 from the jig 20 before restarting the conveyor 22. The sensor 104 may comprise a plurality of hinged top-hung contact rods 106 forming a "curtain" at an entrance 108 of the jig lift 102 as shown in FIG. 14, such that rotation of a rod 106 triggers the conveyor at the unloading station 100 to stop. Alternatively, as shown in FIG. 16, the sensor 104 may comprise a plurality of differently sized rotatable panels 106P instead of rods 106 for appropriately contacting and sensing tableware items 1200 at different heights in an alternative jig 20 (shown in FIG. 16 (a)) if the tableware items 1200 have not been removed from the alternative jig 20.

As shown in FIG. 15 (a), each jig 20 comprises a plurality of differently sized compartments 25 for containing therein a plurality of types of tableware 1200 for washing in the industrial dishwasher 10. Each jig 20 is preferably configured to contain tableware from twenty inflight meal-sets. Preferably, one compartment 25 is configured for containing one tableware item 1200 therein. Each compartment 25 is preferably a generally open space having minimal supporting structures for propping up a tableware item 1200 contained in the compartment 25, so as to reduce weight and bulk of the jig 20. A cutlery and flatware holder 26 may be provided in a jig 20 for containing cutlery and flatware to be washed. The holder 26 may comprise a simple basket placed in the jig 20. FIG. 15 (b) shows how the cutlery and flatware holder 26 may be provided only

in alternate jigs 20A among the plurality of jigs 20 used in the industrial dishwasher 20, so as to provide more overall space in all the jigs 20 for containing tableware 1200 to be cleaned. An alternative embodiment of the jig 20 is shown in FIGS. 32 (a) and (b), wherein the cutlery and flatware holder 26 is integrated in the jig 20 as rows of compartments on one side of the jig 20.

Another alternative embodiment of the jig 20 is shown in FIG. 16 (a). The alternative jig 20 has a stepped floor configured as rows 21 of different heights for containing a different type of tableware 1200 in each row 21. As shown in FIG. 16 (b), compartments 25 in the rows 21 are preferably configured to stagger the tableware 1200 between rows 21A, 21B so as to maximise surface exposure of the tableware 1200 to the pressure sprays during rinsing. The compartments 25 may further be configured to contain rectangular items at an angle as shown in FIGS. 16 (a) and (b). This is to minimize area of contact of rectangular items with the floor of the jig, thereby minimizing liquid collection at the floor of the jig 20 and facilitating drying. Some compartments 25 in the jig 20 may comprise tray slots for washing trays of different sizes, while other compartments 25 in the jig 20 may comprise pockets configured to contain porcelain tableware 1200 such as those used by first class passengers.

Many tableware items 1200 used inflight are made of plastics such as melamine that is buoyant in water. Each jig 20 is therefore preferably provided with a plurality of locking levers 27 configured to lock the tableware 1200 within the jig 20 to prevent flotation of the tableware 1200 when the jig 20 is immersed in the washing liquid 42 of the

ultrasonic washing station 40, 60. In a preferred embodiment of the jig 20, each compartment 25 is provided with a corresponding locking lever 27.

An exemplary embodiment of two adjacent locking lever 27 are shown in FIG. 17, each lever having a pivot point 28 for rotatable connection to the jig 20 and having a somewhat "seahorse" shape. Each locking lever 27 is preferably rotatably connected to the jig 20 at its pivot point 28 as shown in FIG. 18 (a) such that upon immersion of the jig 20 in the washing liquid 42, the locking lever 27 rotates due to natural buoyancy of the locking lever 27 as shown by the curved arrows in FIGS. 17 and 18 (b). Upon rotation of the locking lever 27, an upper portion 29 of the lever 27 above the pivot point 28 comes into contact against a tableware item 1200 adjacent the locking lever 27 in its compartment 25, thereby blocking the tableware item 1200 against upward movement in the washing liquid 42. In this way, all buoyant tableware 1200 are prevented from floating to the surface of the washing liquid 42 during ultrasonic washing and kept fully immersed in the washing liquid 42 to ensure thorough ultrasonic washing of the tableware 1200.

Alternative embodiments of locking levers 27 to prevent flotation of tableware 1200 when immersed in the ultrasonic washing liquid 42 are shown in FIGS. 29, 30 and 31. In a first alternative embodiment of the locking lever 27 shown in FIGS. 29 (a) and (b), the pivot point 28 of each lever 27 is raised on a rigid stalk 28S that is fixed to the jig 20. When the jig 20 is lowered into the washing liquid 42 and the liquid level 43 rises, the locking lever 27 floats as a result of natural buoyancy of the locking lever 27 and rotates about its raised pivot point 28 as shown by the curved arrow, thereby engaging the

tableware item 1200 as shown in FIG. 29 (b). The rotated locking lever 27 thus blocks the tableware item 1200 from upward movement and prevents its flotation in the washing liquid 42. The locking lever 27 in the first alternative embodiment is preferably tapered for easy disengagement from the tableware item 1200 after washing, and is made of a material of lower density than the washing liquid 42 to ensure its buoyancy in the washing liquid 42.

In second and third alternative embodiments of the locking lever 27 shown in FIGS. 30 (a), (b), and (c) and FIGS. 31 (a), (b) and (c), the locking lever 27 comprises a simple rod 27 rotatably connected to the jig 20 at a pivot point 28 located at an upper end of the rod 27, and having a lever floater bulb 27F with a lower density than the washing liquid 42 located at a lower end of the rod 27. Such a locking lever 27 is configured to work with a specially configured tableware compartment 25 as described below.

The specially configured compartment 25 generally comprises a compartment item support 25S for supporting a tableware item 1200 placed in the compartment 25. The compartment item support 25S is generally horizontally disposed and rotatably connected to the jig 20 at a compartment pivot point 25P. The specially configured compartment 25 preferably also comprises a compartment backing 25B attached substantially perpendicularly to the compartment item support 25S for keeping the tableware item 1200 generally upright in the compartment 25. Each specially configured compartment 25 may further comprise an upstanding compartment lip 25L on an opposite side of the compartment item support 25S to which the compartment backing 25B is attached. The compartment lip 25L is for generally keeping the tableware item

1200 within the compartment. Finally, each specially configured compartment 25 comprises a compartment floater bulb 25F for causing rotation of the compartment 25 about its pivot point 25P when the jig 20 is lowered into the washing liquid 42. As shown in FIG. 31 (d), the compartment floater bulb 25F preferably comprises a simple hollow rod or cylinder having a lower density than the washing liquid 42.

In the second alternative embodiment shown in FIGS. 30 (a), (b) and (c), the compartment floater bulb 25F is located between the compartment item support 25S and the compartment backing 25B. When the jig 20 is first lowered into the washing liquid 42, the curved arrow in FIG. 30 (b) shows how the compartment 25 rotates about its pivot point 25P as a result of natural buoyancy of the compartment floater bulb 25F in the washing liquid 42. Rotation of the compartment 25 tips the tableware item 1200 towards the locking lever 27. As the jig 20 is further lowered into the washing liquid 42, the locking lever 27 gets immersed in the washing liquid 42 and the curved arrow in FIG. 30 (c) shows how the locking lever 27 then rotates about its pivot point 28 as a result of natural buoyancy of the lever floater bulb 27F in the washing liquid 42. The rotated locking lever 27 engages the tipped tableware item 1200 as shown in FIG. 30 (c), blocking the tableware item 1200 from upward movement and preventing its flotation in the washing liquid 42.

In the third alternative embodiment shown in FIGS. 31 (a), (b) and (c), the compartment floater bulb 25F is provided at an upper end of the compartment backing 25B. When the jig 20 is first lowered into the washing liquid 42, the locking lever 27 is immersed in the washing liquid 42 and the curved arrow in FIG. 31 (b) shows how the locking lever 27

rotates about its pivot point 28 as a result of natural buoyancy of the lever floater bulb 27F in the washing liquid 42. As the jig 20 is further lowered into the washing liquid 42, the compartment floater bulb 25F on the compartment backing 25B then gets immersed in the washing liquid 42 and the curved arrow in FIG. 30 (c) shows how the compartment 25 rotates about its pivot point 25P as a result of natural buoyancy of the compartment floater bulb 25F in the washing liquid 42. Rotation of the compartment 25 tips the tableware item 1200 towards the rotated locking lever 27, thereby locking the tipped tableware item 1200 against the rotated locking lever 27 and preventing its flotation in the washing liquid 42. In the third alternative embodiment, the tableware item 1200 rests against the compartment floater bulb 25F when the jig 20 is out of the washing liquid 42. Contact pads 25H as shown in FIG. 31 (d) are therefore preferably provided on a chamfered surface 25C of the hollow compartment floater bulb 25F in order to minimize area of contact between the tableware item 1200 and the compartment floater bulb 25F, so as to enhance drying.

Preferably, the industrial dishwasher 10 further comprises a tray washing lane 120 comprising a tray flipping conveyor 121 that uses gravity to remove food debris from trays 1202 among the tableware 1200. In a first embodiment of the tray flipping conveyor 121 shown in FIG. 19 (a), the tray flipping conveyor 121 (the rest of the industrial dishwasher 10 being hidden) comprises a first conveying portion 122 for loading the trays 1202 thereon. The first conveying portion 122 is preferably placed directly above the jig loading station 12 so that operators may, at a single location, load a tray 1202 from a meal-set of used aviation tableware onto the first conveying portion 122 and also load remaining used tableware 1200 from the same meal-set into a jig 20.

The first conveying portion 122 of the tray flipping conveyor 121 is connected to a first end of a twisted conveying portion 124 of the tray washing lane 120. The twisted conveying portion 124 is configured to flip a tray 1202 being conveyed thereon. A second end of the twisted conveying portion 124 is connected to a second conveying portion 126 of the tray flipping conveyor 121. As shown in FIGS. 19 (a) and 19 (b), the conveying portions 122, 126 each comprise a recirculating tray conveying belt 122B, 126B supported on either side by two side rails 128P, 128Q that extend throughout the tray flipping conveyor 121 and along the entire tray washing lane 120.

At the first conveying portion 122, the two side rails 128P, 128Q are oriented such that side rail 128Q is on a right side of the tray washing lane 120, as shown in FIG. 19 (b). At the twisted conveying portion 124, the side rails 128P, 128Q are twisted, preferably also upwardly, such that at the second conveying portion 126, the side rail 128Q has come to be on the left side of the tray washing lane 120. Trays 1202 placed face-up on the first conveying portion 122 are thus overturned 1202T as they are conveyed through the twisted conveying portion 124. No belt is provided between the side rails 128P, 128Q at the twisted conveying portion 124 as shown in FIG. 19 (b), so that food debris may freely fall away from the overturned trays 1202T under gravity as shown in FIG. 19 (c). Food debris is preferably channelled into a solid waste disposal chute 130. In FIG. 19 (c), the twisted conveying portion 124 is hidden for better clarity of the overturning of the trays 1202T. The overturned trays 1202T can then continue through the rest of the tray washing lane 120 on the second conveying portion 126 for similar pressure spray rinsing, ultrasonic washing, sanitizing and drying as the rest of the

tableware 1200 in the various stations 30, 40, 50, 60, 70, 80, 90 of the industrial dishwasher 10.

A second embodiment of the tray flipping conveyor 121 is shown in FIG. 20 with similar reference numerals used for similar corresponding features. In the second embodiment, the tray flipping conveyor 121 comprises a recirculating belt 121B continuously running over two rollers 121R that are spaced apart in parallel, each roller 121R rotating about a horizontal axis, such that the conveyor 121 has an upper portion 121U and a lower portion 121L. Tray holders 121H are attached at regular intervals along the belt 121B. The tray holders 121H are configured for securely holding trays 1202 placed on the belt 121B to prevent the trays 1202 from falling off the belt 121B as the trays 1202T are brought around one of the rollers 121R from the upper portion 121U to the lower portion 121L of the conveyor 121, as shown by the arrows in FIG. 20. In use, the trays 1202 are placed face-up on the upper portion 121U of the belt 121B in the tray holders 121H, so that as the trays 1202T are moved from the upper portion 121U to the lower portion 121 of the tray flipping conveyor 121, the trays 1202T are overturned and food debris naturally fall away from the overturned trays 1202T as a result of gravity. After being overturned, each tray 1202T is then removed from the tray holder 121H that is recirculated back to the upper portion 121U of the belt 121B. The overturned tray 1202Tis then conveyed through the rest of the tray washing lane 120 for further pressure spray rinsing, ultrasonic washing, sanitizing and drying as described above.

A third embodiment of the tray flipping conveyor 121 is shown in FIG. 21 with similar reference numerals used for similar corresponding features. In the third embodiment, the tray flipping conveyor 121 comprises an elevating conveying portion 121E that elevates trays 1202 up to an open drop-off 121D at an upper end of the elevating conveying portion 121E. The elevating conveying portion 121E preferably comprises a recirculating belt passing over a roller having a horizontal axis of rotation at the open drop-off 121D. Elevated trays 1202 are then allowed to fall off the drop-off 121D into a curved chute 121C. The curved chute 121C is configured to guide each tray 1202T as it falls within the chute 121C from a face-up position on the elevating conveying portion 121E to a face-down position on a conveyor continuing through to the rest of the tray washing lane 120. As the trays 1202T are guided through the curved chute 121C and overturned therein, food debris naturally fall away from the overturned trays 1202T as a result of gravity.

By providing the tray flipping conveyor 121 that uses mainly gravity to cause food debris to be removed from overturned trays, energy consumption is thus reduced when compared to using conventional continuous tray vacuum suction systems that are placed directly over face-up trays and that rely on high vacuum suction strength to suck up debris from the face-up trays instead of having the debris fall naturally away from the overturned trays 1202T.

In addition to relying on gravity to remove food debris from the trays 1202, water recycled from one or more of the rinsing stations 30, 50, 70 may also be directed through pressure spray nozzles 32 to spray food debris off the trays 1202 prior to further

washing of the trays through the rest of the tray washing lane 120, as shown in FIG. 21, again reducing water consumption by the industrial dishwasher 10.

As shown in FIGS. 22 (a) and 22 (b), an auxiliary washing lane 140 may further be provided in the industrial dishwasher 10 for washing less soiled tableware items such as glasses 1204 and/or bulk items such as oven racks, reheating containers etc. Preferably, an entry 144 into the auxiliary washing lane 140 is provided adjacent the jig loading station 12 so that the bulk items or glasses 1204 from used meal-sets of aviation tableware may be loaded into auxiliary jigs 142 by the same operators loading the tableware 1200 into the jigs 20, and readily passed into the auxiliary washing lane 140. The side tables 14 at the jig loading station 12 are particularly useful for loading the auxiliary jigs 142 with the bulk items or glasses 1204.

Rollers 145 may be provided at the entry 144 and exit 146 of the auxiliary washing lane 140 for easy movement of the auxiliary jigs 142 into and out of the auxiliary washing lane 140 respectively. The auxiliary washing lane 140 may comprise a recirculating conveyor 147 that passes the auxiliary jigs 142 through a high pressure spray area 148 where the bulk items or glasses 1204 may be sprayed with a washing liquid 149 of water and detergent, followed by spraying with a sanitizing spray 150 and a final rinse with deionized water 152. Washed bulk items or glasses 1204 are then passed through a drying section 154 of the auxiliary washing lane 140 that preferably comprises a plurality of high temperature air-knife blowers 156 for blow-drying the bulk items or glasses 1204 before they leave the auxiliary washing lane 140 through the exit 146.

The industrial dishwasher 10 may also be provided with a cart washing lane 110 adjacent the auxiliary washing lane 140 as shown in FIGS. 3 and 4. The cart washing lane 110 is configured for washing inflight carts 112 or trolleys that are used to transport a plurality of meal sets of tableware 1200 therein. The cart washing lane 110 preferably comprises a number of rinsing stations 114 such as an initial rinsing station, a detergent washing station, an intermediate rinsing station, a sanitizing station, and a final rinsing station. A fast-drying station 116 is preferably also provided to dry the washed carts 112.

Preferably, the solid waste disposal chute 130 comprises a top-opening 132 vacuum compactor (hidden) as shown in FIGS. 23 (a), (b) and (c) for collecting food debris removed from the tableware 1200 at the jig loading station 12, the tray flipping conveyor 124 and the entry 144 of the auxiliary washing lane 140. Collection trays 134 leading to channels or pipes 136 may further be provided to direct the collected food debris onto a debris conveyor 135 for depositing into the top-opening 132 vacuum compactor. The debris conveyor 135 may have through openings for allowing passage of waste liquids (as shown by the dotted arrows in FIG. 22 (c)) to be drained into a waste drainage system 138.

Jig detection sensors are preferably provided at each station 30, 40, 50, 60, 70, 80, 90 of the industrial dishwasher 10 so that each station is only activated to perform its dedicated function upon detection of the presence of a jig 20 at that station. Upon exit of a jig 20 from a station, the station stops its process. In this way, usage of energy, water

and detergent is minimized, and greatly reduced compared to the non-stop washing action of conventional industrial dishwashers 500 as shown in FIGS. 1 and 2.

Safety switches are preferably provided at strategic locations of the industrial dishwasher 10 so that operators may selectively stop movement of the conveyor 22 or a jig 20 if necessary. Emergency stop buttons are preferably also provided for totally stopping the industrial dishwasher 10 if necessary.

The dishwasher 10 may further incorporate digital sensors and logs for controlling and/or monitoring various operating parameters including temperature, liquid pH, resistivity, power consumption, flow rates, machine utilization, detergent usage, water usage, tableware count etc., where relevant and appropriate.

The industrial dishwasher 10 as described above therefore allows a plurality of separate, dedicated dishwashers to be replaced with a single machine, thereby providing a space-saving, labour-saving, energy-saving, water-saving and ecologically-friendly solution for effectively washing a plurality of types of differently soiled tableware and associated catering items in high volume.

Whilst there has been described in the foregoing description exemplary embodiments of the present invention, it will be understood by those skilled in the technology concerned that many variations in details of design, construction and/or operation may be made without departing from the present invention.

CLAIMS

1. An industrial dishwasher comprising:

a tableware washing lane comprising an ultrasonic washing station for ultrasonically washing differently soiled tableware,

a tray washing lane; and

an auxiliary washing lane for washing glassware.

2. The industrial dishwasher of claim 1, further comprising a cart washing lane for washing carts used to transport the tableware.

3. An industrial dishwasher suitable for washing tableware, the industrial dishwasher comprising:

a jig loading station for loading a plurality of types of tableware into jigs, each jig comprising a plurality of compartments for containing therein the plurality of types of tableware for immersing the tableware in a washing liquid;

a first ultrasonic washing station containing the washing liquid for ultrasonically washing the tableware in the jig,

a final rinsing station for a final rinsing of the tableware in the jig after ultrasonic washing;

a drying station for drying the tableware in the jig after the final rinsing; and

an unloading station for unloading the tableware from the jigs.

4. The industrial dishwasher of claim 3, further comprising an initial rinsing station for an initial rinsing of the plurality of types of tableware contained in the jig before ultrasonically washing the tableware.

5. The industrial dishwasher of claim 4, wherein used water discharged from the final rinsing station is recycled for use at the initial rinsing station.

6. The industrial dishwasher of any one of claims 3 to 5, further comprising a sanitizing station for sanitizing the tableware in the jig after the final rinsing and before drying the tableware.

7. The industrial dishwasher of any one of claims 3 to 6, wherein each jig comprises a plurality of locking levers, each locking lever comprising a lever rotatably connected to the jig such that upon immersion of the jig in the washing liquid, the locking lever rotates due to natural buoyancy of the lever and contacts a tableware item adjacent the locking lever to block the tableware item against upward movement, thereby preventing flotation of the tableware item in the washing liquid.

8. The industrial dishwasher of claim 7, wherein at least some of the plurality of compartments are rotatable compartments rotatably connected to the jig such that upon immersion of the jig in the washing liquid, the rotatable compartments rotate due to natural buoyancy of the rotatable compartments such that the tableware items contained in the rotatable compartments are tipped against their

respective adjacent locking levers to block the tableware items against upward movement, thereby preventing flotation of the tableware items in the washing liquid..

9. The industrial dishwasher of any one of claims 3 to 8, further comprising a tray washing lane having a tray flipping conveyor configured to use gravity for removing food debris from trays among the tableware.

10. The industrial dishwasher of claim 9, wherein the tray flipping conveyor comprises a first conveying portion for loading the trays thereon and an overturning conveying portion in connection with the first conveying portion for overturning the trays such that food debris falls away from the overturned trays.

11. The industrial dishwasher of claim 10, wherein the overturning conveying portion comprises a twisted conveying portion.

12. The industrial dishwasher of claim 11, wherein the overturning conveying portion comprises a recirculating belt passing over a roller, the roller having a horizontal axis of rotation.

13. The industrial dishwasher of claim 12, wherein the overturning conveying portion comprises a curved chute.

14. The industrial dishwasher of any one of claims 3 to 13, further comprising an auxiliary washing lane for washing glassware.

15. The industrial dishwasher of any one of claims 3 to 14, further comprising a solid waste disposal chute in connection with the jig loading station, the chute comprising a top-opening vacuum compactor for collecting food debris removed from the tableware.

16. The industrial dishwasher of any one of claims 3 to 15, further comprising a jig return conveyor for returning jigs from the unloading station to the jig loading station.

17. The industrial dishwasher of any one of claims 3 to 16, further comprising a self-cleaning heating coil in the ultrasonic washing station for heating the washing liquid.

18. The industrial dishwasher of any one of claims 3 to 17, further comprising a heat recovery system configured for recovering heat generated at the drying station to heat the washing liquid in the ultrasonic washing station.

19. The industrial dishwasher of any one of claims 3 to 18, further comprising an intermediate rinsing station for an intermediate rinsing of the tableware in the jig after ultrasonic washing in the ultrasonic washing station, and further comprising a second ultrasonic washing station for a second simultaneous

ultrasonic washing of the tableware in the jig after the intermediate rinsing and before the final rinsing.

20. The industrial dishwasher of claim 19 when dependent on claim 3, wherein used water discharged from the final rinsing station is recycled for use at the intermediate rinsing station and used water discharged from the intermediate rinsing station is recycled for use at the initial rinsing station.

21. The industrial dishwasher of claim 19 or claim 20, wherein used washing liquid from the second ultrasonic washing station is recycled for use at the first ultrasonic washing station.

22. The industrial dishwasher of any one of claims 3 to 21 further comprising a cart washing lane for washing carts used to transport the tableware.

23. A jig for use with an industrial dishwasher for washing tableware, the jig comprising:

a plurality of compartments for containing therein a plurality of types of tableware for immersing the tableware in a washing liquid; and

a plurality of locking levers, each locking lever comprising a lever rotatably connected to the jig such that upon immersion of the jig in the washing liquid, the locking lever rotates due to natural buoyancy of the lever and contacts a tableware item adjacent the locking lever to block the tableware item against

upward movement, thereby preventing flotation of the tableware item in the washing liquid.

24. The jig of claim 23, wherein at least some of the plurality of compartments are rotatable compartments rotatably connected to the jig such that upon immersion of the jig in the washing liquid, the rotatable compartments rotate due to natural buoyancy of the rotatable compartments such that the tableware items contained in the rotatable compartments are tipped against their respective adjacent locking levers to block the tableware items against upward movement, thereby preventing flotation of the tableware items in the washing liquid..

25. A tray flipping conveyor for use with an industrial dishwasher for washing tableware, the tray flipping conveyor comprising

a first conveying portion for loading trays from among the tableware thereon; and

an overturning conveying portion in connection with the first conveying portion for overturning the trays such that food debris falls away from the overturned trays under gravity.

26. The tray flipping conveyor of claim 25, wherein the overturning conveying portion comprises a twisted conveying portion.

27. The tray flipping conveyor of claim 25, wherein the overturning conveying portion comprises a recirculating belt passing over a roller, the roller having a horizontal axis of rotation.

28. The tray flipping conveyor of claim 25, wherein the overturning conveying portion comprises a curved chute.

29. A solid waste disposal chute for use with an industrial dishwasher for washing tableware, the chute comprising:

a top-opening vacuum compactor for collecting food debris removed from the tableware.

30. A method of washing tableware using an industrial dishwasher, the method comprising:

loading a plurality of types of tableware into a jig at a jig loading station of the industrial dishwasher;

immersing the tableware in the jig in a first washing liquid and ultrasonically washing the tableware in the jig at a first ultrasonic washing station of the industrial dishwasher;

performing a final rinsing of the tableware in the jig at a final rinsing station of the industrial dishwasher;

drying the tableware in the jig at a drying station of the industrial dishwasher; and

unloading the tableware from the jig at an unloading station of the industrial dishwasher.

31. The method of claim 30, further comprising performing an initial rinsing of the tableware in the jig at an initial rinsing station of the industrial dishwasher before immersing the tableware in the jig in the first washing liquid.

32. The method of claim 31, further comprising recycling used water from the final rinsing for the initial rinsing.

33. The method of any one of claims 30 to 32, further comprising sanitizing the tableware in the jig after the final rinsing and before the drying.

34. The method of any one of claims 30 to 33, further comprising performing an intermediate rinsing of the tableware in the jig at an intermediate rinsing station of the industrial dishwasher after the ultrasonic washing; and immersing the tableware in the jig in a second washing liquid and ultrasonically washing the tableware in the jig a second time at a second ultrasonic washing station of the industrial dishwasher before the final rinsing.

35. The method of claim 34 when dependent on claim 31, further comprising recycling used water from the final rinsing for the intermediate rinsing and recycling used water from the intermediate rinsing for the initial rinsing.

36. The method of claim 34 or 35, further comprising recycling used second washing liquid from the second ultrasonic station for use as the first washing liquid in the first ultrasonic station.

37. The method of any one of claims 30 to 36, further comprising using a tray flipping conveyor to overturn a tray from among the tableware to remove food debris from the tray by gravity.

38. The method of any one of claims 30 to 37, further comprising washing glassware in an auxiliary washing lane of the industrial dishwasher.

39. The method of any one of claims 30 to 38, further comprising collecting food debris removed from the tableware using a solid waste disposal chute comprising a top-opening vacuum compactor.

40. The method of any one of claims 30 to 39, further comprising returning jigs from the unloading station to the jig loading station using a jig return conveyor of the industrial dishwasher.

41. The method of any one of claims 30 to 40, further comprising recovering heat generated at the drying station to heat the washing liquid in the ultrasonic washing station using a heat recovery system.