

SPECIFICATION

A method and apparatus for straightening plate pallets

5 Air cargo is carried in modern aircraft as "unit loads". Each unit load comprises a load pre-loaded on to a rectangular base and secured with nets and straps, or is pre-loaded into a
10 container built on to a rectangular base, each unit load complying with standard sizes within standard weight limitations.

The unit load bases are generally called pallets (and will be so called hereinafter), and
15 are of standard sizes to allow easy interchangeability between different types of aircraft.

Each pallet is formed by a rectangular planar plate of uniform thickness having, in position for use, an upper surface and a lower
20 surface, the plate being bounded at all four edges by stiff edge rails of constant vertical cross-section which are coplanar with the lower surface, or at least do not project beyond the plane containing the lower surface,
25 and extend above the upper surface.

The prepared unit loads are transferred into the aircraft by conveyancing systems inside and outside the aircraft. The conveyancing systems comprise horizontal rows of cylindrical
30 rollers where translation of the unit load in one horizontal direction only is required, and horizontal grids of spheres where translation in any horizontal direction and also rotation about a vertical axis are required. Typically
35 the arrays of spheres or ball mats, are provided at side access doors where unit loads enter and leave the aircraft, while the remainder of the length of the aircraft cargo compartment is provided with parallel rows of rollers
40 in roller trays. Maximum horizontal spacing for the rollers and the spheres are established by international standards and agreements.

When a unit load is loaded, the edge rails of its pallet interface with the aircraft locks
45 and stops which provide restraint against upward vertical forces and horizontal forces, respectively. Downward vertical forces are reacted by bearing of the pallet on to the rollers and balls of the conveyancing systems. High
50 local forces and stresses occur at the line of contact of each roller and point of contact of each sphere with the lower surface of the pallet.

One common form of pallet uses a thin
55 plate of high strength aluminium alloy, usually 4 to 5 mm thick, to provide the planar lower surface with edge rails approximately 25 mm thick and 75 to 100 mm wide attached to the edges. This form of pallet suffers a particular
60 type of cumulative deterioration in service which causes the lower surface of the pallet to become significantly convex, that is to deviate from being a planar surface, by the centre portions being significantly lower than the
65 edge portions. This convexity is known to be

caused by local extensions of the lower surface of the plate when the elastic limit (limit of proportionality of stress and strain) of the
plate material is exceeded at or just above

70 that lower surface. Local stresses above the elastic limit are believed to occur at the interfaces between the lower surface of a pre-loaded pallet and the rollers and spheres when the pallets are moved over the surface
75 of the conveyancing system during transfer to and from the aircraft and associated ground handling equipment or when high vertical forces occur at the interface of the pallet and the conveyancing system during operation of
80 the aircraft and associated ground handling equipment.

Convexity of the lower surface of the pallet greater than approximately 50 mm is generally unacceptable because it becomes difficult
85 to engage the locks providing vertical restraint of the pallet against upward forces and also because the conveyancing system in the aircraft may be damaged by these pallets. It is therefore necessary to rectify the pallets.

90 This may be achieved by removing the convex plate and fitting a new undeformed plate, an expensive method for which the cost of repair is nearly as great as the cost of a new pallet.

95 An alternative method has been used which substantially reduces the convexity of the plate without the need to dismantle the pallet or replace parts. This method uses the process generally known as shot peening to extend
100 the upper surface of the plate by an amount approximately equivalent to the prior extension of the lower surface of the plate.

The shot peening process consists basically of firing small spheres of iron or similar soft
105 metal at high velocity to impact with a surface, whereby their kinetic energy is partially converted at impact with the target surface into strain energy acting on this surface. To be successful, the strain energy must be sufficient for the elastic limit of the target material
110 to be exceeded at the local point of impact so that a permanent strain or extension occurs at this surface. The cumulative effect of a great number of small spheres impacting the target
115 surface area produces an overall surface extension which for a thin plate will cause the impacted surface to tend to become convex, or to bow, towards the shot peening source.

It is apparent that if the upper surface of a
120 pallet, which is initially concave (the lower surface being convex), is shot peened, the concavity can be reduced or even reversed. The plate will also suffer an overall extension which is constrained by the large horizontal
125 dimension of the plate relative to its thickness except at its edges, where it is constrained by the edge rails. This results in the processed plate being wavy, i.e. not planar, away from the edges, and in the edges curving upwards,
130 since the outward forces from the plate on to

the edge rail act below the neutral axis, or axis of rotation, of the edge rail. Nonetheless a substantially flatter pallet is achieved by this processing method.

5 The shot peening process has the following disadvantages:

(a) not all the kinetic energy is converted into strain energy in the upper surface of the plate, some is converted to strain energy in the "shot" causing deformation which require the shot to be frequently renewed. Some is converted to noise energy with the consequent need for noise absorption, ear protection for operators and generally a special area for the process to prevent the noise from interfering with workers in other areas.

(b) Considerable dust with a high metallic content is generated by the process, requiring air extraction and filtering plant.

(c) Considerable cost is involved in providing and maintaining the apparatus which accelerates the shot to the required velocity.

(d) The shot peening apparatus generally has to remain at one fixed location so that pallets have to be transported to the apparatus.

The invention aims substantially to straighten plate pallets having a convex lower surface by extending the upper surface of the plate, thus counter-acting the convexity without dismantling the pallet, as already described for the shot peening process, while substantially avoiding or mitigating at least some of the disadvantages of the shot peening process. A further aim of the invention is to reduce the fixed costs of investment in apparatus and premises, to reduce the operating costs and expenditure of energy, to reduce process noise and air pollution and to reduce process time while increasing process flexibility and controllability.

The invention provides a method of reducing or eliminating the curvature of a curved plate of a pallet, including contacting the substantially concave surface of the plate by at least one hard element, the or each element being so shaped that there is a small area of contact between said element or elements and said surface, applying, via said contact area or areas, a controlled force to exceed the elastic limit of the plate material at or near said surface only, while the opposite surface is supported, and causing relative traversing between the element or elements and the plate in a controlled manner, while said force is maintained, to bring it or them successively into contact with at least a selected part of said concave surface.

The invention also provides an apparatus for reducing or eliminating the curvature of a curved plate of a pallet, the apparatus comprising at least one hard element for contacting the substantially concave surface of the plate, the or each element being so shaped that there is a small area of contact between

said element or elements and said surface, means for applying a controlled force via said contact area or areas to exceed the elastic limit of the plate material at or near the surface only, the apparatus being arranged for relative traversing between the element or elements and the plate in a controlled manner, while said force is maintained, to bring it or them successively into contact with at least a selected part of said concave surface.

A method according to the invention has the following three main objectives:

(a) to provide a small contact area (or areas), between a hard smooth element and the upper surface of the plate,

(b) to apply a controlled force at each contact area so as to at least exceed the elastic limit of the plate material at, or near the upper surface, and

(c) to provide means for traversing the contact areas relative to the upper surface of the plate in a controlled manner, preferably without slip.

If these three objectives are attained, they result in controlled local or overall extension of the upper surface of the plate to counteract the cumulative extension of the lower surface of the plate in service.

Suitable means for achieving a small contact area with the upper surface of the plate is at least one small contact element which has the shape of a body of revolution symmetrical with respect to a plane perpendicular to its axis of symmetry made of a material possessing higher surface strength, hardness and smoothness and a higher modulus of elasticity than the plate material, and rotatable about said axis.

A preferred element is a sphere (hereinafter called "ball"). Also a cylinder or ellipsoid may be used with its axis substantially parallel to the plate surface, although the geometry and sizes of the areas of contact are then more variable than for a ball, and the traversing of the surface must be in a horizontal direction perpendicular to said axes for no slip to occur between the element and the plate surface.

Alternatively, e.g. a cylinder may be used which is provided with one or more projecting rings or helices (continuous or discontinuous) having a suitable cross-sectional outline to provide the desired small contact area. Also e.g. a cylinder provided with a plurality of warts providing said small contact areas may be used.

The controlled force on to the contact area may be applied by any means which can control and vary the force, including dead loads or weights, springs, or pneumatic or hydraulic rams, either directly to the apparatus which houses the elements or through levers or other mechanisms.

The small contact area or areas of the element or elements and the controlled force must be selected so as to achieve surface

extension rather than indentation although a very small indentation, practically unnoticeable by the naked eye, will result.

In a presently preferred method in which a ball is used as the contact element, the size of the ball and said force are so selected that when the ball is stationary it makes in the plate surface an impression of about 2 mm in diameter and 0.01 mm in depth.

The areas of contact may be traversed relative to the plate surface either by moving the pallet horizontally or by moving the elements horizontally, or by a combination of both.

The motion may be imparted manually or by mechanical means, or by a combination of the two, following either a fixed or a variable pattern across the plate surface.

The manner in which the force is transferred to the working element, e.g. a ball, from the apparatus must allow it to rotate freely so that it rolls over the surface of the plate without significant slip (relative horizontal motion) at the interface area with the plate surface. Slipping can result in scuffing, flaking or other similar damage detrimental to the plate surface, as well as wear and other damage to the elements.

While presently freely rotatable elements are preferred for the simplicity of design, it is also possible to rotate the elements by a motor.

Approximate relationships between the process variables of the method are as follows: the local surface and subsurface strains (or extensions) in the plate are directly proportional to the cube root of the force applied to the element (sphere or cylinder) by the apparatus, and are inversely proportional to the cube root of the square of the diameter of the sphere, or the cube root of the diameter of the cylinder.

An apparatus for carrying out the method according to the invention may have various forms. In the forms to be hereafter described with reference to the drawings each form comprises at least one proprietary ball unit, such as that shown in Fig. 1. The ball unit includes a hard, smooth ball 11, e.g. of stainless steel, supported in a housing 12 in a cradle of smaller bearing balls 13, the housing carrying means of attachment 14.

In its simplest form the apparatus comprises a frame to which one said ball unit is attached and which is provided with three outriggers or legs, preferably spaced from each other through 120°, attached at one end to the frame and having at their free or support end a friction-reducing contact element, such as a ball unit or a castor. The purpose of the outriggers is to maintain the frame and the central ball unit in the correct attitude towards the upper surface of the plate or pallet being treated by the apparatus. The frame may be arranged to receive, or be provided with a receptacle to receive weights or ballast above

the central ball unit to obtain desired force acting through the central ball unit on to the surface being treated, and a handle for propelling the apparatus across said surface. The

apparatus will also include a range of weights or ballast and may include a flat horizontal surface on to which the pallet is placed for treatment, although nearly any flat horizontal surface may serve to support the pallet being treated.

This form of the apparatus is operated by placing the pallet on to the flat horizontal surface, placing the frame on to the upper surface so that the central ball unit is in contact therewith, adding a predetermined minimum weight of ballast on to the frame or receptacle and then moving the apparatus so that the ball of the central ball unit rolls over the majority of the surface by repeated horizontal traverses.

Persistent bow can be reduced by progressively increasing the weights or ballast up to a predetermined maximum value. Such an apparatus has the disadvantage that the process time is long for the ball unit to be propelled manually over the entire upper surface of the plate. One complete traverse of a surface of an area 2 m × 3 m using a combination of ball diameter and contact force resulting in the diameter of the contact area being 1 mm, would take at least 5 hours at an average horizontal velocity of 300 mm/s.

Another preferred form of the apparatus is illustrated in Fig. 2. In this form three proprietary ball units 21, such as those shown in Fig. 1, are attached in a symmetrical and balanced pattern on to a disc 22 which is provided with a drive shaft 23 coaxial with the disc 22. Rotation, indicated by the arrow A, is provided at the drive shaft 23 e.g. by an electric motor (not shown in Fig. 2) and a vertical force or reaction, indicated by the arrow B, is provided by the remainder of the apparatus, and possibly by additional means (not shown). The apparatus shown in Fig. 2 could be incorporated into a simple manual apparatus similar to that described earlier as the simplest version.

Fig. 3 illustrates a device for carrying out the method intended for static installation. The device includes an apparatus such as that shown in Fig. 2, driven by an electric or pneumatic motor 32, mounted on a rigid frame 33 attached to the floor. The frame 33 carries a rigid planar bed 34 having a central opening 34' below the apparatus 31. A platform 35 is arranged vertically displaceably through the opening 34' above the plane containing the upper surface of the bed 34. This platform may be connected e.g. to the piston rod of a piston of a pneumatic ram 36.

In operation a pallet having a plate 37 and edge rails 38 is positioned on to the bed 34 and the platform 35 is raised under the pallet to generate forces at the contact areas of the

ball units of the apparatus 31 with the plate 37. Control of the ram pressure will directly control the forces between the balls of the apparatus 31 and the plate 37.

- 5 The apparatus is operated by manually traversing the pallet 37, 38 between the apparatus 31 and the platform 35, concentrating on those areas where most stretching has occurred on the lower surface of the plate 37, and increasing the contact force as necessary as the plate material strain-hardens.

- 10 The sag of the plate 37, with the platform 35 being higher than the bed 34 is caused by the weight of the pallet (and may be increased mechanically), and aids the process by allowing the upper surface of the plate 37 take up a convex shape particularly near the edge rails 38.

- 15 The provision of three (or more) ball units on the apparatus and the driving of the apparatus by the motor 32 allows the plate surface area to be traversed at a much higher rate, thus reducing the process time to a small fraction of that required for manual traversing of an apparatus equipped with a single ball unit.

- 20 A further advantage of the apparatus is that dust and noise are negligible, expenditure of energy is small, and no material is consumed, unless lubrication fluid is used, may be desirable in some cases.

- 25 The equipment shown in Fig. 3 may be refined or developed in many ways, such as by fitting ball units or low-friction material to the top surface of the bed 34 and platform 35, by providing position and force adjustment to the motor 32 or apparatus 31 instead of to the platform 35, or by providing mechanical means to traverse the pallet 37, 38.

40 CLAIMS

1. A method of reducing or eliminating the curvature of a curved plate of a pallet, including contacting the substantially concave surface of the plate by at least one hard element, the or each element being so shaped that there is a small area of contact between said element or elements and said surface, applying via said contact area or areas, a controlled force to exceed the elastic limit of the plate material at or near said surface only, while the opposite surface is supported, and causing relative traversing between the element or elements and the plate in a controlled manner, while said force is maintained, to bring it or them successively into contact with at least a selected part of said concave surface.

2. A method according to Claim 1 wherein the or each element is a rotating or rolling element.

3. A method according to Claim 2 wherein the or each element is a ball.

4. A method according to Claim 3 wherein the or each element is a ball of a ball

unit in which the ball is supported in a housing in a cradle of smaller balls.

5. A method of reducing or eliminating the curvature of a curved plate of a pallet, substantially as herein described with reference to the accompanying drawing.

6. An apparatus for reducing or eliminating the curvature of a curved plate of a pallet, the apparatus comprising at least one hard element for contacting the substantially concave surface of the plate, the or each element being so shaped that there is a small area of contact between said element or elements and said surface, means for applying a controlled force via said contact area or areas to exceed the elastic limit of the plate material at or near the surface only, the apparatus being arranged for relative traversing between the element or elements and the plate in a controlled manner, while said force is maintained, to bring it or them successively into contact with at least a selected part of said concave surface.

7. An apparatus according to Claim 6 wherein the or each element is a rotating or rolling element.

8. An apparatus according to Claim 7 wherein the or each element is a ball.

9. An apparatus according to Claim 8 wherein the or each element is a ball of a ball unit in which the ball is supported in a housing in a cradle of smaller balls.

10. An apparatus according to Claim 9 having one said ball unit attached to a frame, the frame being carried on outriggers or legs each of which has at its end remote from the frame a friction-reducing contact element.

11. An apparatus according to any one of Claims 6 to 10 wherein the frame is arranged to receive ballast substantially above the element or elements.

12. An apparatus according to any one of Claims 6 to 11 including a handle for propelling the apparatus across said surface.

13. An apparatus according to Claim 9 having several said ball units attached in a symmetrical and balanced pattern on to a disc which is provided with a drive shaft associated with a driving motor.

14. An apparatus according to Claim 13 wherein the apparatus is arranged to receive ballast.

15. An apparatus according to Claim 14 including a handle for propelling the apparatus across said surface.

16. An apparatus according to Claim 13 mounted on a rigid frame attached to the floor.

17. An apparatus according to Claim 16 wherein the frame carries a rigid bed provided with an opening opposite said ball units, a platform arranged displaceably through the opening, and means for pressing the platform at a preselected controllable pressure against the ball units.



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unit in which the ball is supported in a housing in a cradle of smaller balls.

5. A method of reducing or eliminating the curvature of a curved plate of a pallet, substantially as herein described with reference to the accompanying drawing.

6. An apparatus for reducing or eliminating the curvature of a curved plate of a pallet, the apparatus comprising at least one hard element for contacting the substantially concave surface of the plate, the or each element being so shaped that there is a small area of contact between said element or elements and said surface, means for applying a controlled force via said contact area or areas to exceed the elastic limit of the plate material at or near the surface only, the apparatus being arranged for relative traversing between the element or elements and the plate in a controlled manner, while said force is maintained, to bring it or them successively into contact with at least a selected part of said concave surface.

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15. An apparatus according to Claim 14 including a handle for propelling the apparatus across said surface.

16. An apparatus according to Claim 13 mounted on a rigid frame attached to the floor.

17. An apparatus according to Claim 16 wherein the frame carries a rigid bed provided with an opening opposite said ball units, a platform arranged displaceably through the opening, and means for pressing the platform at a preselected controllable pressure against the ball units.

18. An apparatus for reducing or eliminating the curvature of a curved plate of a pallet, constructed, arranged and adapted to operate substantially as herein described with reference to, and as shown in, the accompanying drawing.

19. A plate of a pallet the curvature of which has been reduced or eliminated by a method according to any one of Claims 1 to 5.

20. A plate of a pallet the curvature of which has been reduced or eliminated with the use of an apparatus according to any one of Claims 6 to 18.

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