Abstract: The presently disclosed thermoplastic pallet advantageously incorporates fire resistance by virtue of one or more of the following aspects: a sprinkler friendly deck or frame; variable fire retardant or coating distributions; fire collapsible cross beams; foam filled or foam coated parts; and pallet design, including proportioning amounts of plastic and metal utilized in construction. Exemplary combinations of features enable the pallet to meet all the dimensional, mechanical behavior and burn test requirements. The use of metal components including a corrugated aluminum deck having specially position through holes for sprinkler water, and the engineered placement of hollows in the structural plastic parts enables a reduction in the amount of plastic, and the amount of fire retardant in what plastic there is and in the pallet as a whole.
For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.
FIRE RESISTANT THERMOPLASTIC PALLET

TECHNICAL FIELD

[0001] This disclosure relates to a device for the transportation of packaged goods, and, more particularly, to a pallet that meets certain standards set by the Grocery Manufacturers Association (GMA) and others for weight, durability, and strength.

BACKGROUND

[0002] Pallets, both bearing goods and empty, are often stored on racks in warehouses which are fitted with fire-fighting automatic sprinkler systems. The heat and rate of combustion of the pallets made of typical polyethylene or polypropylene pallet material are inherently high compared to traditional wood pallets. A bad conflagration can result, overwhelming the sprinkler system of a typical warehouse, many of which were designed for wood pallets. Adding additional sprinkler systems, or having special areas for plastic pallets, involves substantial unwanted costs or logistics problems.

[0003] A criteria which is used to evaluate plastic pallets is to compare their performance to wood pallets, to find if they perform equal or better than wood pallets under fire conditions. In particular, Underwriters Laboratories (Northbrook, Illinois, U.S.) has developed a Standard, UL 2335, "Classification Flammability of Plastic Pallets". The Standard is consistent with U.S. National Fire Protection Association (NFPA) Standards 231 and 231C, which relate to warehouses and rack (pallet) storage of materials in warehouses. Under the UL Standard, a group of stacked pallets is artificially ignited in a certain defined containment building. Measurements are made of the rate of spread of a fire within a stack of pallets, the amount of heat released during burning of the stack (gauged by the number of standard sprinkler heads which are triggered in the test setup), and the structural stability (resistance to collapse) of the stack.
[0004] Plastic pallets have been in use, but have not gained wide acceptance, since they have not met all the criteria for pallets. Generally, pallets must have certain dimensions, be strong enough to carry specified loads, must not be too heavy, and must be durable in resisting damage during use, as measured by certain tests and field use. In particular, to be accepted, they must meet standards of the Grocery Manufacturers of America (GMA). Among the criteria in the standard are that pallets have fire resistances, sufficient to not exceed the heat release set by Underwriters Lab Standard 2335 when intentionally set on fire in a test facility, to simulate a warehouse fire. The pallet also must not be too heavy, must be strong enough to carry specified loads, and must be durable in resisting damage during use, as measured by certain tests and field use. So far, no pallet has been able to meet all these criteria. Indeed, the more fire retardant included in the plastics, the more fragile the plastic. Thus, other approaches are sought. And of course, cost is important. It has been a stumbling block for pallets to meet the foregoing mechanical and cost criteria to also meet fire resistance standards. One accepted criterion is that, pallets in a rack, subjected to a fire test which simulates a warehouse fire, cannot burn in a way such that they exceed the maximum heat release (heat of combustion in any 10 minute time span) set by Underwriters Lab Standard 3435.

[0005] One solution may appear to be making pallets out of fire resisting plastics, such as Noryl plastic for pallets described and offered by General Electric Co., or such as polypropylene or polyethylene containing significant amounts of fire retardants. However, taking that approach that creates several problems. They variously include additional weight, reduced strength, the toxicity and environmental unacceptability of many of the good fire retardant additives, and increased cost.

[0006] What is needed in the art is a low cost, low weight, durable, fire resistant pallet.

SUMMARY

[0007] The above-described and other problems and disadvantages of the prior art are overcome and alleviated by the present thermoplastic pallet. The presently disclosed
thermoplastic pallet advantageously incorporates fire resistance, while retaining durability, low weight and low cost. Such fire resistance is gained by virtue of one or more of the following aspects: a sprinkler friendly deck or frame; variable fire retardant or coating distributions; fire collapsible cross beams; foam filled or foam coated parts; and pallet design, including proportioning amounts of plastic and metal utilized in construction. Exemplary combinations of features enables the pallet to meet all the dimensional, mechanical behavior and burn test requirements. The use of metal components including a corrugated aluminum deck having specially position through holes for sprinkler water, and the engineered placement of hollows in the structural plastic parts enables a reduction in the amount of plastic, and the amount of fire retardant in what plastic there is and in the pallet as a whole.

[0008] The above-described and other features will be appreciated and understood by those skilled in the art from the following detailed description, drawings and appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] Referring now to the accompanying FIGURES, which are meant to be exemplary and not limiting:

[0010] FIGURE 1 is a semi-schematic elevation view illustrating pallets stored on a rack in a warehouse having sprinklers;

[0011] FIGURE 2 is a partial vertical cross-sectional view of an exemplary pallet including corrugations having holes;

[0012] FIGURE 3 is a perspective cutaway view of an exemplary pallet including corrugations having holes;

[0013] FIGURE 4 is a perspective cutaway view of an exemplary pallet having interconnected corrugations having holes;
[0014] FIGURE 5 is a perspective cutaway view of an exemplary pallet having corrugations interconnected with an angled deck supporting frame having holes;

[0015] FIGURE 6 is a partial vertical cross-sectional view of an exemplary pallet having contoured base portions;

[0016] FIGURE 7 is a partial vertical cross-sectional view of another exemplary pallet having contoured base portions;

[0017] FIGURE 8 is a partial vertical cross-sectional view of another exemplary pallet having contoured base portions;

[0018] FIGURE 9 is a cross sectional view of an exemplary pallet;

[0019] FIGURE 10 is a cross sectional view of an exemplary pallet column;

[0020] FIGURE 11 is a cross sectional view of an exemplary pallet column and deck;

[0021] FIGURE 12 is a cross sectional view of an exemplary pallet corner;

[0022] FIGURE 13 is a cross sectional view of an exemplary pallet deck;

[0023] FIGURE 14 is a cross sectional view of an exemplary pallet component mold;

[0024] FIGURE 15 shows a bottom side of an exemplary plastic pallet having an array of beams which are embedded in the bottom of the pallet;

[0025] FIGURE 16 shows a detail of the top cross section view of an exemplary pallet corner;

[0026] FIGURE 17 is a vertical elevation end view of exemplary pallet supported in a warehouse rack along its opposing lengthwise ends;
[0027] FIGURE 18 is a front elevation view of an exemplary beam incorporated in a pallet;

[0028] FIGURE 19 is a bottom view of a pallet incorporating a plurality of exemplary beams;

[0029] FIGURE 20 is a bottom view of a pallet incorporating a plurality of exemplary beams;

[0030] FIGURE 21 is a bottom view of a pallet incorporating a plurality of exemplary beams;

[0031] FIGURE 22 is a cross sectional view of an exemplary tubular beam and connector;

[0032] FIGURE 23 is a cross sectional view of an exemplary tubular beam construction;

[0033] FIGURE 24 is a partial cross sectional view of an exemplary pallet column incorporating a foam therein;

[0034] FIGURE 25 is a partial cross sectional view of exemplary foam filled pallet deck and columns;

[0035] FIGURE 26 is a cross sectional view of an exemplary pallet I-beam including a foam; and

[0036] FIGURE 27 is a partial perspective view of an exemplary fire resistant pallet.

DETAILED DESCRIPTION

[0037] The presently disclosed thermoplastic pallet advantageously incorporates fire resistance, while retaining durability, low weight and low cost. Such fire resistance is gained
by virtue of one or more of the following aspects: a sprinkler friendly deck or frame; variable fire retardant or coating distributions; fire collapsible cross beams; foam filled or foam coated parts; and pallet design, including proportioning amounts of plastic and metal utilized in construction. Sprinkler friendly decks or frames are described with regard to FIGURES 1-8. Variable fire retardant or coating distributions are described with regard to FIGURES 9-14. Fire collapsible cross beams are described with regard to FIGURES 15-23. Foam filled or foam coated parts are described with regard to FIGURES 24-26.

[0038] Referring now to FIGURE 1, a semi-schematic elevation view illustrates pallets stored on a rack in a warehouse having sprinklers. Pallets 20C are illustrated as provided singly, stacked, and loaded with goods 24, wherein the pallets are stored on racks 22 which comprise opposing side columns 22L and 22R and horizontal rails 34 which are spaced apart to receive the opposing edges of the pallets. The ceiling 30 of the warehouse is fitted with a firewater plumbing system comprising pressurized water pipes 28 and sprinkler heads 26. For typical sprinkler heads, when the ceiling temperature rises above a predetermined design point, established by selection of a low melting point metal that restrains a spring-loaded water valve, the sprinkler heads open and discharge a volume of water W in the form of sprays 32. The spray water falls generally downwardly, to land on the stored pallets below. The aim is to cool the burning objects below the point of ignition, and to prevent non-burning objects from rising to such point.

[0039] Referring now to FIGURE 2, as illustrated by the partial vertical cross section of a pallet 20, the pallet deck 46 of an exemplary pallet 20 is corrugated for strength. Through-holes 40 receive water W within the valleys 45 of corrugations and pass water W to structures 44C below the pallet deck 46, thus cooling those structures below. The edge of a pallet 20 rests on the rail 34 of a rack 22L. It is to be understood that the term corrugation or corrugated should encompass any surface topography that includes at least one channel, groove, depression or valley along which water can be channeled or contained. Additionally, the base of the pallet includes any portions of the pallet below the top surface of the pallet, which top surface may include the deck and the top portions of the frame.
[0040] Referring now to FIGURE 3, exemplary pallet deck 46, which may comprise metal, metal alloy, plastic or other material, is attached to rectangular plastic frame 48 of pallet 20. The frame 48 is mounted on columns 42, 42C which run down to the base comprising outer rails 44 shaped as a rectangle and cross rails 44C which run to and from the midpoints of rails 44, crossing at center column 42C. Metal beams, not shown, or other reinforcing components may be provided within the rails and frame 48 for strength as in U.S. Patent No. 6,705,347, the disclosure of which is incorporated herein by reference. As in FIGURE 2, the exemplary pallet deck 46 has a multiplicity of corrugations for strength which comprise depressions or valleys 45.

[0041] With reference to FIGURES 2 and 3, through-holes 40 are located at the bottom of valleys 45 of the deck. The holes are selectively located over the rails 44C or whatever other structure comprises a lower portion of the pallet. There may be other holes which are not above rails or other bottom structure, for drainage. For instance, if there is a corrugation depression which does not lie above a rail, that corrugation could be fitted with a hole.

[0042] Thus, at least part of the water W which lands on the pallet during a fire, either from sprinklers, or from another pallet stacked above, flows through the specially-positioned holes 40, so the water lands on a thermoplastic rails 44C or other structure which comprise the base of the pallet, to suppress or prevent burning. Improved performance has been seen in the aforementioned Underwriter Laboratories tests. Should a pallet have a continuous bottom deck construction, then holes can likewise be placed in the bottom deck. The valleys 45 may be sloped slightly along their length, so water runs downwardly toward the holes 40.

[0043] With reference to FIGURE 4, another exemplary embodiment is illustrated at 20A. At least some of the corrugations of the deck are connected by connector channels 50, to help distribute the water amongst the different valleys 45. Such configuration tends to even water flow into holes 40, when the water falls unevenly on the surface of the deck. The connectors 50 may also be staggered from valley to valley, for best deck strength.
Referring now to FIGURE 5, part of an exemplary corner of a pallet is illustrated. In one exemplary embodiment, frame 48A, which supports deck 46, has through holes 52, which are configured to drop water on the outer rails 44 of the base. In another exemplary embodiment, the top surface of the outer part of the frame is sloped inwardly toward the center at slight angle Z. In such embodiment, water falling on outer portions of said deck supporting frame will tend to run to inner portions of said deck supporting frame. The top surface of the frame may also provide a gutter 60, so water will flow lengthwise along the frame, as suggested by the arrows. Water flows to the locations of holes 52 which are positioned above base rails 44, as they run between the columns. The water drops onto the base rail 44, and from there onto any pallet below. Thus water which lands on, or flows over typical frame surface portion 56, which is over the corner column 42 (not shown in Figure 5), is usefully directed onto the base or other lower portions of the pallet. In addition, peripheral connector channels 58 may be used to allow water in some of the valleys 45 to flow onto the top of the frame and into the gutter.

In other exemplary embodiments, the top surface of rails 44, 44C may be usefully shaped to help fire resistance. Referring now to FIGURE 6, rail 44A is provided with a slope, which directs water towards internal portions of the pallet or ensures that water will flow through lower portions of the pallet to goods or additional pallets below, rather than allowing water to possibly flow outward, as when the rail 44a is flat or fully crowned. Referring now to FIGURE 7, exemplary rail 44B has a surface which is concave or grooved, such that water flows through holes 62 provided in lower portions of rail 44B and onto goods or additional pallets below, rather than allowing water to possibly flow outward. Similarly, FIGURE 8 illustrates an exemplary rail 44E having a corrugated surface for the similar purpose. Such base portion surface contouring, which contouring selectively directs water, may similarly be applied to base portions provided underneath holes in said deck.

It should be noted that the perforations in the deck and other parts of the pallet need not be round. For example, slots, among other configurations, may be used. At any location, more than one hole may be placed. The holes may also be of various sizes. As should
be evident, the different features described can be combined with each other. Pallet materials may comprise plastics, metals, wood, and the like, as well as combinations of the foregoing.

[0047] Accordingly, the present disclosure provides, in part, a water flow control system for a pallet, which selectively directs water deposited on upper surfaces of a pallet by fire sprinkler systems to lower portions of the pallet that may gain additional fire resistance from exposure to such water.

[0048] Solid particulate fire retardants may also be included in the thermoplastic pallet compositions, for example Grafguard graphite intumescent material, aluminum trihydrate, magnesium hydroxide or antimony trioxide (often used with bromine compounds), among others. The solid fire retardants may be used in combination with other types of fire retardants, for instance, brominated hydrocarbons. It will be appreciated that the invention may be applied to the inclusion of other ingredients, solid particulate or not, in a pallet and to other articles.

[0049] The present invention also recognizes that addition of fire retardants in quantities sufficient to impart minimal to good fire resistance, which in one embodiment, and depending on the material, ranges from 10 to 30 weight percent retardant, correspondingly decreases the fracture toughness of that article. In the example of plastic pallets, the pallet becomes too prone to breakage, particularly around the edges of the pallet where the shanks of the tines of a forklift truck may impact the pallet. Accordingly, an improved article is described, wherein fire resistance of the article is selectively tailored with regard to the geometry and/or position of a component of the article.

[0050] Referring now to FIGURES 9-13, partial vertical cross sections of portions of exemplary thermoplastic pallets are illustrated. Referring to FIGURE 9, exemplary pallet 220 comprises a deck 222, which is welded to the columns 226 of base 224. In this exemplary embodiment, the deck includes a plurality of holes (the deck may take other configurations, e.g., solid or grid-like, among others). The columns 226, which have hollows at their top ends, are interconnected by rails 230. Hollow square cross section metal beams 228 are within the rails. In one exemplary embodiment, deck 222 of pallet 220 has a higher
concentration of retardant relative to the frame 224. As an example, HDPE deck has 10% intumescent composition, and the frame has 5%. (All concentrations are by weight unless otherwise indicated.)

[0051] Referring now to FIGURE 10, a portion of exemplary pallet 222A is illustrated, wherein beam 228 is covered by a floor plate 229. In an exemplary embodiment, the plate 229 is configured to incorporate of the beam 228 within the base and comprises no or low fire retardant relative to other portions of the pallet. In such embodiment, the beam 228 is strategically engineered to fail in the event of a fire. This is due to the lack of significant fire retardant in the plate 229. At an early stage in a fire, the beam 228 will be subjected to heat and will fail according to engineered design.

[0052] Referring now to FIGURE 11, an exemplary pallet 220B is illustrated, wherein such pallet lacks base rails. An exemplary deck is a two-layer composite structure, which may be made for example by co-extrusion, by joining one sheet to another, or by injection molding, among other methods. In one embodiment, the underside layer 227 comprises a first composition with a large amount of fire retardant relative to the top layer 225. Such exemplary configuration provides durability for the top of the deck, but at the same time provides fire protection to the pallet (oftentimes flames will rise up from below, and the lower deck layer provides a lower barrier relative to heat sources from above as well). Other layers may also be interposed between the top and bottom layers, for other properties or fire resistance. The layers may also be contoured to create cavities therebetween, and the cavities may be filled with foam, such as urethane.

[0053] Referring now to FIGURE 12, opposing edges of an exemplary pallet 220D is illustrated, wherein deck 222D has an inner portion comprising a first material having fire retardant (and thus diminished impact or other properties) and an integral edge portion 242 with less fire retardant and better impact properties. In another exemplary embodiment, the edge portion that has minimal or no fire retardant at least spans the openings that are between columns 226D, through which forks enter the space under the pallet for transport.
[0054] Referring not to FIGURE 13, a top view of exemplary pallet 220C is illustrated, wherein deck 222C has a central area 234 with higher retardant content than a periphery portion 232. The dashed boundary line 233 is one exemplary indication of where the composition changes. Depending on the manufacturing technique that is used, and the objective, the demarcation of composition change may be definite or gradual. While the periphery of the deck may be thin and thus should have fire retardant in accord with another teaching herein, the volume of plastic, which has the inferior fire retardant, is a small fraction of the total pallet. Thus, while burn test performance might be somewhat reduced the performance can still be acceptable, and the “give up” is well traded against durability and strength, in considering the total pallet design.

[0055] It is noted that rather than varying the pallet composition, a fire resistant or reflective coating may be applied to portions of the pallet. In another exemplary embodiment, part or all of the pallet surface is coated with a heat reflective material. Additionally, selected under-side exposed surfaces of the pallet may be coated with the heat reflective surface. In an exemplary embodiment, a thin layer of aluminum or other shiny metal is vapor deposited, using well know technology, on the selected surfaces of the plastic. Alternately, aluminum metal foil can be adhered to the surface of the plastic. Thus, the amount of thermal radiation received from adjacent pallets or other materials which may be burning is reduced. The time for the coated pallet portion to rise in temperature and ignite is increased, resulting in improved fire-resisting characteristic.

[0056] Referring now to FIGURE 14, a simplified cross section view of an exemplary mold for a pallet other dual property object is illustrated. The exemplary cavity parts 226CC, 232CC and 234CC are illustrated as corresponding to numeral parts of exemplary pallet 220C. The mold comprises two mating parts 236, 238. When installed in a molding machine, injection mold nozzles feed molten plastic through ports 254, 256. Two different material compositions, one with high retardant content, the other with low or no retardant content are provided by two different sets of nozzles, fed by appropriate injection extruders and supplies. The low content material is injected in the ports 254 while the high content material is injected in
the ports 256. In another exemplary manufacturing alternative, with reference to FIGURE 13, the deck parts 234, 232 may be separately fabricated and then joined together, as by welding.

[0057] The presently disclosed pallet recognizes that when there is a warehouse fire involving molded plastic pallets which are stacked one above another in a warehouse rack, the rate of heat output will be mitigated if the surface area of plastic pallet material which is exposed to flames is reduced. Thus, as described by exemplary embodiments herein, a pallet subjected to the heat of a fire desirably fails and falls from the rack. Such pallet may fall onto an underlying pallet and goods, or onto the floor. When multiple pallets sandwich together, the exposed surface area of burnable material will be reduced, and the access of oxygen bearing atmosphere is inhibited.

[0058] Referring now to FIGURE 15, a bottom side of an exemplary plastic pallet 120 is illustrated, wherein an array of beams is embedded in the bottom of the pallet. Without being limited, pallet 120 may be constructed in accord with the aforementioned commonly owned U.S. Pat. No. 6,705,237 to Moore et al., the disclosure of which is hereby incorporated by reference. The embedded beams are represented in this and other figures by dashed lines.

[0059] Referring still to FIGURE 15, the exemplary beam array comprises lengthwise beams 124 and cross beams 126. (Length and width are arbitrary in this disclosure, except that a pallet is considered to mount in a rack with its length parallel to the rails 130 of the rack.) In one embodiment, the beams are perforated steel box beams. In another exemplary embodiment, the beams run around the rectangular periphery of the pallet. In another exemplary embodiment, the beam ends are close to each other, but the beams are not structurally attached to each other.

[0060] Referring now to FIGURE 16, a detail of the top cross section view of an exemplary pallet corner is illustrated. The beams cross in the center of the pallet. The beams may be in the base and top frame of the pallet and are generally parallel to the plane of the pallet, that is to the plane of the goods-carrying deck 134 at the top of the pallet.
[0061] In one exemplary embodiment, the pallet has a metal deck. In such embodiment, beams are provided in the rails which comprise the base of the pallet. While the above describes exemplary metal reinforcing beams, beams made of other materials, for example composite plastic materials, such as graphite reinforced plastic, or some strong ceramic, may be used. The beam is, in general terms, a member, partially or fully surrounded by the thermoplastic of the pallet (though not necessarily embedded therein), having substantially different properties, in particular, higher elastic modulus and tensile strength.

[0062] Referring now to FIGURE 17, a vertical elevation end view of exemplary pallet 120 is illustrated as supported in a warehouse rack along its opposing lengthwise ends 136. The opposing sides 136 of the pallet rest on opposing side lips of L-shape cross section rails 130 of an exemplary pallet storage rack. Without being limiting, the distance between the inner edges of the racks, RL, is typically about 42 inches, to receive a typical pallet which is 48 inches wide.

[0063] Referring still to FIGURE 17, in another exemplary embodiment, the cross beams 126 have a length LB which is less than the spacing RL between the rails, and the beams are centered between the opposing lengthwise sides 136. Thus, there is a gap G between the vertical extension of the ends of the beams and the vertical extension of the inner edges of the lips of the pallet rack. As used herein, a beam which is shorter than the width between the rack edges is called a “short beam”. Of course, there is some clearance between the vertical sides of the rails of the rack and the outside edges of the pallet. Thus, in another exemplary embodiment, the lengths of beams 126 are sufficiently short to accommodate the resultant play or possible shifting from side to side of a pallet mounted in the rack. Thus, in all cases with regard to this exemplary embodiment, the end of a beam 126 will not be above the vertical extension of the innermost edge of the rail. In other exemplary embodiments, e.g., where one end may extend beyond said vertical extension, and the other does not, the length and/or position of the beams may chosen accordingly to anticipate shifting within the rack.

[0064] In accordance with the above exemplary embodiments, in the event of a fire, the plastic of the pallet softens and loses strength, and or burns away, and cross beam 126
will no longer be supported at one or both of its ends. As the plastic softens or disappears, the one end of the pallet will fall from the rail, and the pallet will collapse into the space between the rails.

[0065] Referring now to FIGURE 20, in another exemplary embodiment, at least one beam 26A is offset (although all beams may be) from one lengthwise edge so that one end of the beam is vertically above the rack rail, but the other end is not. In this exemplary embodiment, the cross beams may be short beams, or they may have lengths which are equal or greater than the space between the rail inner edges.

[0066] As illustrated in FIGURE 15, lengthwise beams 124 run generally parallel to the rails and generally transverse to the cross beams. Lengthwise beams 124 need not have the features of the cross beams. Of course, if the pallet is intended also for mounting in racks which hold the pallet cross-wise, then beams 124 may have the same features as are described for cross beams 126. In a pallet having the desired cross beam features described herein, beams 124 may be displaced inwardly relative to the edges of the rails of the rack, as for example, shown in FIGURE 18 and FIGURE 21. Because, in this exemplary embodiment, the lengthwise beams are not structurally attached to the cross beams, the engineered pallet works even when both lengthwise beams lie vertically above the rack rail when the pallet is stored.

[0067] Referring now to FIGURES 19-21, exemplary beam configurations are illustrated. FIGURE 19 illustrates an exemplary configuration wherein beams 126 overlie one cross rail 30, but not another.

[0068] FIGURE 20 illustrates an exemplary embodiment wherein cross beams 126 are staggered in their offset. Beams 126A are offset to the right, and beam 126B is offset to the left. So, in use two of the beam ends at one side of the pallet have a gap G3 relative to the rail 130L, while the other beam end has a gap G4 relative to rail 130R.

[0069] FIGURE 21 illustrates an exemplary embodiment wherein cross beams 126 are all offset to one side of the pallet. That is, the ends are farther from one side than from
the other side. Thus, in use all the beam ends will be farther from the rail 130L than from rail 130R. Lengthwise beams 124 are also incorporated into the pallet.

[0070] In certain exemplary embodiments, at least one cross beam incorporates the features described. If a pallet has a beam which fully spans the space between the opposing sides of the rack, when one or more of the other beams are configured as described above, in a fire, the pallet can be sufficiently weakened by the loss of support of the short or offset beams, such that it will tip around the one or more full length beams.

[0071] Referring now to FIGURE 22, another exemplary embodiment, incorporates a metal cross beam 126D made of two pieces joined by a press-fit thermoplastic connector 132. In another exemplary embodiment, the connector is offset from the center of the beam length, so it is not under a column. In such embodiment, there will be less mass of plastic to provide thermal inertia and inhibit heating and softening during a fire. The plastic of the connector may have the same or different properties, as compared to the plastic of the pallet. When there is a fire, the plastic of the connector 132 melts and fails, under the stresses imposed by the pallet weight and whatever load is on the pallet, and the pallet collapses. In this embodiment and the following two embodiments, the lengths of the cross beams may be short or of regular length.

[0072] As mentioned above, the beam need not be a metal material, but may comprise other materials. In another exemplary embodiment, a beam is made of composite plastic material, for instance a strong fiber reinforcement, which beam in incorporated into a less strong matrix or molding compound. The matrix is chosen so that it deteriorates when heated, so that the reinforcing material can no longer serve its purpose and the beam collapses. For example, the beam may comprise long strand glass fibers or graphite fibers contained in a thermoplastic matrix which may or may not be different from the thermoplastic material of the pallet. The matrix softens and yields when there is a fire. Thus, the fibers will be no longer firmly gripped, relative to one another. The beam then loses its structural modulus, its shape, and its load capacity, and it and the pallet collapse. As an example, the reinforcement may be
glass or graphite or metal fiber and the matrix may be high density polyethylene HDPE, polypropylene PP, polysulfone PSF, polyethersulfone PES, or analogous material

[0073] In another exemplary embodiment, the beam comprises lamellae, such as strips of sheet metal or strands of wire. For example, the cross section of FIGURE 23 shows tubular beam 126F, comprising shaped pieces of light metal angles 134, held together using a thermoplastic or other heat degradable adhesive, or an injected encapsulating layer, as suggested by the dashed line 136 in the Figure. In a fire, the adhesive fails and the beams fails. While softening is the likely intentional failure mode of the plastics and matrixes here, other modes of failure due to heating may ensue.

[0074] In certain exemplary embodiments, the beam is described as embedded in plastic. It should also be recognized that simply placing the beam near such plastic may be sufficient, as long as melting of the plastic causes the beam to fail or displace. For example, suitable arrangements include placing the beam in a slot, wherein the beam may be partially exposed. Particularly for those embodiments which used a composite structure beam, there may be openings or thinner sections in the plastic around the beam, to speed localized heating and weakening of the beam during a fire.

[0075] The principles of the invention may also be applied to other products where there is a static load or dynamic load on the product and the structure desirably loses its strength in event of a fire or other thermal excursion.

[0076] In another exemplary aspect, the presently described thermoplastic pallet includes a foam material, which material by composition and placement, impart fire-resistant to the thermoplastic pallet. By “fire-resistant”, as described herein, it is meant that the pallet has a desirable combination of properties, including ignition, burning rate, heat release rate, and retention of structural strength, as such are observed when the pallet is subjected to standard and non-standard fire test conditions. For example, the presently described thermoplastic pallet will generate energy at a lower rate than such pallet would otherwise generate.
[0077] A unique plastic pallet design comprising metal reinforcing bars and other special features, to provide efficient design, and to give strength to a pallet under normal and elevated temperature conditions is described in copending United States Patent Application Serial No. 10/729,615. The pallet comprises several structural polymer or metal elements that are assembled and then joined together. In an exemplary embodiment, the pallet structure is made of polypropylene (PP) or high density polyethylene (HDPE). The pallet may have metal pieces as strengthening beams and a corrugated aluminum deck. The assembly nature of pallet design makes it convenient to have portions with differing material properties.

[0078] However, it is noted that in tests, the polyolefin thermoplastics, and in particular common HDPE and PP have poor fire resisting properties. By their nature they lose rigidity and structural strength, and they melt and can form puddles of burning plastic, when subjected to fire. The metal deck helps in providing strength during burning, and the metal deck, compared to a plastic deck, reduces the rate of heat release.

[0079] When there are structural sections of plastic, they may be in cross sections which approximate the cross section shape of I, H, C, O, etc., as appropriate, rather than being made solid, in accord with good design to lighten weight and keep down the cost of polymer and the pallet. Thus, a monolithic polymer beam may be made in the above-described cross section shape. Lightening holes or analogous filigree structure may be used in selected areas, such as in the web of an I beam.

[0080] The pallet component shapes may be complex, but approximations of those various features are used. However, insofar as fire resistance is concerned, these approaches also have the undesirable effect of providing a greater surface area of the plastic member when it partially burns through, and that enhances the propensity for burning in an oxidizing environment. The present application provides a good solution to those undesirable effects by selective application of foam to these structural components.

[0081] Referring now to FIGURE 24, a vertical cross section through a plane, just off the center of an exemplary pallet is illustrated. As illustrated, the exemplary pallet 320 has a
base 36 comprising of cross rails having internal metal beams 326A, 326B, and columns 334 running up from the base (exemplary column 334 is illustrated as positioned at an outer edge 324 of pallet 320), which support a rectangular frame 338, having internal metal beam 326T. A corrugated metal deck 322 is mounted in the frame 338. It should be noted that exemplary components are shown in simplified and conceptual manner. The beams 326A, 326B, 326T are contained within solid plastic sections. In an exemplary embodiment, the structural components also include hollows. More particularly, the outer portion of the frame 338 and the columns (of which in one exemplary embodiment, there are eight around the periphery and one in the center) may be hollow. The hollows 330 of the columns are illustrated as partially or fully filled with foam, which in one embodiment may be a semi-rigid closed cell polyurethane foam. Depending on the nature of the hollows in the frame (with regard, e.g., to design for impact resistance, etc.), and manufacturing limitations, hollows 332 in the frame may or may not be filled with foam.

[0082] Referring now to FIGURE 25, another simplified and exemplary configuration of pallet 320A is illustrated, wherein the deck 322A and columns (or feet) 334 are comprise hollow structural plastic. A foam is provided within the hollow portions of the deck 322A and columns 334. It should be noted that filling the hollow portions of the pallet with semi-rigid foam may provide increase in bending or column strength (particularly with regard to the present embodiment). Also, a significant increase in impact strength may be achieved.

[0083] Any of the foam described herein may optionally include fire retardants (it being understood that the presently described structural components including foam are beneficial without flame retardants). That result can be attributable to the fact that when the foam is confined within the structural plastic which defines the portion of the pallet, the portion acts largely as it would if it were solid. The foam tends not to melt when burning to the extent that the structural plastic would. And of course, being largely void, it has less mass. Furthermore it is insulative. Second, if there is burn-through of the structural exterior, the fire spreads less slowly in the interior because the foam inhibits oxygen and heat from reaching the other interior surfaces of the structure. Thus, the rate of burning and heat evolution of a hollow structural element is thus inhibited by putting foam inside of a hollow article. The amount of
foam can also be varied along the length of a member, so that a controlled collapse of the pallet can be achieved, where it may be desirable to collapse part or all of a burning pallet to reduce exposed surface area and consequently reduce the amount of pallet burn.

[0084] In one exemplary embodiment of the invention, a hollow structure of HDPE or PE (for example the column 334 of FIGURE 24), having a wall thickness of 0.050 to 0.200 inch, is filled Class I polyurethane foam having a density of 2 to 4 lbs per cubic foot (for example, such as is supplied by BASF, Livonia, Michigan). The foam may completely or partially fill the hollow portions and/or may cover the exterior.

[0085] If a fire retarding additive is used in the foam, an exemplary material is Grafeguard intumescent graphite material. The fire retarding additive may be mixed into the the polymer material, e.g., polyurethane, which will comprise the foam before it is "shot" or injected into the hollow spaces. In one embodiment, the intumescent additive content is 5-20 weight percent. Analogously with amount of foam, the amount of fire retardant can be controlled according to the burning behavior which is sought. Other substances may also be incorporated into the foam, as desired.

[0086] The foam which is used will provide a thermoplastic section of the pallet with improved burn test heat release characteristic; and preferably improved impact strength. When a structural element is exposed to fire generally, or ignited at one end, the rate of burning is decreased compared to when foam is not used. Where there is foam, it is first of all insulative. Second, its character upon burning, that it remains substantially in place inhibits oxygen and heat from reaching the surface of the HDPE structural element. Thus, when there is a hollow element filled with foam, even though part of the skin burns away, say at the first end which is ignited, the flame will only progress according to the oxygen which reaches the element on its unprotected exterior, since the interior foam greatly inhibits such on the interior. Thus, the element, and the article as a whole, is found to burn more slowly, which means its rate of heat release is desirably less, in fulfillment of meeting the aims of the UL Standard. Likewise, a structure which heats and burns more slowly will retain its structural strength for a longer time. Other foam materials, and other porous materials, known in the art which behave as described
may be alternatively used in substitution of a thermoset foam or in combination with it. For example, ceramic or glass or expanded mineral foams may be used as fillers within a thermoset or other foam, or by themselves.

[0087] In another exemplary embodiment, a molded column 334 of a pallet, having exemplary dimensions of 8 X 5 X 6 inches, is filled with foam. The foam may be placed within the hollow sections by injection after the pallet is formed, including by use of the techniques where nubs or feet seal the holes of injection at the bottom of a pallet column.

[0088] Referring now to FIGURE 26, another exemplary embodiment illustrates a thermoplastic structural element comprising an I-beam section 330 that is partially or fully covered with foam 342. In one exemplary embodiment, the foam is a low density polyurethane foam (or other composition foam exhibiting comparable properties) adhered to the surface of the structural element. The foam on the exterior may be somewhat less effective than filled interior embodiments, and the foam may be susceptible to mechanical damage, but a significant benefit in burning characteristic is still realized. As noted above, foam may also be placed on the interior and exterior of a hollow member.

[0089] It should be apparent that to the extent inclusion of a fire retardant chemical is economic, does not significantly raise weight, and is otherwise acceptable, it may be included in the foam and will likely enhance performance of the foam.

[0090] Referring now to FIGURE 27, an exemplary combination of certain fire resistant features is illustrated. FIGURE 27 shows a 40 X 48 inch pallet 420, to illustrate the exemplary features of the invention. Pallet 420 has a rectangular base 422 and top 424. The base comprises peripheral rails 428 and cross rails 430. A multiplicity of integral columns 436 (e.g., nine) run upwardly from the base to support the top. There are steel beams 430 within the rails. The columns have hollows 434 which are filled with polyurethane thermoset foam. Top 424 is comprised of rectangular plastic frame 434, which has selectively placed hollows or voids 436, e.g. in the spans between the columns. Metal deck 432, preferably made of corrugated aluminum sheet with drain hole perforations, is supported by and attached to the frame.
[0091] The top cooperates with the structure of the base and columns, to provide requisite strength to the pallet. Since the top is in good fraction aluminum sheet which does not burn readily in a fire test, the amount of plastic in the pallet is reduced. The base has metal beams which are configured for controlled collapse in a fire. The columns have hollows as does the periphery of the frame has voids or hollows. Those and the metal beams, as well as the structural strength of the metal deck, cooperate to reduce the amount of structural plastic in the pallet without compromising structural performance. While thermoset foam burns, it burns at a lower rate than structural thermoplastic. Since the amount of plastic in the whole pallet is reduced, compared to a pallet without the metal parts and without any interior hollows or foam, the amount of heat release from a pallet during a test is reduced. Since the pallet is light, it reduces the amount of thermoplastic and or fire retardant in the pallet. Limiting the amount of fire retardant in a pallet helps keeps the weight within limits and helps costs.

[0092] The pallet of the present invention is by weight about 50-70 percent thermoplastic having flame retardant; and about 30-50 percent metal. In an exemplary polypropylene pallet, the total weight is about 55 pounds, the aluminum deck weighs about 6 lb (11-12%), and the steel reinforcing beams weigh about 12.5 lb (23-25%).

[0093] In burn tests, a comparable dimensioned and structural strength pallet, which metal beams, but which had neither the metal deck nor drain holes nor thermoset foam of the present invention, performed in a far inferior manner to the present invention, when the thermoplastic and fire retardant were the same. Thus, that demonstrates that for a comparable structural performance, the invention features just mentioned enable the plastic to have fire retardant. That enables better properties or less costly raw materials of additives.

[0094] While exemplary embodiments have been shown and described, various modifications and substitutions may be made thereto without departing from the spirit and scope of the invention. It is to be understood that the present invention has been described by way of illustration and not limitation.

[0095] What is claimed is:
CLAIMS

1. A fire resistant thermoplastic pallet; comprising:

   a pallet deck supported over a pallet base, wherein at least one of said deck and base
   comprise a thermoplastic material configured to be fire resistant by virtue of two or more of: fire
   sprinkler water holes provided therein, variable fire retardant or coating distributions, fire
   collapsible components, and foam filled or foam coated parts

2. A fire resistant thermoplastic pallet in accordance with claim 1, further comprising a
corrugated deck supported over a base, the deck having at least one hole in a valley of a
corrugation, wherein the flow area of said at least one hole is located over a part of the base of
the pallet.

3. A fire resistant thermoplastic pallet in accordance with claim 2, wherein when said
pallet rests on a level surface, said at least one hole is located in a lower region of said
corrugation, such that water landing in another portion of said corrugation will tend by gravity to
run towards the portion of said corrugation containing said hole.

4. A fire resistant thermoplastic pallet in accordance with claim 2, wherein a plurality of
corrugations are interconnected.

5. A fire resistant thermoplastic pallet in accordance with claim 4, wherein said plurality
of corrugations are interconnected via staggered channels.

6. A fire resistant thermoplastic pallet in accordance with claim 2, wherein when said
pallet rests on a level surface, an outer length of said deck supporting frame is either higher than
a hole in said deck supporting frame or higher than said deck, such that water will tend to flow
toward said hole or toward said deck from said outer length of said deck supporting frame rather
than flowing over the outer length of said deck supporting frame.
7. A fire resistant thermoplastic pallet in accordance with claim 6, wherein said deck supporting frame includes a plurality of holes, which holes are provided in portions of said deck supporting frame that are lower than an outer length of said deck supporting frame and lower than portions of said deck, such that water will tend to collect or flow between said plurality of holes in said deck supporting frame.

8. A fire resistant thermoplastic pallet in accordance with claim 1, comprising a plurality of thermoplastic portions, wherein at least two of said portions have differential fire resistance, by virtue of compositions or coatings, according to the position or geometry of said portions.

9. A fire resistant thermoplastic pallet in accordance with claim 8, wherein wherein at least one said portion is thinner or has a higher surface area to volume ratio relative to another of said portions.

10. A fire resistant thermoplastic pallet in accordance with claim 8, wherein a deck of the pallet has higher fire retardant content than columns upon which the deck is mounted.

11. A fire resistant thermoplastic pallet in accordance with claim 8, wherein part or all of the periphery of a deck has less retardant or no retardant, compared to the interior of the deck which has fire retardant.

12. A fire resistant thermoplastic pallet in accordance with claim 1, wherein the pallet is storable in a rack having opposing side rails, by resting opposing lengthwise edges of the pallet on the rails, the pallet comprising a plastic portion configured to span the distance between the rails of the rack, wherein at least one cross beam is secured on or within said plastic portion, the cross beam and plastic portion configured such that said cross beam and plastic portion will structurally fail upon exposure to heat from a fire.
13. A fire resistant thermoplastic pallet in accordance with claim 12, wherein said at least one cross beam has a length and location within the pallet, so that one end of the beam is configured such that it is inward from the lengthwise edge of the pallet and inward from the vertical extension of the inner edge of the rail of the storage rack, and wherein, when the plastic portion softens, the end of the beam will fall downwardly from the rack.

14. A fire resistant thermoplastic pallet in accordance with claim 12, wherein said at least one cross beam has a length and location within the pallet, so that both ends of the beam are configured such that they inward from the lengthwise edges of the pallet and inward from the vertical extension of the inner edges of the rail of the storage rack, and wherein, when the plastic portion softens, an end of the beam will fall downwardly from the rack.

15. A fire resistant thermoplastic pallet in accordance with claim 12, wherein said at least one cross beam includes at least one reinforcing material engineered to degrade when exposed to heat from a fire, such that the reinforcing beam will fail upon exposure to heat from a fire.

16. A fire resistant thermoplastic pallet in accordance with claim 1, comprising a thermoplastic structural pallet member including a foam thereon.

17. A fire resistant thermoplastic pallet in accordance with claim 16, wherein the thermoplastic structural pallet member comprises polypropylene or high density polyethylene.

18. A fire resistant thermoplastic pallet in accordance with claim 16, wherein the structural pallet member is hollow and at least partially filled with foam.

19. A fire resistant thermoplastic pallet in accordance with claim 18, wherein the structural pallet member is a pallet column.

20. A fire resistant thermoplastic pallet in accordance with claim 18, wherein the structural pallet member is a deck.
21. A fire resistant thermoplastic pallet in accordance with claim 16, wherein the amount of foam is varied between different parts of the structural pallet member.

22. A strong burn-resisting pallet, predominately composed of thermoplastic, for transporting goods, comprising:

   a base, made of thermoplastic, such as polyethylene or polypropylene, comprising rails between columns, the rails having reinforcing beams within;

   a multiplicity of columns running upwardly from the base; each of said multiplicity having a thermoplastic shell exterior, and filled with foam;

   a top, attached to the tops of the columns, comprising a circumscribing thermoplastic frame, mounted on the columns; and

   a metal deck, attached to and running across the interior opening of the frame; the deck having a plurality of through holes for water drainage, so the water drops onto plastic parts of the bottom of the pallet and onto any pallets mounted below.

23. A pallet in accordance with claim 22, wherein the plastic of the rails, columns and frame contain fire retardant.

24. A pallet in accordance with claim 22, wherein the pallet weighs no more than 55 pounds, wherein the thermoplastic material (including any additive such as fire retardant) is 70% of the weight or less.

25. A pallet in accordance with claim 22, having a corrugated and perforated aluminum sheet metal deck which weighs between about 5 and 7 pounds, and steel beams weighing between about 12 and 13 pounds.