ABSTRACT: A method and apparatus for forming multitransverse folds in limp sheets, preferably polyethylene bags, is disclosed. The method consists essentially of placing the sheet intermediate its ends opposite a pair of adjacent counterrotating rolls having their adjacent surfaces moving away from the sheet, and tucking the sheet into the rolls by applying jets of high velocity air against the sheet in the area opposite the rolls. The pair of rolls draw the sheet between themselves, folding it over itself at the point the sheet enters the space between the rolls. Similarly, a second transverse fold is made by positioning the folded sheet intermediate its folded and unfolded ends opposite a second pair of counterrotating rolls having adjacent surfaces moving away from the sheet, tucking the folded sheet into the second pair of rolls by applying jets of high velocity air against the sheet and drawing the sheet into the second pair of rolls, folding it over itself a second time. The twice-folded sheets are then counted and a predetermined number of sheets are stacked on top of each other before being removed. A machine for accomplishing the method of this invention comprises a frame a first nip roll mounted horizontally on the frame, a second nip roll mounted adjacent the first roll, a third nip roll mounted directly below the second nip roll, all three nip rolls being driven counterrotationally to each other by a motor and suitable gears. A first set of air nozzles are positioned on the frame above the space between the first and second nip rolls and is supplied with air in response to the presence of a sheet in position on the nip rolls. Similarly, a second set of air nozzles are mounted on the frame and directed towards the juxtaposed second and third nip rolls, and are supplied with air in response to the presence of the fold sheet opposite the rolls. Additionally a counter, program timer, counting conveyor, pivoted elevator and holding conveyor are mounted on the frame to count and stack the folded sheets.
FOLDING METHOD AND APPARATUS THEREFOR

BACKGROUND OF THE INVENTION

This invention relates to an improved method and apparatus for folding sheet material. More particularly, the invention relates to a method and apparatus for automatically applying multitransverse folds in limp sheet material such as flat polyethylene bags and for stacking and counting them.

Plastic bags have increasingly become an article of commerce due to their attractive appearance, general impermeability and their relatively low cost. Such bags may be made very cheaply; however, prior to this invention, it has been necessary to individually and manually fold and stack the folded bags prior to placing the stack in the package for shipment. The cost and expenditure of manual labor to accomplish the folding and stacking is therefore prohibitive in the context of the final sale price of the package containing the bags.

A principle obstacle to utilizing existing folding and stacking machines is the nature of the plastic bags themselves. They are made of very thin polyethylene film or sheet and easily punctured. Also they are extremely limp (or flexible) and of such a shape at all and are readily susceptible to crimping and wrinkling by machines employing existing folding methods. Our invention is therefore quite suitable for overcoming such problems in a novel and quite advantageous manner.

SUMMARY OF THE INVENTION

We have invented a method for efficiently, and automatically applying multitransverse folds to a limp sheet material, while counting and stacking the folded sheets preparatory to packaging. The method for folding the sheet comprises placing a sheet intermediate of its ends opposite a pair of adjacent horizontally mounted counterrotating rolls, forcing the sheet against the rolls, the rolls drawing the sheet between the downwardly moving surfaces of the counterrotating rolls thereby applying a transverse fold to the sheet, and moving the remainder of the sheet between the rolls for subsequent stacking or folding. For a second transverse fold the folded sheet is placed opposite a second pair of vertically mounted counterrotating rolls, a tucking force being applied to the folded sheet at a point opposite the second pair of rolls and the sheet is drawn between the second counterrotating pair of rolls folding the sheet a second time and moving the twice folded sheet through the rolls.

Apparatus for applying multitransverse folds to sheets according to this invention comprises a frame, a first nip roll horizontally mounted on the frame, a second nip roll horizontally mounted adjacent the first roll, drive means for applying counterrotating motion to the rolls and means for applying a tucking motion to a sheet opposite the rolls. The tucking means are nozzles supplied with high pressure air from a source which is responsive to the presence of the sheet in position opposite the rolls. Additionally a third nip roll is mounted below and adjacent to the second nip roll with a second set of nozzles and means for applying jets of air toward the space opposite the second and third nip rolls in response to the presence of the onced folded sheet. Also mounted on the frame are means for feeding the unfolded sheets to the nip rolls, means for removing the folded sheets from the nip rolls, and means for counting and stacking a predetermined number of folded sheets.

With reference to the method and apparatus according to this invention, the following description of the drawing and preferred embodiments is given.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of the folding and stacking machine as viewed from the feed end;

FIG. 2 is a schematic elevation of the operative mechanisms of the machine;

FIG. 3 is a schematic diagram of the sequential multifold method of this invention;

FIG. 4 is a schematic diagram of the single folding method of this invention;

FIG. 5 is a schematic diagram of the apparatus controls for counting and stacking, and

FIG. 6 is a graphic illustration of the time sequence of the stacking operations.

BRIEF DESCRIPTION OF THE PREFERRED EMBODIMENT

The operative mechanisms of the machine are mounted on a substantially rigid upright frame. The frame is formed from four legs connected by various longitudinal and transverse members. The major longitudinal members are a pair of upper and lower longitudinal members, and respectively which are parallel and connect at their ends respectively to the top and the midpoint of two of the legs on each side of the machine. The frame is joined transversely by a number of cross members. Extending out longitudinally from the two rearmost legs are two cantilevered extensions each welded to a rear leg midway between the levels of the upper and lower longitudinal members. An angled brace is connected at one end to each rear leg and the other end to the cantilevered extension provided stiffening for the extension.

A horizontal feed conveyor is mounted on top of the frame, extending from the top of the two rearmost legs to about the middle of the upper longitudinally members where a first folding station is located. The feed conveyor is constructed of a number of V-belts extending horizontally between an equal number of pulleys on an undriven feed pulley assembly rotating mounted on the frame at the feed end. At the other end of the conveyor, a driven pulley and nip roll assembly is rotated mounted in journals located on the inner side of each of the longitudinal upper members. The driven pulley and nip roll assembly has interspersed between each pulley a nip roll element of which is a rather wide metal disc covered at its outer edge with a rubberlike material and having a diameter slightly larger than the pulley and V-belt together so as to extend radially beyond the surface of the feed conveyor V-belts.

Mounted parallel to and somewhat below the first driven pulley and nip roll assembly at a distance equal to slightly more than the diameter of the nip rolls is a driven nip roll assembly in which a set (specifically 10) of the nip roll elements are similar in size and construction to the aforementioned elements is mounted. The nip roll elements are in the nip roll assembly are mounted on a shaft in equally spaced arrangement with spacers between the outer surfaces and are opposite the outside surface of the nip roll elements on the feed conveyor pulley and nip roll assembly. Both the feed conveyor pulley and nip roll assembly and the nip roll assembly have equal size and meshing spur gears and mounted near their right ends when viewed from the feed end of the machine. The spur gears are in obvious rotation counterclockwise to each other at the same rotational speed.

The feed conveyor pulley and nip roll assembly element and roll elements on the roll assembly therefore operate in unison as the first folding station.

The nip roll assembly is mounted slightly below the level of the first pulley and nip roll assembly in order to allow space for a curved guard plate. The curved guard plate is mounted above the nip roll assembly and bends down to prevent the sheets from contacting the nip roll elements on the assembly unless the sheet is tucked into the folding station between the rolls.

Directly below the nip roll assembly a second driven pulley and nip roll assembly is mounted having nip roll elements and pulleys in alternating sequence. The assembly has pulleys, nip roll elements, and a sprocket gear and arrangement of its elements is similar to those forming the feed conveyor pulley and nip roll assembly. At the other end of the sprocket second pulley and nip roll assembly opposite the spur gear, a sprocket gear is mounted and is driven by an endless
sprocket chain 58 connected to a sprocket drive gear 60, which is rotationally driven by a motor 62. Finally a driven pulley assembly 64 is similarly spaced apart to the other assemblies and at the same height as the first pulley and nip roll assembly 36 but on the other side of the nip roll assembly 42. The pulley assembly 64 has a similarly mounted spur gear 66 to the other adjacent assemblies and is in meshing relationship with the nip roll assembly spur gear 48, therefore rotating counter to the nip roll assembly 42. The pulley assembly 64 is a number of pulleys mounted on it separated by spacers, and operates to drive upwardly an inclined conveyor 68 moving away from the first folding station.

The inclined conveyor 68 is made up of a number of V-belts which are driven by the pulley assembly at its lower ends and are supported by another undriven pulley assembly 70. The undriven pulley assembly 70 is supported by journals 74 located in the upper ends of a pair of slotted inclined brackets 76. The inclined brackets 76 are attached to the upper longitudinal members 16 at their midpoint adjacent the first folding station and supported at their upper ends by upright stations 78 which are extensions of the rear legs.

Adjustably attached on the inside on the inclined bracket is a U-shaped holder 80. The holder 80 is secured to the inclined bracket by a threaded bolt and washer arrangement 82, the shank of the bolt extending through a slot 84 in the inclined bracket, is secured to the base of the holder. The U-shaped holder is therefore positioned on its side having a leg above the top of the inclined conveyor V-belt and another leg in the space between the upper and lower belt of the conveyor.

A photocell 86 is mounted on the lower leg of the holder with its sensitive face portion pointed upwardly through the space between two of the conveyor V-belts. The opposite end on the upper leg of the holder has a light source 88 attached to it with the light shining down through the space between the V-belts towards the photocell 86. Therefore any opaque matter entering on the inclined conveyor would when it reached the location of the holder, obstruct the light beam and trigger the photocell. The photocell 86 is connected through appropriate circuitry to actuate either one or two pneumatic servo valves depending on whether a double fold or a single fold is desired.

As shown in FIGS. 2, 3 and 5 the photocell 86 upon sensing the presence of the sheet on the inclined conveyor actuates a pneumatic servo valve 90 through control unit 92 thereby allowing high pressure air to pass to an air manifold 94 mounted above the first folding station. The manifold 94 has several air nozzles 96 directly attached to its bottom, the nozzles being directly downwardly toward the tops of the first pulley and nip roll assembly and the nip roll assembly. Air jets exhausting from the nozzles on a limp sheet material positioned on the conveyors above the first folding station blow the sheet into the area between the nip roll and the first pulley and nip roll assembly allowing the counterrotating nip rolls to grasp the intermediate portion of the limp sheet and draw it between the rolls causing the sheet to transversely fold over itself.

A vertical slotted bar 100 is attached at its ends the nearmost upper and lower longitudinal member. The bar 100 is located in the line below the first folding station and has adjustably attached to it by a bolt 102 and a second U-shaped holder 204 mounted with its legs in a horizontal plane. Attached to the left end is a photocell 106 similar to the one hereinafter described. A light source 108 mounted on the other end is secured to the back of the photocell. In operation as the first folded sheets pass through the first folding station the leading edge of the sheet moves between the second photocell and its light beam breaking the beam, and triggering the photocell 106. The photocell in turn activates its control unit shown as element 110 to operate pneumatic servo valve 112 causing high pressure air from a source not shown to be supplied to a second air manifold 114 attached to the frame beneath the first folding station. A number of air nozzles 116, are attached to the manifold and have their opening directed toward the area adjacent the second nip roll and third nip roll and pulley assemblies constituting the second folding station. When the folded leading edge of the sheet obstructs the light beam to the second photocell, the air supply to the second set of nozzles is activated and directs jets of air against the side of the sheet causing or that rather tucking it into the second and third nip rolls. The counterrotating nip rolls in turn draw the sheet between them, transversely folding it over a second time. Teeth 119 mounted between the nip roll elements 44 of the nip roll assembly prevent the twice folded sheet from being carried around the nip roll assembly.

The third nip roll and pulley assembly acts as a drive for a horizontal counting conveyor 120. The conveyor is supported at the other end by a pulley assembly 122 mounted in journals on the inside of the rearmost legs. Folded sheets therefore are drawn between the second and third nip rollers onto the moving and counting conveyor and fall off the end of the conveyor onto stacking elevator 130, the operation of which will be elaborated on.

Prior to reaching the elevator 130 the sheets move past a third photocell 132. The photocell 132 is mounted on a bracket 134 above the counting conveyor 120 with a light source 136, shown mounted below the conveyor, directing a beam between two of the conveyor belts. The folded sheet obstructs the right beam as it passes through the photocell. The photocell via its control unit 138 actuates an electromechanical counter 140. The counter 140 may be preset to any desired number, after which it electrically actuates a program timer 142. The program timer 142 is a conventional device driven by a constant speed motor and having a number of switches which are actuated by cams. The cams driven by the motor automatically actuate the switches relative to each other during a single cycle. FIG. 6 is illustrative of the stacking cycle of the timer in controlling the various elements of the apparatus of this machine concerned with stacking the folded sheets, and shows the actuators in extended condition.

The elevator 130 is a flat plate pivotally mounted at the end furthest away from the counting conveyor. The pivoted end of the elevator 130 is connected to a lever arm 146 in which turn is connected to a rod 148 of a dual acting pneumatic actuator 150. The actuator 150 is powered by high pressure air directed to wither side of the actuator piston from a pneumatic servo valve 152 which itself is controlled by one of the switches in the control timer. The specific cycle of the elevator is shown in FIG. 6 wherein the elevator is pivoted to a horizontal position from its inclined position for approximately one-fourth of the cycle. During the time the elevator is in the horizontal position the stacked folded sheets are pushed onto a moving holding conveyor 154. This conveyor similar in size and appearance to those described hereinafter is constructed of a number of V-belts mounted on two sets of pulley assemblies 156 and 188, respectively. The shaft and pulley assembly 156 nearest the elevator, has a large sprocket wheel 160 attached to its end, which extends through the nearmost cantilevered extension. The large sprocket wheel is connected by an endless sprocket cam 164 to another smaller sprocket wheel 166 similarly mounted on the withdrawal end of the counting conveyor, thereby driving the stacking conveyor 154 at a reduced speed of the other conveyors all of which has similar linear speeds.

Mounted on an inverted U-shaped bracket 168 on the cantilevered extensions above the elevator pivot are a pair of dual acting axial pneumatic actuators 170 each controlling a piece stop 172, extending downward when in extended position to slightly below the elevator when in the extended position. The stops act as piece retainers on the elevator when in extended position. Their position is controlled by a servo valve 174 actuated by the control timer to feed high pressure air to the appropriate end of the actuator as depicted by the cycle illustrated in FIG. 6. As shown the stops 172 are extended downward during most of the cycle except for the period shown from just after the elevator has moved to the horizontal position and for a fraction of a second after the elevator
returns to the inclined stacking position to allow time for the stack to clear the stops.

A pusher is mounted below the elevators and consists of a pair of dual acting pneumatic pusher fingers actuators 178 vertically mounted and attached to a drive rod 180 of a horizontally mounted dual acting pneumatic pusher actuator 182. Each of the pair of push rod actuators 178 has a movable pusher finger 184 extending upwardly and positioned to pass through one of the two longitudinal slots 173 in the elevator. The rod actuators are connected via two air lines to a servo valve 185 actuated by the program timer which causes the fingers to be in retracted position during the portion of the cycle, in which the pusher returns to its original position nearest the counting conveyor. This prevents the pusher fingers from interfering with folded sheets coming off the counting conveyor.

Another set of vertically mounted dual acting pneumatic actuators 186 are located below the holding conveyor 154 in transverse positions each of them have a stack stop 188 positioned to extend upwardly through the spaces between the conveyor V-belts. The stack stops 188 while in extended position stop the movement of the stack of folded sheets on the holding conveyor 154, aid in squaring the stack and hold the stack for a limited time in a fixed position so that the operator can remove the stack from the conveyor and place the stack in a container. Each of the stack stops 188 are powered by one of the pair of actuators 186 which in turn are controlled by a servo valve 190 for supplying high pressure air to the appropriate end of the actuators. The servo valve 190 is controlled by the program timer so as to work in conjunction with the other operations of the stacking cycle.

A fold selector switch 192 is mounted in the electrical control lines from the first and second photocell to the respective air nozzles control servo valves 90 and 112. The switch is in one position allows the photocells to each control one of the servo valves feeding air to the nozzles and such a position is used when two transverse folds are desired. By placing the selector switch in the second position, the second photocell 106 is disconnected from its servo valve 112 which is now connected to the first photocell control unit 92 to operate in union with the other valve 90 and thereby supply air to both sets of tucking nozzles in unison. This mode of operation results in the smallest of folds, as illustrated in FIG. 4 of the drawings the first fold is accomplished as previously described. However, after the folded end of the sheet passes through the first folding station it is blown into the space between the second and third rolls constituting the second folding station and drawn between the rolls without a second fold.

In operation flat bags of polyethylene are placed on the feed conveyor and are carried over the first folding station and onto the inclined conveyor. The photocell mounted adjacent the inclined conveyor detects the leading edge of the sheet and activates the first servo valve 90 causing jets of air from nozzles 96 to impinge on the top of the sheet opposite the rolls, blowing the sheet at the point to be folded against the first set of nip rolls at the folding station. The first set of rolls draw in the sheet folding it over itself, and feed the sheet vertically downward with the folded edge not forming the leading edge. The folded edge passes between the first folding station and the second set of air jets till it reaches the second photocell 106. Breaking of the light beam by the passage of the folded edge initiated activation of the second set of air nozzles 116. The force of the high velocity jets of air from the second set of nozzles at the second folding station in turn forces the sheet against the nip rolls, in turn drawing the sheets between them and folding the sheet transversely over itself again.

Passing through the second folding station the twice-folded sheet is moved on the counting conveyor past the third photocell and moves off the counting conveyor belt onto the elevator 130 where it falls either on top of the preceding folded bag or on the upwardly inclined elevator. The third photocell upon being activated by the presence of the twice folded sheet trips an automatic counter remotely. The counter is set to activate the sequence controlled by the program timer after a preset number of folded bags have passed the third photocell, in turn dropping the elevator, and pushing the stack of folded bags off the elevator and onto the stacking conveyor. The stack stops 188 hold the stack on the holding conveyor and tend to square the stack until the operator manually removes the stack from the conveyor.

Alternatively, it is desired to make only one transverse fold in the bag, selector switch 192 is thrown causing both the first and second set of air nozzles to operate in unison. That is when the leading edge of the plastic bag reaches the first photocell the first and second sets of air nozzles are supplied with air and immediately after the folded leading edge of the bag passes out of the first folding station, it is forced against the second set of nip rolls passing between them without being folded and following the same sequence as described below above.

Having fully described the method and apparatus of out invention and wishing to cover those modifications and variations which would be apparent to those skilled in the art without departing from the spirit or scope of the invention, we claim:

1. Apparatus for folding limp plastic sheets, said apparatus comprising:
   a. a frame,
   b. a first nip roll rotatably mounted on a horizontal axis on said frame,
   c. a second nip roll rotatably mounted adjacent said first roll and having an axis parallel to and slightly above said first roll,
   d. a third nip roll rotatably mounted adjacent and directly below said first roll on said frame,
   e. drive means connected to said first, second and third nip rolls for rotatably driving said first and second rolls counterclockwise to each other, and said first and third rolls counterclockwise to each other,
   f. conveyor feed means mounted on said frame adjacent said second roll for feeding sheets transversely onto said second roll,
   g. conveyor sheet positioning means mounted on said frame adjacent said first roll for moving the leading edge and a portion of said sheets over said first and second rolls,
   h. guard means mounted above said first roll, said guard means guiding said sheets from said conveyor feed means onto said conveyor sheet positioning means,
   i. a first sheet sensing means mounted on said frame in spaced relation to said conveyor sheet positioning means for sensing the presence of a sheet on said positioning conveyor,
   j. a first air jet tucking means mounted on said frame above said first and second nip rolls and directing a jet of air towards said first and second rolls for tucking sheets between said counter rotating first and second rolls, said air jet being applied responsive to said first sheet sensing means whereby a sheet is first folded intermediate its ends by said first air jet forcing said sheet between said first and second nip rolls,
   k. a second sheet sensing means mounted on said frame below said third roll for sensing the presence of a folded sheet in position for a second fold opposite said third rolls,
   l. a second air jet tucking means mounted on said frame in spaced relation to said first and third roll for directing an air jet towards said first and third rolls said air jet being applied responsive to said second sheet sensing means.

2. Apparatus according to claim 1 which additionally comprises:
   a. means for counting each of said folded sheets, and
   b. means for stacking a predetermined number of folded sheets upon each other.

3. The apparatus of claim 1 wherein said first and second sensing means adjutably mounted on said frame thereby providing means for varying the position of the folds in said sheets.
4. The apparatus of claim 3 wherein said first and second sensing means are each a photocell mounted in spaced relationship to a light source, each light source being adjustably mounted in said frame, the positioning of a sheet in proper position for folding obstructing the appropriate light source beam.

5. The apparatus of claim 4 wherein said conveyor sheet positioning means is mounted at an acute angle with the horizontal from said first roll, thereby being inclined upwards from said first roll.

6. Apparatus for folding limp plastic sheets comprising:
   a frame,
   a first nip roll rotatably mounted on a horizontal axis on said frame, a second nip roll rotatably mounted on said adjacent said first nip roll, and having an axis parallel to and above said first roll,
   a feed conveyor mounted on said frame said feed conveyor moving in a direction towards and transverse to the axis of said second roll, said second roll serving as a pulley for said feed conveyor,
   an inclined sheet positioning conveyor mounted on said frame adjacent said first roll and moving in a direction away from said first roll and transverse to the axis of said first roll,
   a guard plate mounted on, said frame above said first roll, said guard plate guiding the sheets from said feed conveyor onto said positioning conveyor,

   a third roll rotatably mounted on said frame directly below and parallel to said first roll,
   drive means connected to said first, second and third nip rolls for rotatably driving said first and second rolls counter rotatilly to each other and said first and third rolls counter rotatingly to each other,
   a first sheet sensor mounted on said frame in spaced relationship to said positioning conveyor in position to sense the presence of the sheet at the proper position for tucking,
   a first air jet blower mounted on said frame above the intersection of said first and second roll and applying a jet toward said intersection in response to said first sensor sensing the presence of a sheet in proper position for folding,
   a second sheet sensor mounted on said frame below said first and third rolls for sensing the presence of a first folded sheet in position for a second tucking operation,
   a second air jet blower mounted on said frame opposite the intersection of said first and third rolls and applying a jet of air toward said first and third roll intersection in response to said second sensor, sensing the presence of a sheet in proper position for folding.

7. The apparatus of claim 6 wherein said first and second sensors are adjustably mounted on said frame so as to be able to accommodate various size sheets.