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Textile yarn logistics

9.1 Introduction

The term logistics is here interpreted to encompass the areas of yarn handling, packaging, transport, both internal and external, and storage. The systems employed will to a certain extent depend upon the specific fibre, the type of package wound and the internal layout of the manufacturing environment, nylon yarns in particular requiring special storage and handling systems.

The aim of logistics within a manufacturing environment must be to maintain the security of the product all the way through the manufacturing process and to ensure that when the yarn eventually reaches the customer it is both in optimum condition and well presented. Within this brief both the maintenance of a safe working environment (wherever mobile equipment is used there is the potential for accidents to occur) and the achievement of economic cost, i.e. material flow, have to be considered. This starts from the time the POY is first loaded into the texturing machine creel and does not end until the customer unloads the product and takes responsibility for it.

9.1.1 Product identification

Any logistical system designed for the transport of yarn packages, either internally or for final shipment, will fall flat if the identification system fails. Every single package of yarn must have a unique identification that not only defines it as belonging to one specific product type, but also gives its time and place of production. In a manufacturing environment with many different products having combinations of denier, lustre, fibre cross-section and types of intermingling, this is essential in order to prevent the consequences of possible yarn mixes. This applies not only to the textured yarn but also, equally as important, to the POY feedstock used.

Thus identification can be sub-defined as:

1 product type;
2 package within product type

9.1.1.1 Product type

The primary method of defining the type of yarn wound on a package is normally by using a combination of unique code number and a tube whose colour is also unique to that product. However, other methods are also available such as the use of various colours of fugitive tints or stamping the yarn itself with a unique code number (also in fugitive tint) which equally well defines the product. The tube itself may also be stamped with a code which is unique to that product. Regardless of what method is chosen, the two most important factors are that the form of identification should always be both highly visible and unique to that product.

9.1.1.2 Package within product type

The identification of the individual package is important in order to allow the exact time, date and place of production to be determined should any problem arise with yarn from that package, either during subsequent in-house testing or at the customer. This identification would normally encompass the machine on which the package was produced, the position of the machine on which it was produced and the time and date it was produced. This would usually be encapsulated in a simple label and fixed to the inside of the tube as it is doffed from the machine. Bar coding is now a viable option to replace conventional printed labels.

It is important that package dye yarns are treated somewhat differently regarding identification, since a sticky label would dislodge from the tube during dyeing and could cause severe problems in the dye vessel. For this reason it is normal practice either to remove the package identification (ID) before shipping or to use water-soluble labels when shipping package dye products.

9.2 Handling

9.2.1 POY handling

Dependent upon the situation in the texturing plant, POY may arrive in a wide range of packaging from outside suppliers (external supply). However, if the texturing plant is adjacent to an extrusion plant (internal supply) then a different situation applies. No matter from where the POY originates the aim must be to maintain it in first-class condition until

Table 9.1 Typical POY tube sizes

Internal diameter (mm)	Outside diameter (mm)	Tube length (mm)
75.2	85.7	185
75.2	85.7	285
75.2	85.7	300
109.7	126	200

such time as it is transferred from its container and loaded into the texturing machine creel. When loading it into the creel, there must neither be disturbance to the wind nor any mechanical damage. The POY should be stored in conditions of temperature and humidity that are experienced in the manufacturing area (see Section 4.6.1). This is especially important in the case of nylon yarns, which are very sensitive to changes in humidity.

There are a wide variety of POY package sizes, dependent upon the equipment being employed in the extrusion plant. The overall dimensions of the POY package will have obvious implications for the design of any material-handling equipment. They range from peg spacing on storage trolleys to the diameter of a claw designed to fit the internal diameter of the tube. Some typical POY tube sizes are shown in Table 9.1.

It should be noted that these sizes are nominal and there will be a small manufacturing tolerance allowed on all dimensions. Other POY tube sizes exist; the ones quoted above are only a small selection of those available.

Automated systems are available for handling POY, which are usually custom-designed to suit that particular manufacturer's mode of operation. These can be sophisticated or simple as expenditure will allow. A comprehensive system, for internal supply, would start with automatic doffing of the POY package in the extrusion plant and range through to cassette loading of the texturing machine creel – in effect, a 'no touch' system from the time the POY package is doffed in the extrusion plant until the transfer tail is dressed and spliced in the texturing creel. This of course is the ideal system, which avoids the chance of accidental mechanical damage to the POY package. However, the cost of such a system may well be prohibitive. Therefore most manufacturers will use either a wholly manual system or a semi-automated system.

In situations where a wholly manual system is employed it is essential that all operatives involved in the handling of POY packages are given training in the correct method of lifting and handling them. This is necessary not only to help prevent damage to the POY itself but, equally important, to ensure that the operators incur no repetitive strain injuries. POY packages are heavy, often in the region of 12–20 kg weight. In some cases POY packages substantially heavier than these can be produced. These very heavy package weights require specialised handling equipment to prevent injuries to operators.

For handling of the POY in the texturing environment, there should be provided at the least some sort of manual assist that can fit inside the core of the POY tube, that will enable it to be lifted by the operative onto the texturing machine creel. With such an assist, it should be possible to load the package without the yarn being touched and sustaining any disturbance to the package wind. Such devices can range from a simple, hand-held claw which fits inside the tube core to overhead hoists mounted adjacent to the machine creel. Mobile devices that have provision to carry a palletised container for the POY and which also incorporate some form of mechanical lift are available.

9.2.2 Textured yarn handling

With the advent of texturing machines with automatic doffing the handling of textured yarn packages has been revolutionised. Prior to the arrival of these machines, all packages had to be removed from the machine by hand and placed upon a suitable trolley, or palletised at the machine. As can be appreciated, this resulted in an increased risk of incurring dirt marks on the yarn itself, or the possibility of either the yarn or the tube sustaining some form of mechanical damage.

9.2.2.1 Manual doffing

Manual doffing of texturing machines can be accomplished in a variety of ways, largely determined by the speed of the process and the denier of the textured product. It is possible for a trained operator to hand doff a machine with the assistance of the machine aspiration system, if both the yarn speed and the denier do not exceed a value of 700 in either case. At speeds greater than this it is usual for a simple suction gun to be employed either with its own mobile vacuum system or which simply plugs into the machine aspiration system. If the yarn denier is greater than 700 it becomes impossible for the operator to break the running thread by hand and scissors are normally used. Whatever method is employed the next step in the process is the removal of the yarn package from the machine. It is usually placed upon a trolley and the running thread is entrained on an empty tube.

In the case where a low-density dye pack on a compressible tube is being doffed and placed on a trolley, it should be handled with care. Harsh handling may cause the body of yarn on the package to move thus making that package an automatic downgrade after examination even prior to any subsequent testing.

It is essential at this stage that the package of yarn is labelled in a unique manner immediately after removal from the machine for subsequent identification during testing or subsequent processing.

The trolley on which the textured yarn package yarn is placed may come in a variety of designs. Whatever the design, it must have the following features:

1 peg spacing large enough to accommodate the textured yarn packages with no chance of adjacent packages hitting or rubbing against each other;
2 not be so large that the weight of the trolley plus yarn packages becomes too heavy to be pushed by the operator without chance of injury;
3 be narrow enough to fit within the machine-operating aisle;
4 have a wheelbase that gives stability to the trolley and also a low centre of gravity to prevent it from toppling over;
5 have some provision for identification of the product that is stored on the trolley;
6 possibly have some linking mechanism so that trolleys can be linked together for towing by a small, motorised tractor unit.

As with POY, texturing tubes come in a variety of sizes dependent upon the design of the machine and these dimensions must be taken into account when considering any transport system for moving textured yarn around the plant. Some examples are shown in Table 9.2.

As with POY tubes there will be a small manufacturing tolerance allowed on these dimensions.

Table 9.2 Typical texturing tube sizes

Internal diameter (mm)	Outside diameter (mm)	Length (mm)
57.0	64.5	230.0
57.0	64.5	265.0
42.0	49.7	265.0
73.0	79.2	238.0
73.0	79.2	290.0
57.2/68.3*	74.7	290.0
58.0/69.0*	74.5	289.0

* Indicates tubes of bull-nose design, which have different internal diameters at each end of the tube. These tubes offer the customer improved off-winding compared to straight-cut tubes.

9.2.2.2 Automatic doffing

Automatic doffing of texturing machines is a comparatively recent innovation. Apart from the obvious implication for labour, and hence cost saving, it also has major benefits in improved handling of the textured yarn package. Automatic doffing lends itself to automatic package retrieval either by machine-dedicated robots or remote-roving robots. The type of robotic system employed will be determined by the design of the machine itself. Is the machine inboard doffing or outboard doffing? An inboard doffing machine doffs the full-sized, textured yarn package inwards into the operator aisle, i.e. towards the centre line of the machine. An outboard doffing machine doffs the full-size package toward the back of the machine, i.e. towards the POY creel. As can be appreciated, space restrictions with an inboard doffing system lean this system towards a machine-dedicated, robotic system, whereas outboard doffing gives more freedom regarding space requirements so that in this case either machine-dedicated or remote robotic systems can be considered. Both systems have their own advantages and the choice of which one is employed will take into consideration both plant layout and economics. As will readily be appreciated any robotic system can greatly reduce the incidence of dirty packages of textured yarn and can significantly reduce occurrences of yarn damage by poor handling techniques.

With all robotic systems, it is imperative that the textured yarn package is identified before leaving the texturing machine. Regardless of whether the package has been doffed by robot or not, the next step in the process is as described above in that the yarn will normally be placed upon a trolley for transport to a storage area before being released for packing. Should this be the case then the statements made in Section 9.2.2.1 above hold.

If package collection is made by remote robots, there exists the possibility of using the robot to transport the packages to a packing area which itself may be automated. This will be discussed in Section 9.4 below. It is important to note that if the textured yarn packages are transported automatically to the packing area, the texturing machine should be equipped with some form of on-line monitoring. By this means the quality can be determined and logged for each package on the machine prior to its removal by the robot.

9.3 Internal transport systems

The transportation of yarn packages within the manufacturing environment can be accomplished in a variety of ways. No matter what type of system is used, there are two overriding considerations. These are:

1 the systems should be designed to be safe and prevent as far as possible accident or injury to those working in the plant;
2 they should be designed to protect the product from damage.

Obviously, when considering how yarn is to be transported around a manufacturing plant, economic considerations must be taken into account as well as the factors mentioned above. Transport systems can be as simple or complex as desired ranging from simple, hand-pushed trolleys to fully automated systems either suspended from overhead rails or using wire-guided robots.

Simple systems may consist only of hand-pulled trolleys and hand-operated pallet trucks to move either textured yarn or POY around the plant. Of course this could be taken a stage further and be motorised. Electrical power is preferred, provided by rechargeable batteries to reduce the element of pollution from either diesel or propane-powered vehicles. A more complex machine-dedicated or remote robotic system offers the potential of long-term cost savings owing to reduced manning requirements. It also has benefits in reducing the incidences of mishandled packages.

When designing any logistical system, the physical layout of the plant is important. Any mobile equipment employed must be capable of negotiating aisle ways, doorways and any corners that are encountered. This may seem obvious but could be the source of some embarrassment!

9.4 Packing line

The overall design of the packing line has to be considered from the standpoint of achieving a swift and economic flow of material such that the minimum of floor space is occupied and there is a quick turnaround of storage trolleys. To this end it is preferable that several packing stations are joined to one conveyor line and that all cartons are then delivered to a central location for weighing and palletising.

Each packing station should have room for at least two storage trolleys, the yarn is being unloaded from one for inspection and packing and a second to hold any packages of yarn rejected by the inspector. There should be an adequate supply of plastic bags, empty cartons and labels available at each packing station. It is also advisable to have each packing station equipped with a top pan balance, capable of weighing up to 10 kg, and size-gauging equipment, so that each package can be checked for correct weight and size range if applicable to that product. Consideration should be given to the installation of a second conveyor system to deliver empty cartons to each packing station.

Automatic packing is now a feasible and cost-effective option. Packages of yarn can be delivered to a conveyor line by remote robots and the robot itself can place these packages on to suitable dollies for transporting along the line. The only operation that requires manual input is the final checking of the package by a trained inspector, and even this can be semi-automated by having the package of yarn automatically rotated in front of a seated inspector. Subsequent operations such as bagging the package and placing it into a carton and finally weighing and labelling the cartons can all be easily accomplished by robotic means. Such systems would usually be custom-designed to meet the requirements of the manufacturing plant.

These systems are obviously expensive to install but can be justified by the long-term cost savings provided by reduced labour requirements. They should therefore be given serious consideration.

9.5 Yarn packaging

Packing yarn for shipment is a process that requires some thought if it is to be accomplished in the most economic manner. All transport is expensive and every effort should be made to maximise the weight of yarn shipped per load in order to keep the transport cost per kilogram of yarn as low as possible. Consequently it follows that the design of any cartons or pallet packs are such that they maximise the available space for packages of yarn. Most modern cartons or pallet packs within mainland Europe are designed either to fit the format of the so-called ‘Europallet’, which is 750 mm wide × 1120 mm long, or to be multiples of this size. These are designed to maximise the space available within a 12 m container. Obviously these dimensions will differ in other regions, particularly within the United States.

After visual inspection by a trained inspector, the package is usually placed in a plastic bag and then into a cardboard carton. For some end uses, notably package dye yarns, the actual yarn package may be shrink-wrapped in perforated film so as to minimise disturbance to the wind of the package during the dyeing process.

The cartons may be constructed to take various numbers of packages and may be sized to take six or 12 full-size packages, i.e. two layers of six packages, though the number actually placed in each box will differ according to the finished package size. Some fabric manufacturers’ equipment may dictate that they cannot accommodate full-size packages. The cartons are transported either by hand or by conveyer line to a staging area where they are stacked onto pallets and bound in some way to prevent cartons toppling over during subsequent transport.

In instances where customers have their own in-house systems that can accommodate larger palletised deliveries, there is a trend toward the use of bulk packs which can accommodate far more packages than the 12 mentioned above. Where it is possible to use such systems, this should be pursued to take advantage of the obvious cost savings involved. Not only are there savings to be gained in the cost of raw material, i.e. fewer cartons used per kilogram of yarn, but they also allow the use of more substantial types of packaging such as polypropylene mouldings. These can be used over and over again so further reducing the overall packaging costs. In all other respects, such as the labelling and weighing of these larger bulk packs, the same rules apply as for normal palletised consignments.

It is of vital importance that all cartons are labelled in a manner that immediately informs the consumer of the contents of that carton (see Section 5.2). Though the format of the label will obviously differ from location to location, it should contain at least the following information:

1. product description indicating ply, denier, filament count, lustre, twist direction and cross-section;
2. quality code or description;
3. date and time of packing;*
4. gross weight;
5. net weight;
6. some form of identification of the person who packed the carton.

As a matter of course, to enable accurate accounting, the exact weight of yarn must be accurately recorded for all qualities including those which arise from downgrading. It is usual for the boxed yarn to be weighed prior to despatch. Therefore it is essential to engage a reputable supplier of packaging materials so that the net weight of the packaging does not vary from batch-to-batch outside of the agreed limits. When placed on a pallet for shipment, it is prudent to secure the cartons to the pallet itself either by suitable strapping or by shrink-wrapping the whole assembly.

9.6 Warehousing

The final stage of the process is to store the palletised yarn in a warehouse prior to despatch. A properly organised and maintained warehouse requires sufficient rack space in which to store all the yarn. A series of unique racking positions needs to be allocated in which yarn belonging to each product category can be stored.

Aisle ways between the racks must be wide enough to enable access for stacking trucks and for reasons of operator safety all stacking trucks should be fitted with either audible or visual warning devices. Also ease of access to loading bays should be of paramount importance to facilitate the quick turnaround of transport.

* The date and time of packing are especially important in the case of nylon yarns, which are age sensitive and should be used in date order.

Yarn is stored usually until such time as either the customer calls off a delivery or sufficient yarn is available to make up a full load to meet a much larger on-going order. This is why having a precise record of where each pallet of yarn is stored is important so that a load can be assembled quickly and economically.

In the case of nylon yarns the recording of where each pallet is stored must be accompanied by a date code. Owing to the fact that nylon yarns are age sensitive the yarn must be shipped from the warehouse on a first in, first out basis (FIFO) (see below).

It is possible to automate a warehouse fully and should the volume of yarn passing through the warehouse be large enough, this can be a cost-effective option. In this case all rack positions are bar coded and stacking trucks rove between the aisle ways, automatically depositing the pallets in the predetermined rack positions by reading the bar code at each available position. Similarly when removing pallets from storage for shipment to the customer, a listing of the required rack positions can be fed to the robotic stackers by the software and the pallets can be picked out automatically for loading into the container for shipment.

9.7 Product logging

Each pallet, when it arrives from packing, must be given its own unique space on the racks; this is to enable it to be easily picked for shipment at a later date. This rack position together with all details relevant to that pallet must be accurately recorded and passed forward to the accounting department, i.e.

1 net and gross weight;
2 product description;
3 quality;
4 date of packing.

Similarly this information must also be logged as each pallet is removed from the warehouse for shipment to customers. The date of first racking is particularly relevant to nylon yarns which, as they are age sensitive, in a well-managed warehouse, are shipped on a first in first out basis.

The information above is vital to the running of an efficient business with accurate accounting systems. Without this information, it is impossible to balance the worth of finished goods against the manufacturing costs or to know the amount of money tied up in finished goods held as stock at any time.

Any business whose prime accounting method is dependent upon the weight of goods shipped and on knowing the worth of each kilogram of these goods, must have an accurate weighing system. As such, all balances, scales and weighbridges must be regularly and routinely calibrated with known international standard weights and accurate records of these calibrations must be maintained.

9.8 Load planning

For economic reasons the planning of the load which goes into each container for shipment requires careful thought. As the cost of transport is an ever present and rising cost, loads should be planned so that whenever practical:

1 all of one load goes to one customer; or
2 different loads within a shipment are planned so that two or more customers that lie within a small radius of each other can be serviced from one load (the yarns should be placed in the container in the reverse order to the order of unloading).

Also, if at all possible, it should be arranged that the lorry never returns empty to the manufacturing plant. It should be loaded to return with either re-usable packaging from the customers or raw materials needed to service the plant. Careful planning can substantially cut transport costs leading to a more economically viable operation.