Mechanical and Electrical safeguards in Belt Conveyor systems

Dr. Shyamal Dey (Ph.D., Mechanical Engineering)
Technical Manager, Materials Handling.
Hyder Consulting India Pvt Ltd (GEC)

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1. Introduction:

Belt conveyors are among the most efficient machines for transporting large quantities of material from one place to another at reasonable cost.
The advantages of belt conveyors include:
i) Operate in harsh weather,
ii) Low labour requirements for both operation and maintenance,
iii) Minimal environmental impacts,
iv) Independence from fuel oils,
v) Operational flexibility.

Belt conveyors of various types and sizes are becoming the preferred method of material handling in the industrial complex. Belt conveyors are tailor made to suit specific requirements, the length may vary from 3m to 15 km of single flight, capacity may go beyond 20,000 tph, and so there are possible chances of over design or under design of conveyors which may lead to inefficiency of the conveyor system and / or unsafe design which may cause accidents. Improper design may cause problems like spillage and wastage of valuable material and may in turn lead to occupational safety, health hazards, breakdown of conveyor system and thus loss of revenue.
Continuous technological improvement in belt conveyor mechanical components, electrical controls and safety devices made it possible for the modern high speed, heavy duty, large capacity and longer belt conveyors.

2. Safety Description:

What is safety?

Belt conveyor safety usually starts with sound design.

During designing, following two things should be considered in belt conveyor:

1) Safety of the personnel working nearby the belt conveyor and

2) Devices that protect the conveyor components.

Why safety is important?

- Safety is the first requirement of our life.
- We want to live more & more time in this beautiful world.
- We love our family & friends and want to be with them.
- It protects us incident like injury & fatal.
- To achieve our dreams.

3. Moving /rotating parts of conveyor:

Operators and users should be careful from the part of the conveyor mentioned as below:

1. Conveyor belt moves all along the length of a conveyor.
2. Rotating idlers.
3. Rotating pulleys and
4. Rotating Drives etc.

4. How safety is achievable?

Safety is achievable with minimum efforts and cares of individuals.

1. Slope of conveyors should be designed in such a way that materials should not rollback.
2. There should not be slippage between belt & pulleys.
3. No spillage or accidental dropping of the conveyed products under normal working condition.
4. Inspection door at suitable locations.
5. Suitable sealing shall be provided wherever belt conveyor crossing the roads, railway tracks and buildings.
6. Counter weight movement area should be guarded from operating personnel.
7. Adequate walkways should be provided for the movement of maintenance people. In case, conveyor slope is above 6°, steel rods shall be welded across the walkway and more than 10° should be stepped.
8. Fire resistant belts shall be used in fire prone area.

5. Safety devices:

For safety of the personnel working near the belt as well as to prevent damage to the belt conveyor components, the following" Safety devices" are provided:

i) Hold-backs,
ii) Pull cord switches,
iii) Centrifugal switches,
iv) Belt sway switches,
v) Magnetic separators,
vi) Metal detectors,
vii) Safety guards,
viii) Mechanical torque control devices- Fluid couplings.
ix) Flywheels,
x) Brakes.
xi) Belt anti-rip detectors,
xii) Plugged chute detectors,
xiii) Load control switches,
xiv) Travel limit switches,
xv) Audible or visual signals,
xvi) Vibration Monitor & Absorber,
xvii) Bin Vibrator / Air Blaster etc.

5.i) Hold-back (or backstop):

Hold back is a mechanical safety –device fitted to prevent the loaded inclined belt to roll back. Any loaded inclined belt if stopped tends to roll back and accidents may occur and the damage to belt, drive and other components may be disastrous.
An automatic Hold back allows free rotation in one direction, while in the other direction it engages without the help of any external mechanism. Hold-backs may be pawl & ratchet type or roller type or could be an electrical brake type too.
Location-wise, the hold back is either mounted on high speed reducer shaft or more safely it is mounted on an access end of pulley shaft. From safety point of view, the low speed location is the safest, because if there is any failure in low speed coupling or gear, the hold back will prevent roll back. Whereas if located on high speed side the hold back will not be able to stop the belt conveyor.
Any conveyor which requires, more power to lift the material than to move the loaded belt horizontally needs a hold back. For inclined conveyors having average angle less than 2 degrees, we need not consider Hold backs.

5.ii) Pull Cord switches:

Pull cord switches are mounted at regular intervals (generally 30 m apart, preferably on both the sides of the belt conveyor) along the conveyor length connected with pull wires. Generally, the pull cord wire consists of multistrand steel wire with PVC coating all round. In an emergency situation, the conveyor can be stopped from anywhere along the conveyor length by just pulling the cord.

5.iii) Centrifugal switches:

Conveyor belts should run at the rated speed. Slowing down of the belt can cause overloading of belt thus leading damage to the belt or other components. These switches also known as slip and snap switches, will automatically stop a conveyor in case of falling of belt speed below a permissible value, due to slippage of belting or snapping of belt etc. They can also give permissive signal for preceding conveyor to start on achieving of 90% of the rated belt speed. One switch is fixed on each conveyor.

5.iv) Belt-sway switches:

A belt can get damaged and accidents may occur due to extreme lateral movement of the running belt from the conveyor centre line. These switches are fixed at regular intervals (generally 50 m apart in pairs) along the belt and stop the main drive in case the belt crosses its maximum safe sway limit.

5.v) Magnetic separators:

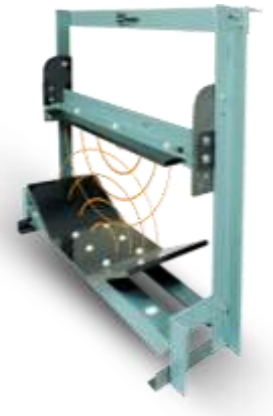
Magnetic separation of Tramp Iron from material flow:
Tramp iron, carried with load on the belt, can "wedge itself" at any location and rip a belt. Tramp iron should be totally eliminated from the material flow to avoid damage to belt and other components. Protection against this sort of damage is achieved by providing In-line magnetic separator, Cross-belt magnetic separator (CBMS), Magnetic pulley and Metal detector. Bolts, loosened liner plates from chutes are the main sources to create such problems (it is necessary to thoroughly check feed and transfer points during periodic inspections).Belt conveyors feeding to crushers are normally provided with Magnetic separators in order to avoid tramp iron pieces entering the crushing chamber. This avoids major and costly crusher break-down. Thus Magnetic separators ensure safety of Belt / Crusher operations.

5.v.i) In-line Magnetic Separator (ILMS):
This consists of a magnet with short belt conveyor suitably mounted around it so that this conveyor belt continuously slides below the magnet face in the same direction as the main conveyor moves. The separator is placed over the trajectory of the material discharged in line with the main belt conveyor. Tramp iron picked up from the main belt conveyor is held underside of the cross belt by the magnet. When the Tramp iron moves out of the magnetic field, the iron drops into a separate tramp iron chute.

5.v.ii) Cross-Belt Magnetic Separator (CBMS):
CBMS has same short belt conveyor suitably mounted around a magnet, similar to In-line magnetic separator. However, the short belt which extends beyond one side of the main conveyor moves right angle to the main conveyor. So tramp iron pulled out of the main conveyor travels right angle to the main conveyor. Tramp iron after crossing the main conveyor travels beyond magnetic field where it drops into a tramp-iron chute.

5.v.iii) Magnetic Pulley:
An electromagnet is incorporated into a head pulley of a conveyor so that the tramp-iron does not get discharged along with the material but sticks to the belt and passes the material discharge point. When the belt travels beyond the magnetic field, the tramp iron automatically drops into tramp iron chute.

5.vi). Metal Detectors:



This unit has highly sensitive search coil which can sound an alarm and stop the conveyor, wherever any non-ferrous metal or piece of iron or any magnetic substance passes with the material flow. The detector may also be able to drop an indicator to show the position of the piece of metal. The indicator may be in the form of coloured powder spray or sand or saw dust.

5.vii) Safety guards:

Belt conveyor moving components must be suitably guarded. Guide lines in this connection are as mentioned in IS: 7155 (Part 2) - 1986& IS: 7155 (Part 3)-1986.
Guards may be made from suitably steel sections and sheet or expanded metal. Guards shall be firmly fixed in position and wherever required, may be Refer Annexures A to F.

5.viii) Fluid Couplings:

Conveyor belts must be accelerated gently during starting, particularly for the modern high-speed, heavy duty, large capacity and long conveyors. The high torque and shock loads normally encountered when squirrel cage motors are started and unacceptable because they can easily overstress and damage the belting, drive system and other components. Case histories of unexplained belt damage, pulley failures, drive failures and take-up failures are there. The take-up weights move violently up and down as a reaction to such starts, enhancing the conveyor belt loads even more. Thus, to avoid such situations, squirrel cage motors with fluid couplings are the solution, so that the drive system can get a “soft start”.
A fluid coupling transmits power from one shaft to another shaft by means of the kinetic energy of the fluid. Some of the inherent advantages accruing from the use of fluid couplings are as follows:
i) Light load starts,
ii) Reduced electrical energy,
iii) Reduced heating in motor,
iv) Accurate overload protection,
v) Motor sized for running duty,
vi) Smooth controlled acceleration.
When the motor of the conveyor is switched on, the fluid coupling has no torque capacity. The motor starts accelerating quickly, the fluid coupling torque remains low. As the motor runs up to speed quickly the torque of the fluid coupling increases smoothly to starts the belt conveyor.
As per the normal practice Fluid couplings shall preferably be used when conveyor power requirements exceed 50 Kw.

5.ix) Flywheels:

In emergency situations, the conveyor system needs to be stopped as quickly as possible for safety of the personnel or to protect the conveyor components. But, it becomes necessary that each conveyor should stop before the succeeding conveyor stops. This will avoid spillage and overloading of succeeding conveyors. Thus the coasting time of succeeding conveyors should be more. This is also applicable in case of power failure.
Coasting time of a conveyor can be increased by incorporating a large flywheel to the high speed shaft of the conveyor drive or decreased by applying mechanical brakes in the same location. Flywheel, a mechanical control, adds MK^2 value to the total conveyor mass and thus increases the coasting time.

5.x). Brakes:

To shorten the coasting time and regulate stopping distance of a conveyor an automatic brake is installed on the high speed shaft of the conveyor drive. It also holds the conveyor when it has come to rest. Particularly, brakes are required for long horizontal conveyors or declined conveyors (not regenerative type) where coasting time is quite high.
Generally, electrically operated friction brakes are used. For safe operation, such brakes are engaged by springs and disengaged by power, either by electro-magnet or hydraulic pressure.
Hold back is not required for regenerative declined conveyor. However a brake is required to bring the fully loaded regenerative conveyor to a stand still within an acceptable time limit, when power is cut off.

5.xi) Belt anti-rip detectors:

Belt anti-rip devices can help detect and protect longitudinal slit of the conveyor belt (rather, they help in limiting damage by a considerable amount), which otherwise would lead to costly belt replacement and shutdown operations. These safety devices are rightly justified for expensive conveyor belts and conveyors where shutdown must be kept to a minimum. Rip often occurs when tramp iron or rock or failed idler roller / belt scraper jams between the conveyor technological structure and belt, often at the loading point. Particularly steel cord belting, having low rip resistance may cut longitudinally into two halves by a jammed tramp iron or so.
Presently a few types of Anti-rip detectors are developed. BF Goodrich of USA has developed an anti-rip detector system known as “sentre” working in heavy duty applications including iron ore, coal, limestone etc.
BFG sentre, an electronic watchman, provides dependable belt surveillance in the following manner:
A high frequency signal is continuously transmitted from the control box to a transmitting probe. Each time a conductive antenna passes the transmitting probe; a signal is conducted across the belt and picked up by a receiving probe. Conductive antennae are

placed transversely across the belt between the bottom cover and the bottom fabric ply. The antennae can be affixed to any fabric or steel cord belt carcass at intervals along its length.
The signal is then transmitted from the receiving probe back to the control box. Each probe, linked electronically to the control box, is placed transversely across the other and directly below the belt edges.
When the control box receives the expected signal, the detection circuit is automatically reset, and the detector starts looking for the next signal. If the control box does not receive the next signal as programmed, the logic circuit interprets this absence as a rip indication and a command is given to stop the motor.

5.xii). <u>Plugged chute detectors:</u>

Chocking takes place in a chute (or hopper) when the material bridges across the chute mouth. Rapidly the material piles up in the whole chute resulting in material spillage and can cause damage to the discharging belt conveyor. Protection is ensured by suspending a switch from the chute work above the material trajectory. This switch stops further flow of material into the chute by stopping the discharging conveyor.

5.xiii). <u>Load Control Switches:</u>

These switches are used in belt conveyor systems to prevent overloading of the main belt conveyor by the preceding belt conveyor / feeder. The switch automatically stops the preceding feeder when the belt conveyor gets overloaded. Thus it limits the belt stress to a safe limit. It can also give visual or audible warning so that feed can be reduced.

5.xiv). <u>Travel limit switches:</u>

These switches are provided in travelling component / equipment such as take-up carriages, travelling trippers, shuttle conveyors, plough feeders, telescopic chute etc. to limit the travel of such component / equipment within safe limits.

5.xv) Audible or Visual signals:

These signals shall be provided along the length of belt conveyors so that operator is able to give adequate warning to personnel in the vicinity of belt conveyor installation, about the imminent starting of belt conveyor system. Warning hooters are generally used as audible signals for belt conveyors, particularly for long conveyors. Sufficient quantity of warning hooters should be located along the conveyor length so that they are distinctly audible.

5.xvi). Vibration Monitor & Absorber:

Vibration Monitor is used to measure the vibration level of the supporting structures and to display the level of vibration through Monitor.

Vibration absorbers reduce the effects of harmonic vibration in buildings or other structures. A relatively small mass is attached in such a way that it can dampen out a very narrow band of vibration of the structure.

5.xvii) Bin Vibrator / Air Blaster:

To facilitate materials flow from bins and hoppers for all types of materials, including large aggregate and sand, fine powders, flakes, pills, bottle caps, jars and just about any material that tends to stick or clog inside a bin or chute a Vibrator / Air Blaster is used.

In case material is not moving the most likely reason is friction between the material and the bin or chute skin. During that time to break the friction with vibration, installation of a vibrator will keep the material flow continuously through the discharge. It gives much more efficient and reliable material flow.

Experience says, sometimes Bin Vibrator does not work properly for many reasons. Sometimes it helps to rammed and solidify the materials inside the Bin or chute, besides clearing the same. In that case, Air blasting machines works fine. It gives certain jerks with high air pressure at certain prefixed time interval on the jammed materials, inside the Bin or chute to crack and break the accumulation of materials, which in turn helps the materials flow out freely from Bin & chute.

6. Safety Requirement Design consideration:

Belt conveyors shall confirm to all the statutory requirements as mentioned "Code of recommended practice for conveyor safety". Any additional safety requirements to the extent specified by the purchaser shall also be taken into consideration.

Belt shall be of sufficient width to suit the specific load and material to be conveyed.

General formula for calculation of the capacity of all types of belt conveyors" shall be as follows to avoid spillage:

$C = 3600. \rho. A.S.k$ t/h.

C = Conveyor Capacity t/h,
ρ = Bulk Density of materials, kg/m3,
A = Area of cross-section of materials on the Conveyor Belt, in m2,
S = Conveyor Belt Speed in m/sec.
k = Conveyor slope factor.

To take surges and unevenness in loading operations into account, the capacity of belt conveyor calculation mentioned above shall be generally limited to 90%. In case of conveyors with belt width up to 600 mm, the capacity shall be reduced to 75%).

Guiding and centering devices shall be provided, if necessary, at the feed points.

i) The in-running nips and pinch points of the conveying device (belts, pulleys, idlers etc.) and the movable parts (chain sprocket, couplings etc.) shall be completely guarded.

ii) The slopes and the characteristics of the conveying elements shall be designed so, as to avoid slipping and / or unintentional dropping of the conveyed products under normal working conditions.

iii) Inspection doors shall be provided in hoppers and chutes.

iv) Where belt conveyors pass above workstations or passageways (roads, railways tracks etc.) suitable protection (like seal plate) shall be provided against accidental dropping of conveyed materials or objects over such area / personnel.

v) Counter-weight tension devices shall be guarded at points normally accessible to operating personnel.

vi) Travelling equipment, such as travelling trippers, shuttle conveyors, travelling feed hoppers, feeders etc., whether self-propelled or manually controlled, shall be fitted with guide idlers so as to minimize effects of undue belt sway.

vii) The above travelling equipment shall be guarded at working points accessible to service personnel under normal working conditions.

7. General safety requirements:

i) The design of platforms, walkways and ladders shall be such that adequate clearance is provided for normal operations, servicing and maintenance, giving sufficient room for freedom of movement and access for carrying out such duties.

Some important points are mentioned below as a ready reference:

a) A maintenance walk way of 800 mm minimum width along the run of the conveyor in a gallery shall be provided.
b) Handrails:
c) Handrails shall be provided around all openings. They shall also be provided on walkways in belt conveyor gallery having slope more than 6°. The section for hand railing generally be galvanized pipe of 32 NB unless specifically required by purchaser.
d) The walkway along the inclined belt conveyor shall be provided with antiskid surface. In case of conveyor installations with more than 10° inclination, stepped walkways shall be provided.
e) Wherever a conveyor has to run in an underground tunnel, a clear walkway space of 800 mm shall be provided along the length of conveyor on either side. For conveyors used in underground mines this clear space shall be not less than 1 m along the length of conveyor on either side from any structure of the conveyor. In case of double conveyors a central walkway of minimum 800 mm width shall be provided ensuring that at least 500 mm is available at drive or head pulley end.

ii) The whole belt conveyor path and especially the loading, unloading and transfer points, shall be designed so as to avoid as much as possible all spillage of products or conveyed material.

a) Whenever an operator is expected to remain on the travelling equipment, a platform shall be provided and be so designed as to prevent any accidental contact with mobile components or any part of the fixed installation.

b) Where walkways are provided on both sides of a conveyor and where convenient access to either side of the conveyor may be required by employees, who regularly work in the area. Crossover shall be provided at appropriate intervals and at the head and tail ends of the conveyors where no other crossing is available. Safe means of access shall be provided at crossovers. (If required, the conveyor shall be of removable type in sections to permit removal of drive unit or any other components).

8. General Safety Information:

This standard covers general information in connection with the recommended practice to be adopted in the safe use of conveyors and conveying machinery.

Materials:
Unless otherwise specified, all materials used in the construction and operation of a conveyor and its supporting structures shall comply with the requirements of relevant Indian standards. Materials equivalent to or superior to these specified may be used subject to agreement between the manufacturer and the user.

Manufacturers have developed cover grade “FR” conforming to the most stringent specification laid down in the Canadian Bureau of Mines Specification Services for the Underground Mining and Equipment and Materials, EMR, Canada-ERP / MRL 80-21 (TR) September 1980 for fire resistant properties.

Safety requirement in connection with lighting Electrical Equipment, Fire protection, Dust and Fumes etc. shall be in line with the guidance specified in that country’s codes.

8. Conclusion:

Being a conveyor system designer, time and again I am repeating that Belt conveyor safety usually begins with sound design.

While designing a belt conveyor system, two things should be considered.

i) Safety for the personnel working near the belt conveyor, and
ii) Devices that protect the conveyor components.

Provision of safety devices shall keep the conveyor system in safe operation round the clock, reduce breakdown and enhance life of the components and hence lead to optimum utilization of the plant.

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