Conveyors

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Material handling principles (Groover principles)

Principle 1 - PLANNING PRINCIPLE:

All material handling should be the result of a deliberate plan where the needs, performance objectives, and functional specification of the proposed methods are completely defined at the outset.

The plan should be developed in consultation between the planner(s) and all who will use and benefit from the equipment to be employed.

Success in planning large-scale material handling projects generally requires a team approach involving suppliers, consultants when appropriate, and end user specialists from management, engineering, computer and information systems, finance, and operations.

The plan should promote concurrent engineering of product, process design, process layout, and material handling methods as opposed to independent and sequential design practices.

The plan should reflect the strategic objectives of the organization as well as the more immediate needs.

Material handling principles (Groover principles)

Principle 2 - STANDARDIZATlON PRINCIPLE:

Material handling methods, equipment, controls, and software should be standardized within the limits of achieving overall performance objectives and without sacrificing needed flexibility modularity, and throughput.

Standardization means less variety and customization in the methods and equipmentt employed.

Standardization applies to sizes of containers and other load forming components as well as operating procedures and equipment.

The planner should select methods and equipment that can perform a variety of tasks under a variety of operating conditions and in anticipation of changing future requirements.

Standardization, flexibility, and modularity must not be incompatible.

Material handling principles (Groover principles)

Principle 3 - WORK PRINCIPLE: Material handling work should be minimized without sacrificing productivity or the level of service required of the operation.

The measure of material handling work is flow rate (volume, weight, or count per unit of time) multiplied by distance moved.

Consider each pickup and set-down, or placing material in and out of storage, as distinct moves and components of the distance moved.

Simplifying processes by reducing, combining, shortening, or eliminating unnecessary moves will reduce work.

Where possible, gravity should be used to move materials or to assist in their movement while respecting consideration of safety and the potential for product damage.

Material handling principles (Groover principles)

Principle 3 - WORK PRINCIPLE:

Material handling work should be minimized without sacrificing productivity or the level of service required of the operation.

- The Work Principle applies universally, from mechanized material handling in a factory to over-the-road trucking.
- The Work Principle is implemented best by appropriate layout planning: locating the production equipment into a physical arrangement corresponding to the flow of work. This arrangement tends to minimize the distances that must be traveled by the materials being processed.

Material handling principles (Groover principles)

Principle 4 - ERGONOMIC PRINCIPLE:

Human capabilities and limitations must be recognized and respected in the design of material handling tasks and equipment to ensure safe and effective operations.

Ergonomics is the science that seeks to adapt work or working conditions to suit the abilities of the worker.

The material handling workplace and the equipment must be designed so they are safe for people.

The ergonomic principle embraces both physical and mental tasks.

Equipment should be selected that eliminates repetitive and strenuous manual labor and that effectively interacts with human operators and users.

Material handling principles (Groover principles)

Principle 5 - UNIT LOAD PRINCIPLE:

Unit loads shall be appropriately sized and configured in a way which achieves the material flow and inventory objectives at each stage in the supply chain.

A unit load is one that can be stored or moved as a single entity at one time, such as a pallet, container, or tote, regardless of the number of individual items that make up the load.

Less effort and work are required to collect and move many individual items as a single load than to move many items one at a time.

Large unit loads are common in both pre- and post-manufacturing in the form of raw materials and finished goods.

Smaller unit loads are consistent with manufacturing strategies that embrace operating objectives such as flexibility, continuous flow and just-in-time delivery. Smaller unit loads (as few as one item) yield less in-process inventory and shorter item throughput times.

Material handling principles (Groover principles)

Principle 6 - SPACE UTILIZATION PRINCIPLE: Effective and efficient use must be made of all available space.

Space in material handling is three-dimensional and therefore is counted as cubic space.

In storage areas, the objective of maximizing storage density must be balanced against accessibility and selectivity.

When transporting loads within a facility, the use of overhead space should be considered as an option. Use of overhead material handling systems saves valuable floor space for productive purposes.

Material handling principles (Groover principles)

Principle 7 - SYSTEM PRINCIPLE: Material movement and storage activities should be fully integrated to form a coordinated, operational system that spans receiving, inspection, storage, production, assembly, packaging, unitizing, order selection, shipping, transportation, and the handling of returns.

Systems integration should encompass the entire supply chain, including reverse logistics. It should include suppliers, manufacturers, distributors, and customers.

Inventory levels should be minimized at all stages of production and distribution while respecting considerations of process variability and customer service.

Information flow and physical material flow should be integrated and treated as concurrent activities.

Methods should be provided for easily identifying materials and products, for determining their location and status within facilities and within the supply chain, and for controlling their movement.

Material handling principles (Groover principles)

Principle 8 - AUTOMATION PRINCIPLE: Material handling operations should be mechanized and/or automated where feasible to improve operational efficiency, increase responsiveness, improve consistency and predictability, decrease operating costs, and eliminate repetitive or potentially unsafe manual labor.

In any project in which automation is being considered, pre-existing processes and methods should be simplified and/or re-engineered before any efforts to install mechanized or automated systems. Such analysis may lead to elimination of unnecessary steps in the method. If the method can be sufficiently simplified, it may not be necessary to automate the process.

Items that are expected to be handled automatically must have standard shapes and/or features that permit mechanized and/or automated handling.

Interface issues are critical to successful automation, including equipment-to-equipment, equipment-to-load, equipment-to-operator, and in-control communications.

Computerized material handling systems should be considered where appropriate for effective integration of material flow and information management.

Material handling principles (Groover principles)

Principle 9 - ENVIRONMENTAL PRINCIPLE: Environmental impact and energy consumption should be considered as criteria when designing or selecting alternative equipment and material handling systems.

Environmental consciousness stems from a desire not to waste natural resources and to predict and eliminate the possible negative effects of our daily actions on the environment.

Containers, pallets, and other products used to form and protect unit loads should be designed for reusability when possible and/or biodegradability after disposal.

Materials specified as hazardous have special needs with regard to spill protection, combustibility, and other risks.

Material handling principles (Groover principles)

Principle 10 - LIFE CYCLE COST PRINCIPLE:

A thorough economic analysis should account for the entire life cycle of all material handling equipment and resulting systems.

Life cycle costs include all cash flows that occur between the time the first dollar is spent to plan a new material handling method or piece of equipment until that method and/or equipment is totally replaced.

Life cycle costs include capital investment, installation, setup and equipment programming, training, system testing and acceptance, operating (labor, utilities, etc.), maintenance and repair, reuse value, and ultimate disposal.

A plan for preventive and predictive maintenance should be prepared for the equipment, and the estimated cost of maintenance and spare parts should be included in the economic analysis.

Material handling principles (Groover principles)

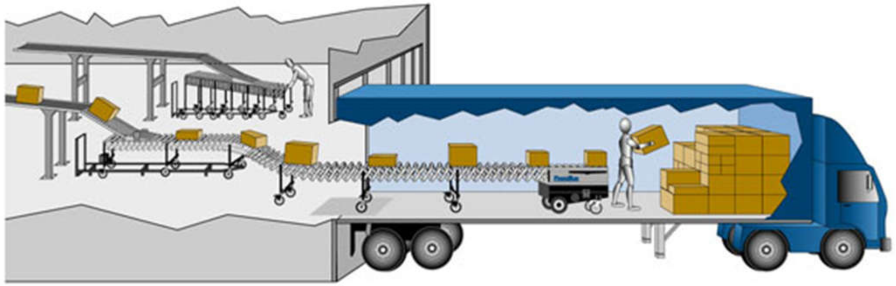
Principle 10 - LIFE CYCLE COST PRINCIPLE: A thorough economic analysis should account for the entire life cycle of all material handling equipment and resulting systems.

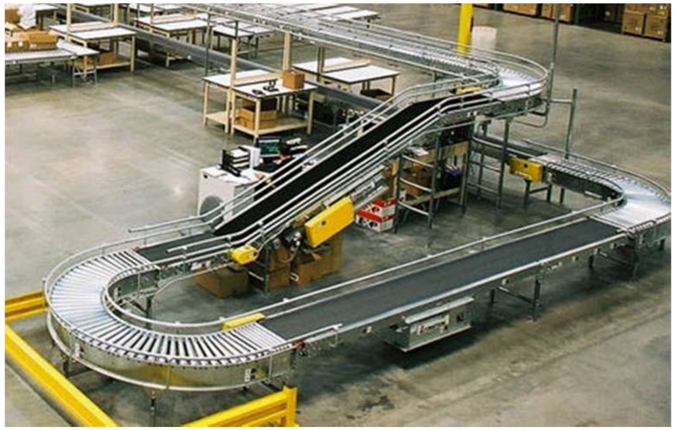
A long-range plan for replacement of the equipment when it becomes obsolete should be prepared.

Although measurable cost is a primary factor, it is certainly not the only factor in selecting among alternatives. Other factors of a strategic nature to the organization and that form the basis for competition in the market place should be considered and quantified whenever possible.

Conveyors

Definition - A conveyor is a mechanized device to move materials in relatively large quantities between specific locations over a fixed path.



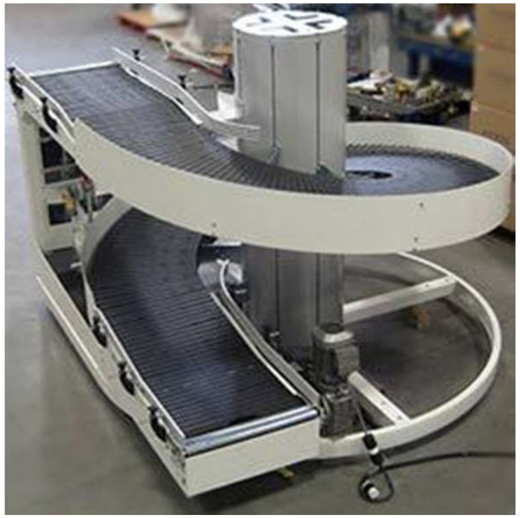



Conveyors - division

Roller conveyors - Series of tube rollers perpendicular to motion direction, which can be powered or use gravity for motion.

Skate-wheel conveyors - Similar to rollers but use skate wheels parallel to motion direction.

Belt conveyors - Drives move flat or belts shaped into a trough.



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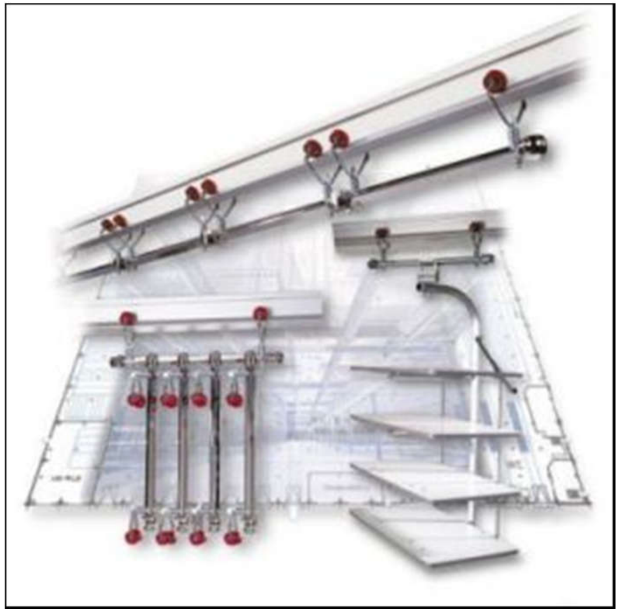
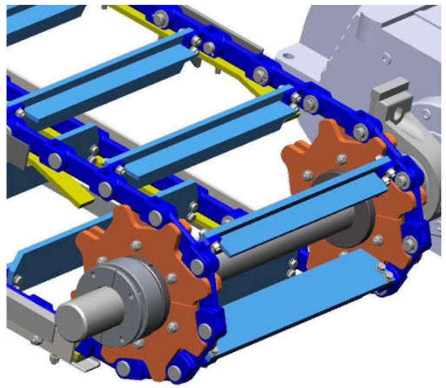
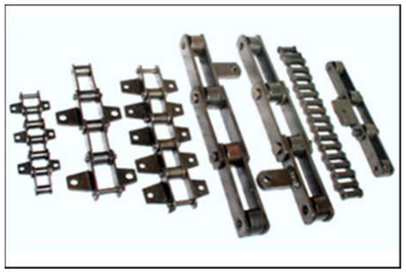
Conveyors - division

Chain conveyors - Uses loops of chain that are typically moved by sprockets as driven by motors.

Overhead trolley conveyors - Items are moved in discrete loads by hooks or baskets suspended from overhead rails.







Conveyors - division

In-floor towline conveyors - Similar to overhead trolley but carts are pulled by hook to in-floor conveyor.

Cart on track conveyors - Items are moved by a cart attached to a rail system, which uses a rotating tube to move the cart along the rail.

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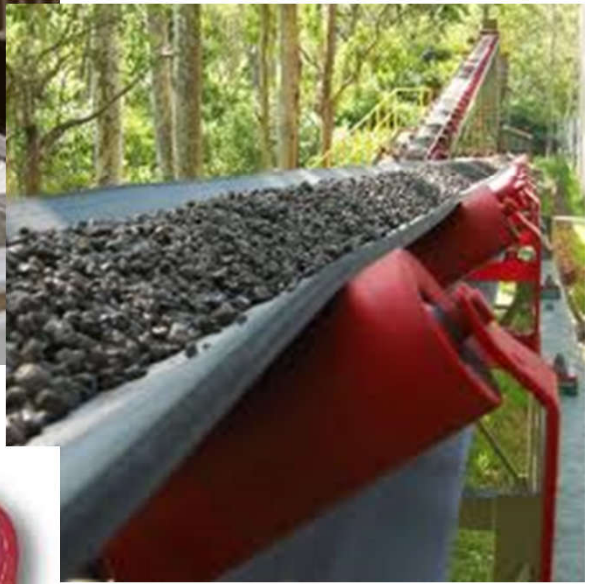
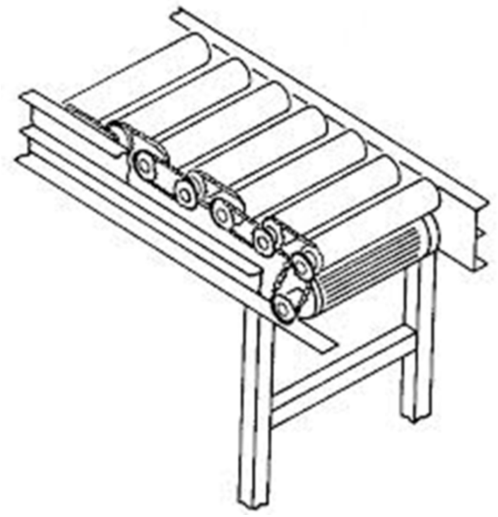
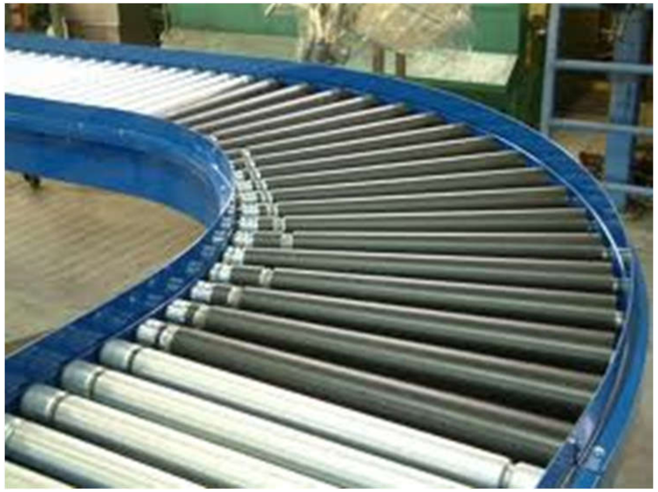
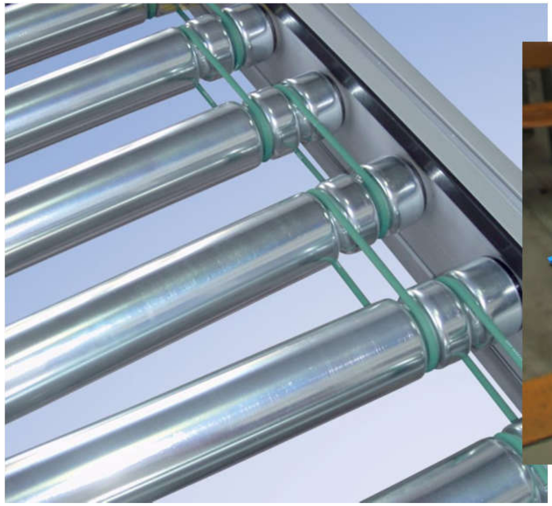
Belt conveyor

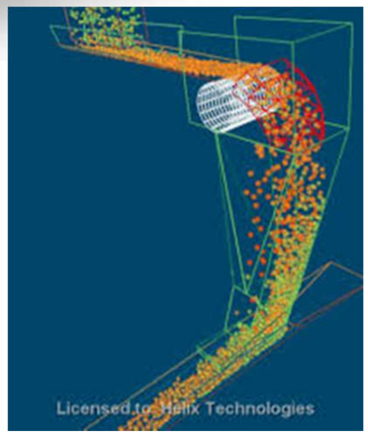


Roller conveyor

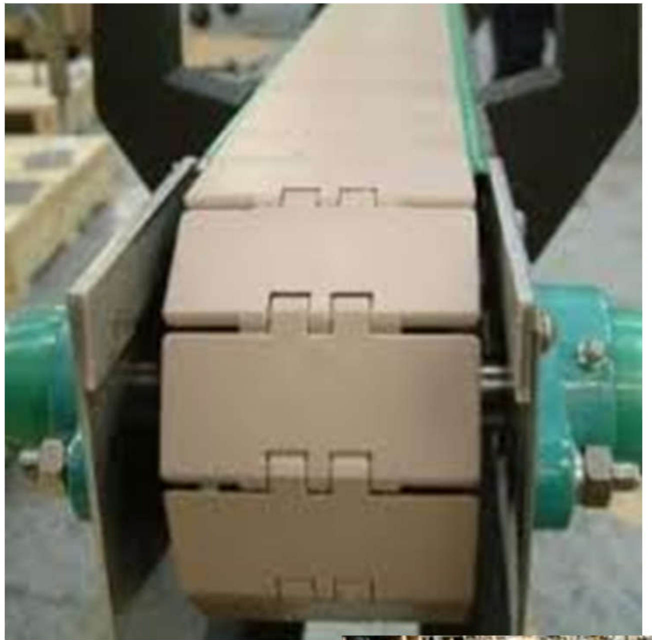



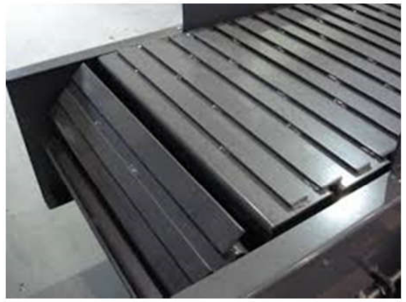




Chute conveyor

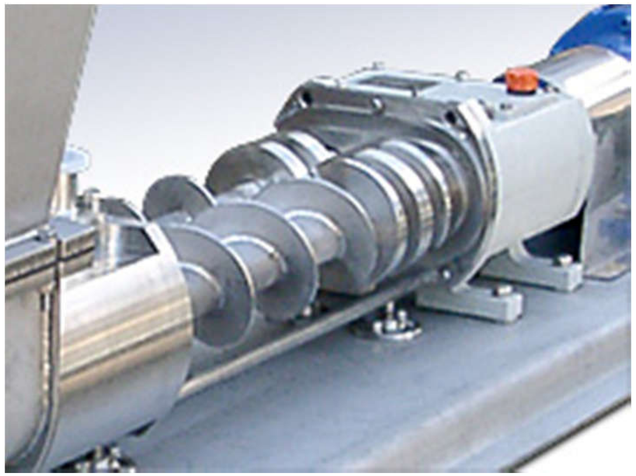


Slat conveyor



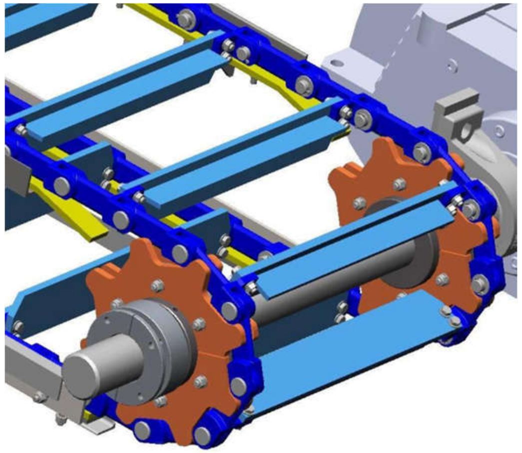


Screw conveyor



Chain conveyor






Overhead monorail conveyor

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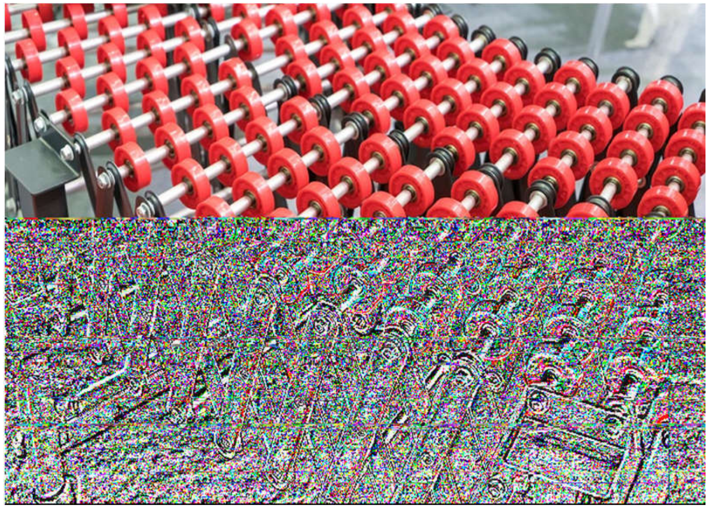
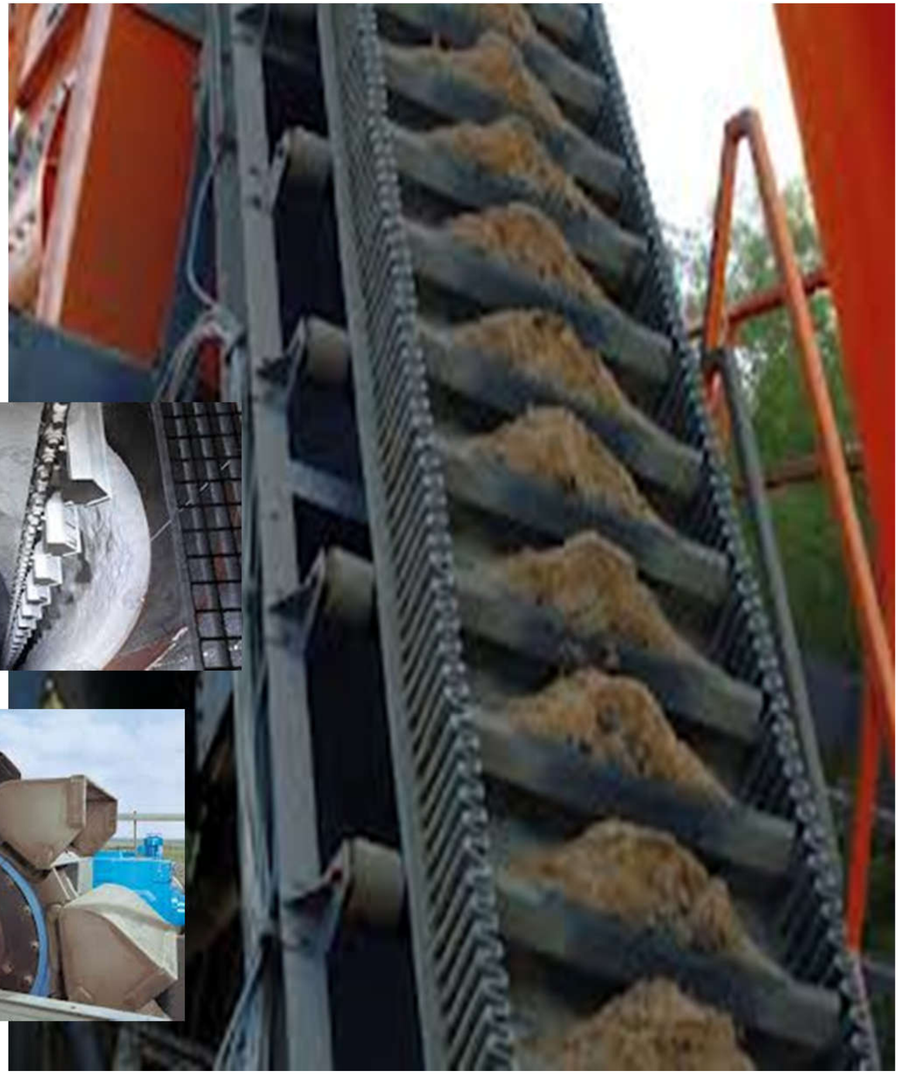
Wheel conveyor



Bucket conveyor



Pneumatic tube conveyor

Conveyor handling analysis

Equations – single direction:

time from load to unload	$T_d = L_d / v_c$	(min)
	"delivery time = delivery distance divided by carrier speed"	
material flow rate $(n_p = 1)$	$R_f = R_L = v_c / s_c \leq 1/T_L$	(num carriers/min)
	"system flow rate = loading rate = flow rate of carriers on conveyor"	
material flow rate $(n_p > 1)$	$R_f = n_p v_c / s_c \leq 1/T_L$	(num parts per min)
	"system flow rate = loading rate of parts = flow rate of parts on conveyor"	
unloading constraint	$T_U \leq T_L$	(min)
	"unloading time must be less than loading time or else pile up carriers"	

Conveyor handling analysis

Equations – continuous loop:

time to complete loop $T_c = L/v_c$ (min)

"full loop carrier time = loop distance divided by carrier speed"

time in delivery $T_d = L_d/v_c$ (min)

"delivery time = delivery distance divided by carrier speed"

number of carriers $n_c = L/s_c$

"num of carriers = loop distance divided by carrier spacing"

total parts in system $N_p = n_p n_c L_d/L$

"parts in system = num of parts per carrier times num carriers with parts"

material flow rate $R_f = n_p v_c/s_c$ (num carriers per min)

"material flow rate = num parts per carrier times carrier flow rate"

Conveyor handling analysis

Equations – recirculating:

Speed rule – operating conveyor speed must fall within a certain range

from load/unload rates $R_f = n_p v_c / s_c \geq \text{Max}\{R_L , R_U\}$

"flow rate of parts on conveyor must exceed the max load or unload part rate to maintain part spacing"

from time to load/unload carriers $v_c / s_c \leq \text{Min}\{1/T_L, 1/T_U\}$

"flow rate of carriers on conveyor must exceed the max load or unload carrier rate to maintain part spacing"

Capacity constraint –conveyor capability ($n_p v_c / s_c$) must exceed desired/specified flow rate R_f

conveyor speed and carrier parts $n_p v_c / s_c \geq R_f$

Uniformity principle –loads should be distributed uniformly over the conveyor