

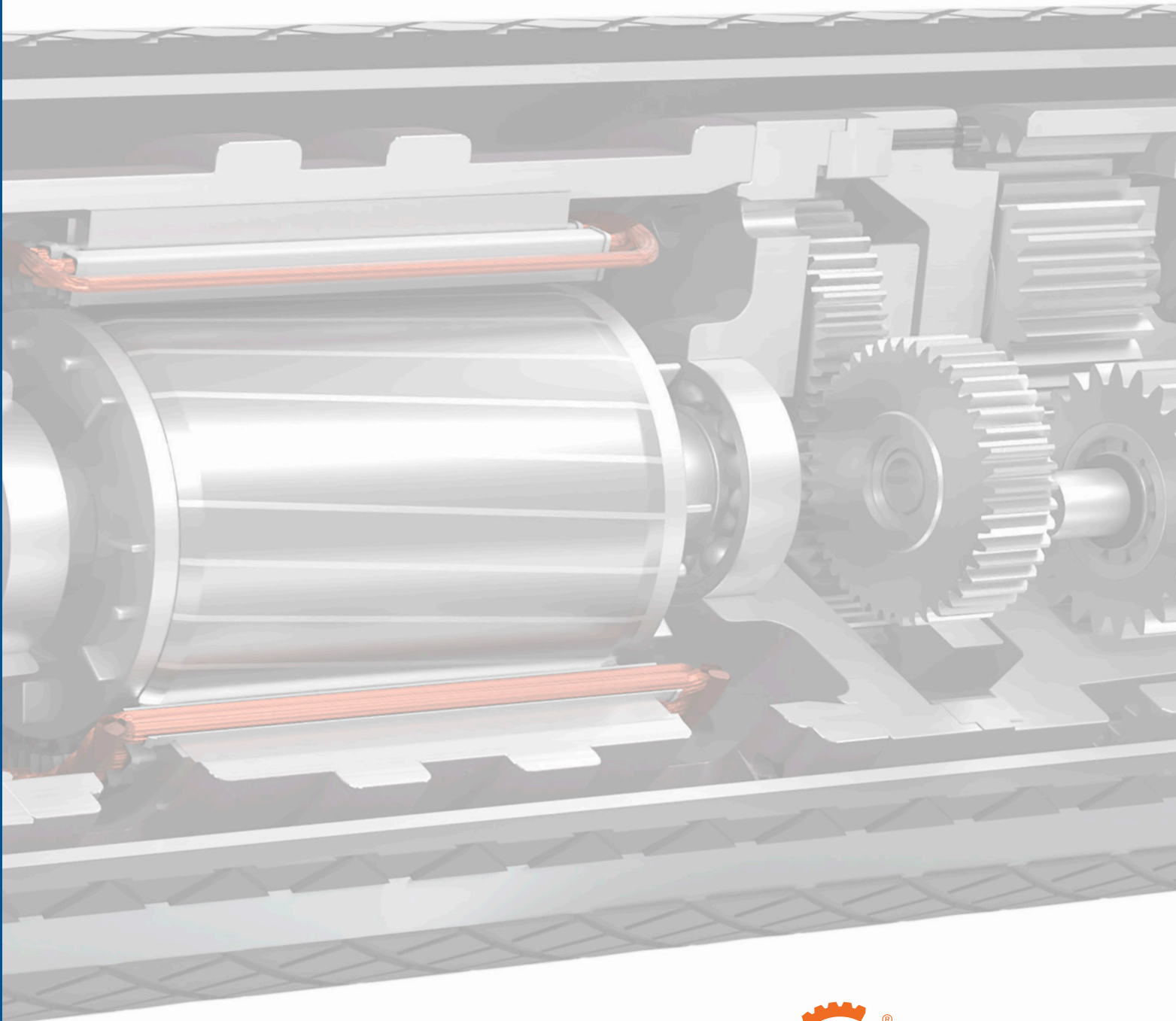


Design Improvements Through Innovation

The Evolution of the Drum Motor

By Alexander D. Kanaris

11/15/2019



The Evolution of the Drum Motor

DESIGN IMPROVEMENTS THROUGH INNOVATION

The drum motor conveyor-belt drive design entered the market in the early 50's. What sets the drum motor apart from a conventional conveyor drive is that the drum motor has all drive components, including the electric motor, gear reducer, and all bearings housed inside the drum. Without any exposed drive components and with no other drive parts rotating outside the conveyor frame, the drum motor presents a unique belt drive design. The drum motor also maximizes space utilization and worker safety by rendering external components such as the electric motor, gear reducer, bearings, chain, and chain guards, usually mounted outside the conveyor frame, redundant. Those components can all be hazardous to people required to work in proximity to conventional conveyor drives.

Most standard conventional conveyor drives either use a 90-degree gear reducer mounted directly to the drive shaft or use a combination of sprockets and chain to drive the head conveyor drive drum. Using 90-degree gear reducers, particularly worm gear reducers, impedes on the maximum possible efficiency of the drive due to significant mechanical losses. In the drum motor conveyor drive, the motor is coupled in-line to the gear reducer. This increases mechanical efficiency by 20% to 40%, depending on the type of gear reducer it is compared with.

In summary, a conventional conveyor drive system has all drive components that rotate the drive drum mounted externally. In comparison, the drum motor conveyor drive features no external drive components, resulting in a more streamlined conveyor design.

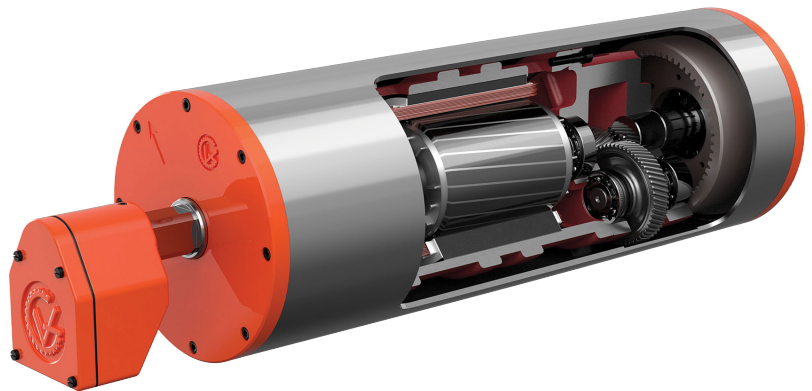
DESIGN OVERVIEW

A drum motor consists of one cylinder, the drive drum, with two square shafts on either side and an electrical connection box protruding from one side of the drum motor. The shafts are stationary, fixed and mounted to the conveyor frame, eliminating the need for pillow block bearings. The electric motor that is housed inside the drive drum is an AC squirrel cage type motor. The stator does not rotate, and therefore does not require rotating brushes or slip rings delivering power to the stator windings.

The rotor shaft is the input pinion driving either a two or three stage gear reducer. The final stage of the gear reducer is driving a ring-gear which is fastened directly to the end-flange, which is then bolted directly onto the rotating drive drum.

All internal components, including motor, gears, and bearings, are working in an oil bath. The drum motor is hermetically sealed and filled to approximately one third with oil. The oil inside the drum motor provides both lubrication and cooling. When the drum motor is running, the oil transfers heat that is generated by

the electric motor and gear reducer to the rotating drum. This heat is then dissipated by the conveyor belt.



As the temperature inside the drum motor rises, the internal pressure can rise up to 1 Atm (atmosphere) or 14.6 psi. Because of this internal pressure, it is necessary for the drum motor to be hermetically sealed to prevent oil leaks.

DESIGN SPECIFICATIONS RELATING TO BELT SPEED, HP, AND DIAMETER

Depending on the manufacturer, drum motors are available in different drum diameters, belt speeds, and horsepower (HP). The diameter of the drum

The Evolution of the Drum Motor

DESIGN IMPROVEMENTS THROUGH INNOVATION

motor is dictated by the required horsepower and belt speed. Since all mechanical and electrical components have to fit inside the cylinder, the drum motor rating is geometrically restricted. In order to achieve the required belt speed, drum motors offer a range of fixed gear ratios. When a different belt speed is required, it can be done by changing the ratio of the gear reducer or by using a variable frequency inverter.

INDUSTRIES USING DRUM MOTORS

Due to the self-contained design and the ability to withstand high pressure wash down procedures, the drum motor is a unique and attractive alternative to a conventional conveyor drive for the food processing industry. Industries using drum motors also include warehousing, airport baggage systems, postal parcel, mining, aggregate, and other various belt conveyor applications.

ADVANTAGES AND DISADVANTAGES OF USING A DRUM MOTOR

Drum motors are more mechanically efficient than externally mounted belt drives, which have the motor and gear reducer at 90 degrees. The drum motor design has the motor coupled in-line with the gear reducer, which results in reduced mechanical losses, leading to lower energy consumption without loss of torque.

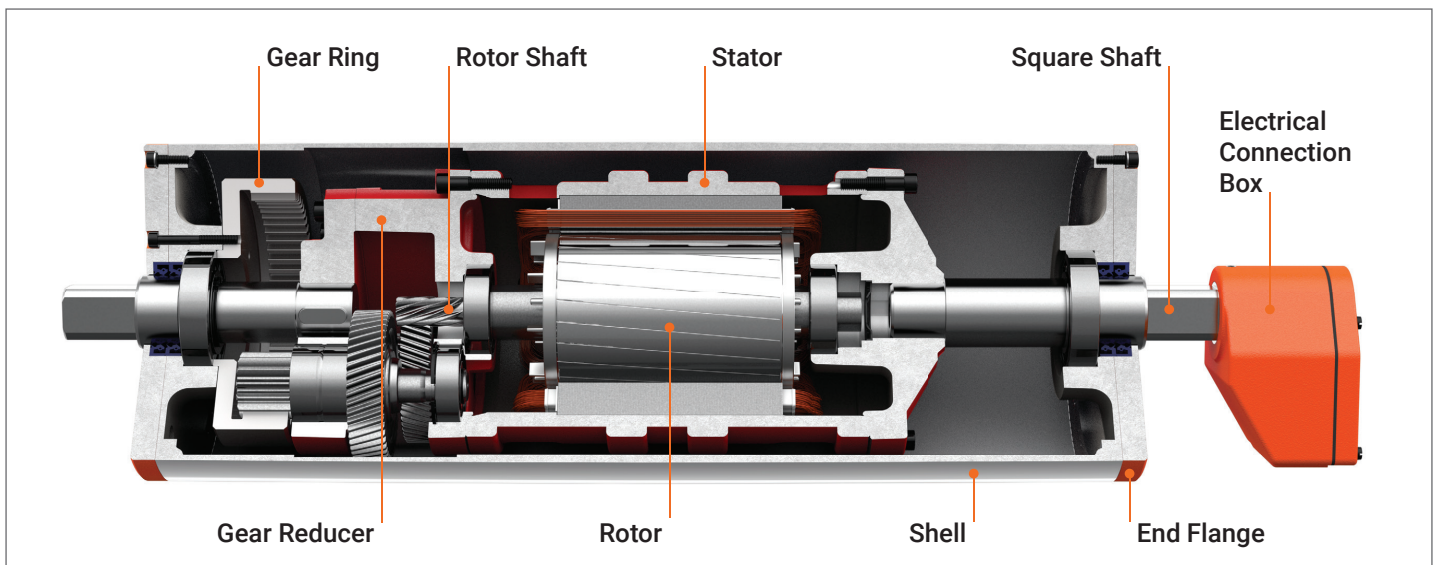
With all external drive components such as chain and sprockets eliminated, the drum motor contributes to a streamlined conveyor design and promotes workplace safety. The amount of time required to install a drum motor into the conveyor frame is much less than the time required to install a conventional external drive.

The drum motor does not require any maintenance. However, in the event of electric motor or gear reducer failure, the drum motor must be removed from the conveyor frame. Using a conventional external motor/gearbox drive system means that repairs may be completed in less time because all drive components are located externally and are therefore more easily accessible by maintenance personnel.

MARKET PENETRATION

In North America, the drum motor represents approximately 7% of overall conveyor drive applications. With all of the benefits that the drum motor offers, it would be reasonable to ask why the drum motor has such a small market penetration.

When drum motors first appeared on the market, the overall selection of belt speeds, horsepower, drum diameters, and drum lengths were very limited, with belt speed selection being the larger issue. For these



reasons, the conventional external conveyor drive solution remained most popular.

Changing belt speed on conventional conveyor drives can be achieved simply by replacing the drive sprockets, resulting in different drive ratios. Changing the belt speed of the drum motor requires removing the drum motor from the conveyor frame and changing the gear ratio of the gear reducer. This problem has been largely eliminated with the introduction of variable frequency inverters. The introduction of the variable frequency inverter contributed to a relatively small increase in drum motor market penetration.

Market studies indicated that conveyor manufacturers and end users implement the drum motor into their conveyor systems only when there are space constraints. Market feedback also revealed issues with oil leaks and premature bearing, gear, and electric motor failure. These drum motor issues had to be addressed in order to increase drum motor market share.

DRUM MOTOR DESIGN ISSUES AND SOLUTIONS

Most drum motor manufacturers are producing drum motors as a sideline to other industrial products they manufacture or supply. Combined with low market penetration, these companies have little incentive to allocate funds and resources towards research and development to improve their designs in order to increase the drum motor market share.

Established in 1985, VDG (Van der Graaf) is an exclusive drum motor manufacturer with facilities in USA and Canada, that continually invests in research and development using the latest manufacturing production technology to innovate and improve upon the drum motor design. In 2012, after an extensive two-year study, VDG developed a number of design changes that revolutionized today's drum motors. This study revealed that insufficient heat dissipation was a major issue impacting overall product reliability.

The basic principle of an electric motor design is the cooling method, and the majority of electric motors used as conveyor drives are fan cooled. This is a very effective method of cooling an electric motor. However, since all drum motor drive components are housed internally, fan cooling is not possible. Instead, the drum motor uses oil to transfer heat from the electric motor to the drum, which is then dissipated by the belt. Cooling the drum motor by oil submersion is not as effective as the fan cooling method of a standard conveyor motor.

Operating conditions can negatively impact the effectiveness of the heat transfer from the motor to the belt. If, for example, an application requires the drum motor to have rubber lagging for belt traction, the rubber lagging will inhibit heat from being dissipated to the belt. Stainless steel drum motors for sanitary and food processing applications are particularly sensitive to temperature elevations because stainless steel has poor heat transfer properties. Without sufficient heat dissipation the oil temperature rises, and the oil viscosity decreases and may not provide adequate lubrication. This will lead to premature mechanical component failure. In addition, the elevated oil temperature increases the internal pressure, which can affect the sealing system of the drum motor, increasing the potential for oil leaks.

In the past, all of these issues were regarded as an inconvenience to end users but not a major detriment. Belt conveyor engineers over-designed and were liberal when selecting motor horsepower. Frequently the specified horsepower of a drive would be double the required horsepower needed to drive the belt conveyor. Due to this over-designing strategy, conveyor drives, including drum motors, were not subjected to continuous full load conditions. Today, energy conservation is more important than ever before. Conveyor equipment needs to operate for longer hours, at full load and close to the rated drive performance. Equipment manufacturers and drum motor manufacturers alike have been facing the same challenges.

The Evolution of the Drum Motor

DESIGN IMPROVEMENTS THROUGH INNOVATION

In an electromechanical device such as the drum motor, there are two sources generating heat; the electric motor and the gearbox. The gear reducer accounts for approximately 15% of the heat generated, while the majority of the heat is generated by the electric motor. Heat from the electric motor is also generated from two sources: the current density of the stator winding, and the magnetic density of the laminated core. By increasing these densities, the heat generated by the electric motor will increase, and by reducing them, the temperature will decrease. However, reducing the current density and magnetic density of the electric motor to achieve a lower operating temperature would also reduce the amount of work the motor will produce. This would result in a reduction of torque and horsepower. Therefore, the standard method of calculating electric motor windings is not valid and cannot be used to design the electric motor for drum motor applications.

CONCLUSION

The result of the dedicated R&D conducted by VDG was a mandate for a new motor design that generates less heat inside the drum motor. The new motor design, by using a new method of calculating the electric motor windings with

much lower densities, in combination with different lamination sizes and materials with different metallurgic composition, has substantially reduced drum motor operating temperatures. The end result is a drum motor that doesn't require any heat transfer methods because it does not generate the amount of heat that affects the viscosity of the oil. The outcome of these design changes produced a more reliable, efficient, and robust drum motor with all components designed for up to 80,000 hours of continuous operation before maintenance is required. This drum motor is available in diameters from 3.1" to 42.0", with a horsepower range from 0.25 HP to 500 HP.

VDG's continuous investments has led to additional conveyor drive solutions such as the intelligent drum motor with a variable frequency inverter and motor diagnostic built in, and which is capable of communicating with central monitoring systems. The latest development from VDG is the patented IronGrip™ lagging system which eliminates lagging delamination, provides accurate belt tracking, and extends belt life. Today, the new cooler running drum motor offers an unmatched option for powering belt conveyors.

