

# Belt Conveyor Improvements for Minerals Extraction: Eastern European Lignite and North American Stone

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**Preface:** Trans Tech Publications originally published this paper in "Surface Mining, Braunkohle & Other Minerals" in June 2001 when Gresch and Gawinski were with Interroll (see note at end of paper.)

## 1. Introduction

How would minerals be extracted from continuous surface mines without reliable conveyor belt drives and idlers? This paper suggests two proven belt conveyor mechanical components to optimize surface mine conveyor systems. It also highlights trends in equipment utilization at surface mines in Europe and North America. The mechanical components described in this paper were manufactured at Interroll's FAA production center in Aschersleben, Germany.

FAA has significant experience in meeting the needs of the continuous surface mining industry because of its membership in the TAKRAF Group from 1956 to 1990. The mine operators FAA served during that period included lignite surface mines, ore mines (see Fig. 1), limestone quarries (see Fig. 1), sand and gravel pits, and salt mines. In 1990 FAA became a part of Interroll.

## 2. Continuous Surface Mining of Lignite in Eastern Europe

Industry analysts agree that the majority of new continuous surface mines and existing surface mine upgrades and expansions will be in the eastern part of Europe. Regions in which these developments will occur include: former Yugoslavia, Hungary, Turkey, Poland, Bulgaria, Greece, Macedonia, Romania, and the Czech Republic.

Local demand for electrical power and fossil fuel, as well as the size and



Fig. 1: Overview of Harz Kalk open pit continuous limestone mine in Rübeland, Germany built in 1983. Limestone is transported from quarry to processing plant via 2.2 km overland conveyor belt.



Fig. 2: One of three mobile primary crushers installed in Harz Kalk limestone mine. This mobile crusher uses a 50 HP tail-mounted motorized pulley to drive elevating transfer belt.



Fig. 3: Close-up of Interroll motorized pulley installed on TAKRAF mobile primary crusher in 1983. Use of motorized pulley simplified the mounting of this 50 HP conveyor drive in the tail position in a screw take-up.

location of coal reserves, are often cited as the leading stimuli for this anticipated mine development. For example, lignite was used to generate 76% of the electricity consumed in Greece in 1998 (up from 69% in 1996.) Lignite was used to generate 67%, 51%, 36%, 35%, and 30% of the electricity consumed in Yugoslavia, Czech Republic, Poland, Bulgaria, and Turkey, respectively [1].

During the last decade mine developers have adopted less of a centrally planned approach and more of a market-driven approach to equipment utilization decisions. This means that component suppliers such as Interroll have been able to suggest technical innovations directly to system operators and designers.

This market-driven approach has enabled us be more flexible for our customers. Our ideas were incorporated into systems more quickly than previously possible. These ideas not only included adaptations of existing technologies but also new approaches to materials handling.

What is the primary motivation for mine developers to work closely with component suppliers? It is the requirement to maximize long-term system reliability while minimizing exposure to the variable cost of production and maintenance. See Figures 2 and 3.

### 3. Stone Extraction and Processing in North America

Pressure remains strong in the North American mining industry to minimize the cost of stone and ore production. A ten-year trend of passing some of the production costs directly to customers continues.

This is very evident where customer rolling stock is required to come down into the pit, load product at the working face, go back up to grade, and travel to the jobsite (see Fig. 4). This eliminates the need for the mine operator to install and maintain a



Fig. 4: Overview of gravel pit in central Wisconsin, USA. Note that customer's truck is being loaded inside the pit. This has become typical in the USA. All crushing and screening equipment can be transported to other pits.



Fig. 5: This rig includes two triple deck vibrating screens. Two 3 HP motorized pulleys for 24 inch wide "cross belts" and four 4 HP motorized pulleys for 30 inch wide "cross belts" simplified the design, assembly, and maintenance of this congested transfer point.



Fig. 6: Transfer point on floating conveyor system at lake dredge sand and gravel production plant in Germany installed in 1992. This compact 30 HP motorized pulley protects conveyor drive motor and gearbox from wet, abrasive environment.

product delivery system from the working face up to a central loading point.

This trend has stimulated demand for light, mobile crushing and screening equipment, as shown in Fig. 5, in lieu of traditional fixed conveyors, crushers, and screens. This equipment must not only be flexible enough to move with the working face, but also be transported from pit to pit. This latter requirement, which includes the necessity to adhere to US highway clearance regulations, makes equipment compactness extremely important.

#### 4. Optimal Belt Conveyor Drive: Motorized Pulleys

The locations and physical requirements of these two types of mines vary. However, there is one common thread between them. They both need reliable and compact conveyor belt drives to handle bulk materials in harsh environmental conditions (see Figure 6).

Power requirements, tonnage rates, belt widths, and belt speeds are dissimilar. However, the mine operator's desire for high reliability and low operating and maintenance costs are identical.

Therefore, motorized pulleys are providing service in all of these areas. In general, lignite surface mines use very large, fast, and powerful drives; while stone pits and quarries use small, slower, and less powerful drives, in direct proportion to the required tonnage rate.

The motorized pulley (also known as "drum motor") includes the use of an AC motor and a gearbox within the shell of a hermetically sealed conveyor belt drive pulley. Sealing and lubricating a motor and gearbox within a pulley shell protects all moving parts while minimizing the space occupied by the drive.

The pulley is partially filled with oil to

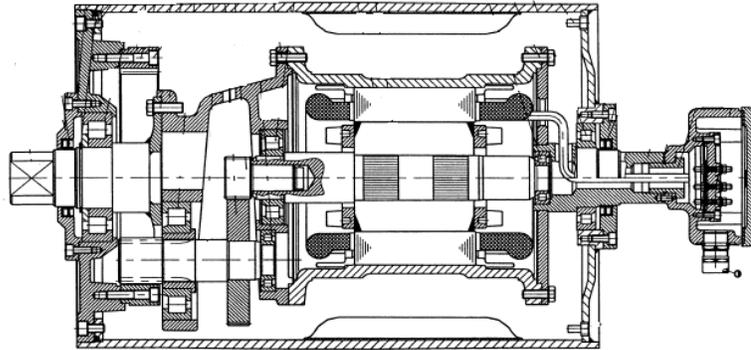


Fig. 7: Cross sectional diagram of motorized pulley. AC squirrel cage induction motor and helical/spur gearbox are shown. Note that pulley shaft is "dead" (non-rotating) and all electrical terminations are made at the shaft-mounted junction box. "Drip lips" are welded to the pulley shell inner surface to circulate oil for motor cooling and mechanical lubrication.

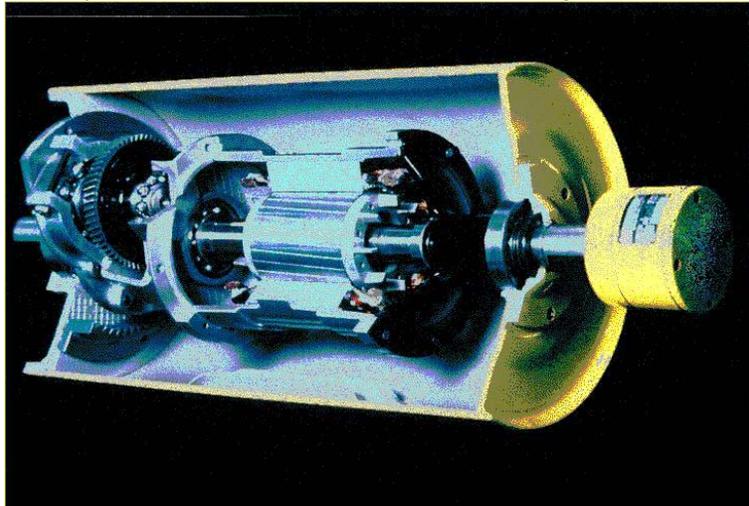


Fig. 8: Cut-away view of motorized pulley key internal components including three phase AC motor and gearbox. Units are 1/3 filled with oil (not shown) for cooling and lubrication.



Fig. 9: This 30 HP primary elevating belt drive, installed at sand and gravel facility in Germany in 1989, provided years of reliable service in harsh environment. Pulley diameter is 19.72" in diameter and drives a 30" wide belt at 300 fpm.

lubricate the moving parts and cool the motor. As shown in Figures 7 and 8, “drip lips” are welded to the inside of the pulley shell to pour oil onto the motor stator like a waterwheel. The oil draws heat from the stator and continuously transfers it to the pulley shell.

The conveyor belt then acts like an infinite “heat sink” to pull heat from the pulley shell and maintain an appropriate steady state heat for the drive system (see Fig. 9).

The purpose of manufacturing conveyor drives in this manner is to accomplish these five goals:

- increase system reliability,
- minimize conveyor drive size and weight,
- decrease maintenance expense,
- improve operator safety, and
- lower electrical power cost.

## 5. Optimal Overland Conveyor Idler: Heavy Duty Garland

Interroll’s Garland and Heavy-Duty Garland idlers have also provided a reliable, cost-effective means to support continuous surface mine conveyor belts, as shown in Fig. 10.

The conventional use of the garland idler concept is shown in Fig. 11. In 1999 Mitteldeutsche Braunkohle AG (MIBRAG) installed 12,000 of these 6.25” diameter Interroll garland idlers in a moveable conveyor system to handle overburden and lignite.

Figure 12 illustrates the cost-saving “Heavy-Duty” Garland idler innovation. Lausitzer Braunkohlen AG (LAUBAG) installed 5,000 Heavy-Duty Garlands at the Jänschwalde lignite mine in the year 2000. This special idler incorporates the use of a 12.64” diameter roller at the center position and two 7.68” diameter rollers on the wings. The center roller’s size and strength enables two of these heavy-duty garlands to replace three “conventional size” garlands on each moveable scaffold,



Fig. 10: MIBRAG used Interroll garland idlers in the 6 mile long overland conveyor system to transport overburden and lignite at Schleenhain, Germany.

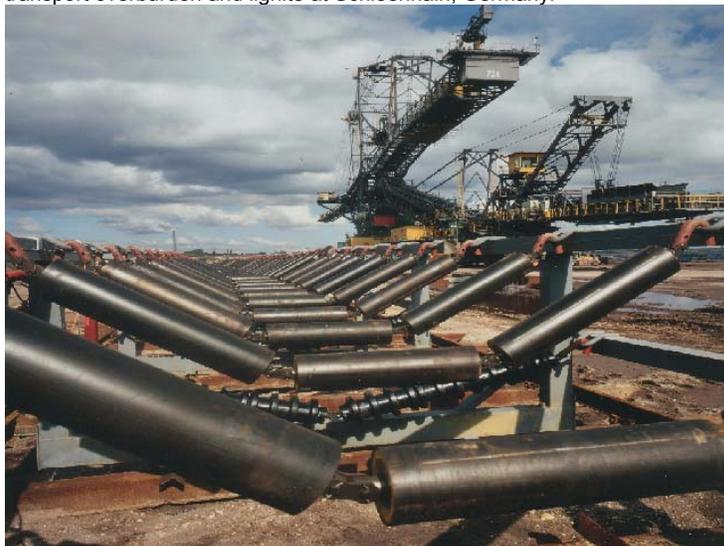


Fig. 11: Close-up photograph of moveable conveyor with Interroll garland idlers (taken during construction in 1999) at MIBRAG surface lignite mine in Schleenhain, Germany. Center roller and wing rollers have 6.25” diameter.



Fig. 12: New cost-saving Interroll Heavy-Duty Garland idlers. Photo taken during construction of LAUBAG surface lignite mine in Jänschwalde, Germany in 2000. This special idler requires two instead of three garlands per scaffold. Center roller is 12.64” in diameter and wing rolls are 7.7” in diameter.

making the overall support structure lighter, less expensive, and easier to move.

Note also that the heavy-duty roller includes the use of Interroll's non-contacting three chamber labyrinth seal (see Fig. 13). This special sealing system and the packed-for-life bearings enable the Interroll design to extend roller life in applications with abrasive material such as overburden. This idler design not only yields a life expectancy of 30,000 to 50,000 hours, it also minimizes roller noise.

## 6. Case History: Bucket Wheel Excavators

Nothing typifies the technical challenge of continuous surface mining better than the crawler-mounted bucket wheel excavator (BWE). In a sense, it is the heart of the surface mine. Why?

- The BWE must handle a variety of types of material, in some cases, light, soft, organic overburden and dense, hard rock.
- The BWE is usually located in a remote location with harsh environmental conditions.
- It must be compact and highly mobile.
- It must continuously and reliably extract overburden or minerals at a high rate, usually thousands of tons per hour.

Nothing typifies the mechanical challenge of the BWE better than driving the boom and tail conveyor belts. Why?

- They must handle product densities from 45 to 110 pounds per cubic foot.
- They must be compact to allow operator access to transfer points in case of spillage or plugging.
- They must be powerful, highly reliable, and simple to maintain.

For these reasons motorized pulleys have been the drive of choice for

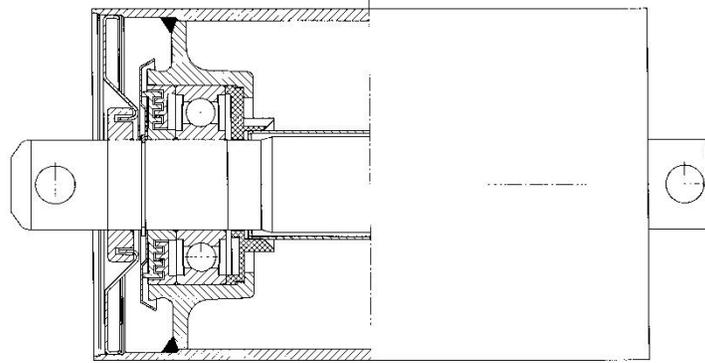


Fig. 13: INTERROLL Heavy-Duty Rollers incorporate a three-chamber labyrinth seal; use 6308, 6310, or 6312 type bearings; and have a shell thickness of 0.16" to 0.31".



Fig. 14: Crawler-mounted Bucket Wheel Reclaimer built in Germany 1963. This photograph, showing a motorized pulley on the tail belt, illustrates that bucket wheel excavator designers have taken advantage of the compactness of motorized pulleys for nearly 40 years.



Fig. 15: Interroll 75 HP motorized pulley was installed on this KRUPP Crawler-mounted Bucket Wheel Reclaimer in 1994 when the equipment was converted from hydraulic drive to three phase AC electric power. The 48" boom belt carries 1,000 tph at 620 fpm. This equipment is in service at a continuous surface mine for lignite near Skopje Macedonia.

BWE belts for decades (see Fig. 14).

In some cases operators have replaced hydraulically powered pulleys with AC motor-driven motorized pulleys to improve reliability and reduce maintenance requirements (see Fig. 15).

In other cases operators had to replace old motorized pulley designs with improved ones (see Fig. 16).

One BWE manufacturer's experience with motorized pulleys is representative of the industry. FAM, Magdeburg, formerly part of the TAKRAF Group, has produced 30 BWE since 1986. 17 of these incorporated motorized pulleys into the boom and tail belt drives (see Figures 22).

These 400 to 5,000 ton per hour BWE were placed into service handling coal, clay, sand, overburden, and potash throughout Germany, Yugoslavia, and Hungary. Boom lengths were as small as 18 feet and tail lengths were as long as 75 feet. As shown in Fig. 23, Interroll motorized pulleys (100 to 180 HP) enabled designers to provide ample access to transfer points.

In the 1960's motorized pulleys were a specialty item and equipment manufacturers were faced with rudimentary pulley designs as well as small, regional pulley manufacturers. Today's motorized pulley manufacturers supply and service products globally and, as explained in Section 9, are continuously improving their designs

## 7. Case History: Mobile Crushing and Screening Equipment

Ten years ago North American mobile crushing and screening plant manufacturers turned to motorized pulleys as they sought to improve the design of their equipment. Now American, Canadian, Norwegian, and Swedish mobile plant manufacturers all use motorized pulleys as standard



Fig. 16: DEMAG bucket wheel stacker reclaimer installed at a rail-to-ship transfer terminal for taconite pellets in Escanaba, Michigan, USA in 1967. In 1980 original Kufnagel motorized pulleys were no longer available. Therefore, 200 HP Interroll motorized pulleys were installed on boom and tail conveyors. These units are still in service, handling abrasive product in extremely cold environmental conditions.



Fig. 17: Overview of 800 tph mobile crushing/screening plant designed by US subsidiary of Swedish equipment manufacturer in 1995. US highway restrictions limited this rig to 13'-6" high by 12'-0" wide. Driving the 36" wide elevating screen feed belt at 384 fpm required 23.5 HP. Equipment designer selected Interroll's "dual drive" arrangement.



Fig. 18: Close-up of 15 HP elevating screen feed head drive pulley (in operating position.) Note optimal use of limited space. Motorized pulley was fixed to bottom of pivoting conveyor structure.

equipment [2].

One obvious place to use motorized pulleys was “cross belt” drives. These belts transfer material from one of several screen decks outward from the rig. As many as six drives can be tightly packed into the center of a double deck screening plant as shown in Fig. 5.

Because motorized pulleys require no cantilevered motor, gearbox, and V-belt assembly, they are also commonly used to drive crusher recirculating belts, under screen belts, and screen feed belts.

In 1995 one particular crushing/screening plant design required an innovative approach to drive a screen feed belt (See Fig. 17).

The system design required that the screen feed conveyor pivot from above the screen into a position adjacent to the screen for transport. The rig’s maximum width was 12 feet in order to adhere to the US highway department regulations.

Since a 25 HP drive was needed at the head end of the conveyor, but its overall width could not exceed 50 inches Interroll suggested a ‘Dual Drive’ option. This included a 15 HP unit (with a 16 inch diameter and 50 inch face width) at the head and an identical one at the tail instead of a 25 HP unit (with a 20 inch diameter and 60 inch face width.)

More than six rigs like this have been placed into service since 1995. No operators have encountered problems with the Dual Drive concept.

In Fig. 20 the screen feed belt is in the transport mode. This 36 inch wide conveyor was required to transfer 800 tph of stone from the tail to the centerline of the upper screen deck at 384 fpm and also rest onto the support bracket adjacent to the screen for transport.

The 15 HP head drive unit is shown in Fig. 18. Note that the drive pulley was easily mounted onto the bottom flange of the support structure.

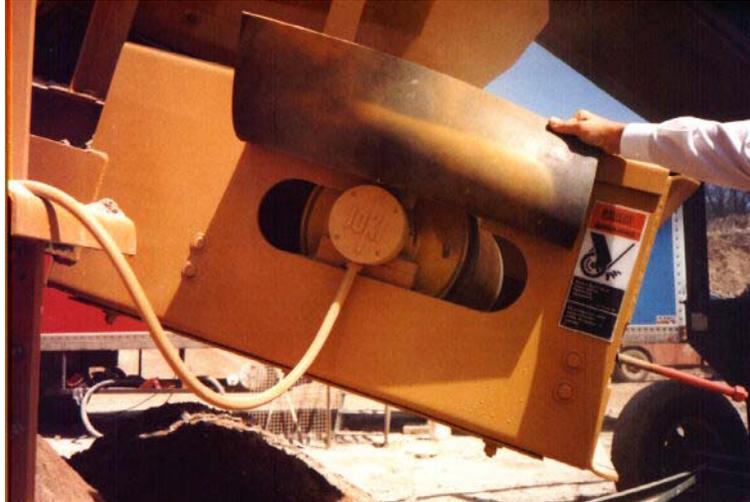


Fig. 19: Interroll 15 HP elevating screen feed tail drive pulley. Motorized pulley was mounted in screw take up. Festoon loop provides long power cord to accommodate belt stretch.



Fig. 20: 800 tph pivoting screen feed belt (pinned in transport position.) US highway clearance requirements limited head pulley maximum width to 50 inches. 25 HP drive pulley width would have been 60 inches. Therefore, two 15 HP drives were used (at head and tail.)



Fig. 21: One section of 6 mile long overburden conveyor at Lausitzer Braunkohlen AG lignite surface mine in Janschwalde, Germany. The conveyor is equipped with INTERROLL FAA Heavy-Duty Garland idlers.

The tail drive of the dual drive design is shown in Fig. 19. Note that the motorized pulley was mounted onto a screw take-up. The only special arrangement necessary was to allow enough power cable festoon loop to accommodate screw take up travel as the belt stretches.

Neither special motor nor control circuits were required. Each drive is independently powered by 460 volt 3 phase 60 Hertz power source. No effort to synchronize the drives was necessary. Normal Design C, Class F, AC squirrel cage induction motors with 5% slip at full load were used. If one motor attempts to spin faster than the other, it draws a negligibly higher amount of current.

## 8. Variable Frequency Drives and Motorized Pulleys

Variable-speed belt conveyors are now used to transport lignite and ore in open-cast mines in Germany and Chile, primarily to minimize energy consumption and equipment wear.

In 1999, for example, FAM Forderanlagen and Siemens Mining Technologies cooperated on an overburden removal for Laubag's Janschwalde project.[3]

To optimize the amount of material carried on the 6 mile long overland conveyor system (see Fig. 21) through light earth, heavy earth, mud, and rocks of the Horner plateau, a laser scanner measures material cross section on the bucket wheel excavator belt while another sensor measures excavator belt speed. A bucket wheel excavator similar to the one shown in Fig. 22 was used.

The control system continuously interprets this data in order to optimize the material fill factor on the overland conveyors. The speed of the 1,200 to 1,700 HP conveyor drive motors is varied as a function of the volume of material on the belt.



Fig. 22: Two Interroll 100 HP motorized pulleys were installed on this bucket wheel excavator built by FAM in 1998 for Tagebau Alsen AG at the Lägerdorf sand surface mine. Two motorized pulleys were also used to drive the 48" wide 1,200 tph tripper car belts at 620 fpm.



Fig. 23: Close-up of congested boom-to-tail transfer point on FAM bucket wheel excavator at Lägerdorf sand surface mine. Compactness of Interroll 100 HP motorized pulleys streamlined the design and allows room for maintenance personnel access.



Fig. 24: Close-up of one of four discharge points beneath limestone storage silos at taconite production plant in Hibbing, Minnesota, USA, taken after 1995 conveyor drive conversion.

Interroll 100 HP motorized pulleys were used to drive the boom and tail belts of the FAM bucket wheel excavator for the reasons mentioned in section 4 (see Fig. 23). No attempt was made to minimize energy consumption by varying the speed of these belts because the power difference between them and the overland belt drives is one order of magnitude.

However, motorized pulleys are commonly controlled through variable frequency drives in the USA. The reasons for this are:

- lower initial cost when compared to DC drives of comparable power
- higher system reliability and efficiency in harsh conditions
- easier to maintain and troubleshoot

A major taconite producer in Hibbing, Minnesota converted five-silo unloading conveyor belt drives in 1995 (see Fig. 24). It was necessary to continuously adjust belt speed in order to maintain a constant tonnage feed rate in the taconite ore production system. The twenty year old DC motors, sprockets and chains, and control system had become unreliable and expensive to maintain.

Interroll motorized pulleys (see Fig. 25) replaced the DC motors, chains, and sprockets; improving drive efficiency from less than 87% to more than 95%. Figure 26 demonstrates the obvious advantages of the new ABB VFD motor control when compared with the old silicon controlled rectifiers, relay banks, and timer banks.



Fig. 25: Interroll motorized pulleys at 1995 US taconite plant limestone feed system conversion. These two 20" diameter 5.5 HP motorized pulleys were controlled by ABB variable frequency drives. They replaced a 20 year old DC motor drive system.

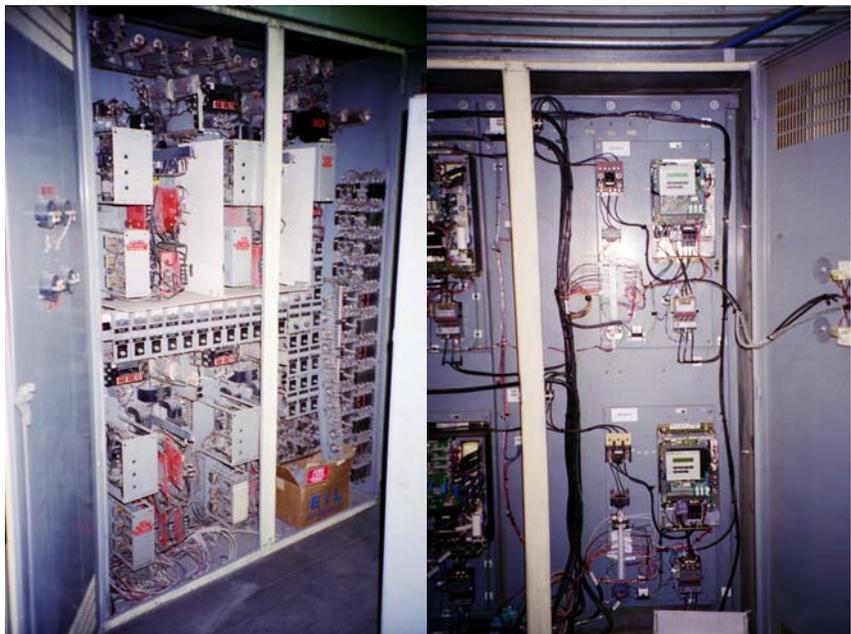


Fig. 26: Left side shows control panel of taconite plant DC powered variable speed conveyor control system taken in 1995 before conversion to AC drives. Note SCR's relay banks and timer banks. Right side shows control panel of after conversion to AC motorized pulleys controlled with ABB variable frequency drives. Elimination of SCR's and relay banks improves reliability, simplifies troubleshooting, and reduces energy loss.

## 9. Future Developments

What motorized pulley innovations and improvements should conveyor operators and designers anticipate?

Concepts which should soon be broadly available include

- "smart" motorized pulleys with built-in speed sensors
- higher efficiency motors
- high duty cycle (60 start/stops per minute) motorized pulleys with electromagnetic brakes

## 10. Conclusion

Today large, global motorized pulley and roller manufacturers meet most of the world's demand. They have taken the place of the small, regional motorized pulley manufacturers of yesterday.

These motorized pulley companies are responsible for

- developing the oil-cooling concept
- improving motor design (Class F motor with VFD compatibility is standard, Class H available as option)
- incorporating high quality cold-bonded SBR rubber lagging
- electromagnetic brakes available in a wide array of supply voltages

An international network of company-owned sales and service organizations has been essential in convincing operators throughout Europe, as well as regions such as North America that the European motorized pulley idea is beneficial.

## References

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## Note to Reader

*Trans Tech Publications originally published this paper when the authors were with Interroll. Rulli Rulmeca S.p.A., Italian idler producer, subsequently acquired Interroll's bulk handling business unit, including motorized pulley and idler production facilities in Germany, Spain, the United Kingdom, and Thailand.*

*With this acquisition Rulmeca strengthened its standing as supplier of components to the world bulk materials handling industry, completing a process which was initiated in 2000 with the acquisition of the companies of the Precismeca Group, including idler production facilities in Germany, Canada, and France.*

*Wolfgang Gresch now serves as Managing Director of RULMECA FAA GmbH, Aschersleben, Germany. RULMECA FAA manufactures motorized pulleys, heavy duty conveyor rollers, and other pulleys at this production center. Michael Gawinski now serves as President of RULMECA Corporation, headquartered in Wilmington, North Carolina. Rulli Rulmeca formed Rulmeca Corporation in 2003 to serve the North American bulk materials handling market with Precismeca Limited of Nisku, Alberta, Canada.*