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Developments and Trends in Conveyor Belts
reinforced with Kevlar Aramid Fibre

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DEVELOPMENTS AND TRENDS IN CONVEYOR BELTS

REINFORCED WITH KEVLAR* ARAMID FIBRE

SYNOPSIS

"Kevlar" aramid fibre, five times as strong as steel on an equal weight basis, is used in a wide range of industrial applications, including conveyor belts.

Currently well over 100,000 metres of conveyor belting reinforced with "Kevlar" is in use in underground coal mines, surface mines and port terminals in 13 countries. The first South African installation is at Richards Bay Coal Terminal. Other potential sites have been identified.

This paper covers the reasons for "Kevlar" being so attractive for conveyor belting as well as discussions of some of the installations where real benefits have accrued.

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* Du Pont's registered trademark

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1. Summary

"Kevlar" aramid fibre is gaining rapid acceptance as a reinforcement in conveyor belting, replacing steel and conventional synthetic fibres. Currently over 100,000 metres of conveyor belting are operating in underground coal mines, surface mines and port terminals throughout 13 countries. Based on the practical experience to date, aramid fibre can be the preferred reinforcing material for a significant portion of the high performance conveyor belt market world-wide in the decade to come.

The nature of "Kevlar" and the principal properties it can bring to conveyor belting are reviewed. Basic carcass constructions for high strength belting reinforced with aramid are discussed, with special reference to South African manufacturing requirements. Advantages of conveyor belts reinforced with "Kevlar" versus steel cord and conventional textile reinforced belts are highlighted.

Trade experience at coal mines, in iron ore mines and in port terminal operations are discussed, and it is shown how these installations compare to similar S.A. installations. Finally, development activities including those of local S.A. belting manufacturers are reviewed. These activities should lead to new applications and expanded opportunities for "Kevlar" in conveyor belts beginning with the first S.A. installations in 1985.

* Du Pont's registered trademark

2. Introduction

"Kevlar" is the high strength aramid fibre developed by Du Pont for a wide range of demanding industrial and advanced-technology applications. It has been called the most important development in man-made fibres since the discovery of nylon.

Several types of "Kevlar" are produced to meet the needs of a variety of end-uses. "Kevlar" type 956 is specifically engineered for rubber products, providing high strength and modulus along with light weight, toughness and durability. Its unique balance of properties make it ideally suited for conveyor belt reinforcement.

Conveyor belt manufacturers worldwide have recognized the value of "Kevlar" and have incorporated it in their belting lines in several styles. Over 100,000 metres of belts are now in operation in a wide variety of conveyor applications.

During a seminar organized under the patronage of the University of Witwaterstrand (1) in 1982 the South African mining community was familiarized with the use of "Kevlar" aramid fibre in conveyor belts. At the Beltcon II conference (2) held in 1983 in Johannesburg, the development status and the trade experience worldwide were reviewed. This paper gives a further update on the developments and trends in conveyor belts reinforced with "Kevlar", with special reference to the South African market.

The subjects to be covered include : The key properties of "Kevlar"; belt carcass constructions; advantages of "Kevlar" versus steel and conventional textile reinforcing fibres; current limitations; and a status indication on developments and trade experience.

3. "Kevlar" - The High Strength Belt Reinforcement

Fibres are the building blocks of a conveyor belt carcass, and as such, their properties play a major role in determining how a conveyor belt will perform. "Kevlar" occupies a unique position in the spectrum of reinforcing fibres. It has high tenacity and modulus, low elongation and creep, and good thermal stability - qualities normally associated with steel. Yet "Kevlar" retains the low density, fatigue resistance and the handling characteristics of an organic fibre.

"Kevlar" is an aromatic polyamide (aramid) with highly orientated molecules. Chemically, "Kevlar" is poly-paraphenylene terephthalamide. The key to the exceptional properties of "Kevlar" lies in the rod-like molecular structure of the polymer chain. In solution these rods begin to associate in parallel alignment. Randomly orientated domains of internally highly orientated polymer chains develop. During spinning the random domains become orientated in the direction of the fibre axis, contributing to the unique combination of properties of the fibre.

3.1 Fibre Properties

3.1.1. Mechanical Properties

Typical mechanical properties of the aramid fibres used in belting are shown in Table I and are compared to other organic fibres and steel wire. The aramid fibre has the highest strength to weight ratio, i.e. 2 to 3 times higher than other organic fibres and 5 times higher than steel. For comparable cord or cable diameters, "Kevlar" will have the same strength as steel, but will be 5 times lighter. The modulus is about 10 times that of nylon, 4 times that of polyester and about 1/3 that of steel for equal cross sections. The fibre elongation to break at 4 % is low compared with that of other organic fibres while higher than that of steel. The density is 1.44 g/cm3, higher than that of nylon or polyester, but only 1/5 of steel.

Table I

PROPERTIES OF INDUSTRIAL FIBRES

	"Kevlar"	Nylon	Polyester	Steel wire (stranded)
TENACITY (dN/tex)	19.0	8.6	8.2	3.0-3.5
TENACITY (N/mm^2)	2760	990	1150	2400-2800
MODULUS (dN/tex)	400	49	97	180-250
MODULUS (kN/mm^2)	59	5.5	13.8	150-200
ELONGATION AT BREAK (%)	4	17	14.0	2
DENSITY (g/cm^3)	1.44	1.14	1.38	7.85

The nearly linear stress/strain curve to failure of "Kevlar" is unlike those of other organic fibres or that of steel. Because it is relatively insensitive to fibre surface defects, the tensile strength of "Kevlar" is uniform along the length of the fibre; for example a twisted 1670 dtex yarn tested at 2.5 m gauge length retains 95 % of its 2.5 cm gauge strength.

The creep rates are low relative to nylon and polyester; however, they are higher than those of steel.

Extrapolation of stress rupture tests (life-time under dead-weight load) demonstrate that yarns and cables of "Kevlar" aramid will support a load of half their breaking strength for long periods of time. Although an organic fibre, its high strength and modulus, its low elongation and creep position the aramid fibre alongside steel.

The response of "Kevlar" to compressive stresses differs significantly from the tensile response.

While the fibre has very high tensile properties, its compressional strength is moderate (about 18 % of the tensile strength) and reinforcement designs must take this into account.

3.1.2. Fatigue Resistance

"Kevlar" fibres have excellent tension-tension fatigue resistance; equivalent to nylon and superior to that of steel. The inherent compressive fatigue resistance of "Kevlar" is not as good as that of nylon but is better than that of steel. However, proper choice of twist in yarn and plied cord as well as changes in reinforcement design supplies good resistance to compressive fatigue.

This has been proven through practical tests :
Several conveyor belts have shown no strength loss after 2 to 3 years in actual use. It is, furthermore, reported (3) for a conveyor belt reinforced with cords of "Kevlar" that in a dynamic test involving load cycles between 7 and 32 percent, 1.2 million revolutions were achieved on the Hannover University (RFA) test rig without any noticeable loss in strength or any sign of fatigue. (For dynamic tests of conveyor belt splices this test calls for only 180,000 revolutions).

3.1.3. Thermal Properties

"Kevlar" aramid has good thermal stability, retaining a high percentage of room temperature properties when tested up to 160 °C. "Kevlar" does not melt or support combustion under normal environmental conditions but will carbonize at about 425 °C. At arctic temperatures of -45 °C, it exhibits essentially no embrittlement or degradation of fibre properties.

"Kevlar" is thus essentially unaffected by long term exposures to temperatures experienced in most belting applications.

3.1.4. Chemical Resistance

The basic chemical structure responsible for the thermal stability of "Kevlar" also provides very good resistance to a wide range of chemicals. "Kevlar" cannot rot or mildew, and it cannot rust. Generally it requires long exposure to relatively concentrated acids or bases to affect "Kevlar" significantly.
These outstanding mechanical, thermal, and chemical fibre properties make "Kevlar" ideally suited for reinforcing conveyor belt carcasses.

3.2. Carcass Constructions

"Kevlar" is being used today as the reinforcement in high strength belting principally in three carcass constructions: cord, straight warp, and solid woven. Carcass construction influences belt strength and elongation, cover material choices, and splice options. The following is a general description of the carcass types.

Cord constructions have "Kevlar" lying straight within the carcass resulting in high strength efficiency and low elongation in use, typically less than 0.5 %. Cord reinforced belts with strength up to 3150 N/mm are in operation today. Since light pick yarns are used, breaker fabrics are sometimes incorporated in belts of this type to enhance impact-and slit-resistance. Rubber covers are used with this carcass style, compounded to meet the needs of each application.

Straight warp constructions are similar to cord constructions but have higher strength transverse reinforcement which usually eliminates the need for a breaker fabric. Commercially available straight warp belts are rated up to 2000 N/mm with a single warp and up to 3150 N/mm with a double warp.

Solid woven constructions allow incorporation of a large amount of warp yarns in a single, compact ply, allowing production of very high strength belts: up to 4000 N/mm. "Kevlar" yarn in the solid woven construction is crimped, resulting in a higher initial elongation in use of typically

1.0%. The "permanent" portion of this elongation is removed after initial tensioning and a brief run-in, leaving an "elastic" elongation in use slightly higher than that of the cord and straight warp carcasses.

Solid woven carcasses are impregnated with PVC or urethane. These elastomers may be used as the cover material or rubber covers can be provided to enhance wear and frictional properties.

Solid woven belts offer outstanding impact-and slit-resistance.

Table II gives a summary of the carcass constructions currently available.

Table II

Carcass Constructions for Conveyor Belts
Reinforced with "Kevlar"

BELT TYPE (N/mm)	CORD		STRAIGHT WARP		SOLID WOVEN
	1 LAYER	2 LAYERS	1 WARP	2 WARPS	
630	X				
800	X				
1000	X		X		
1250	X		X	X	X
1600	X		X	X	X
2000	X	X	0	X	X
2500	0	X		0	X
3150		X		0	X
4000					X

X Commercial

0 Developed, limited experience

Because of the open type of the solid woven construction which is impregnated with PVC or urethane, adhesion of the polymer to "Kevlar" is not a problem. As a result of this, the solid woven construction is a very attractive proposition to local South African converters and belt manufacturers, and trials are underway.

Were a cord or a straight warp belt to be built in this country, the dipped fabric would have to be imported. This is due to the fact that fabrics of "Kevlar" have to be double dipped at elevated temperatures and relatively high tensions to develop adequate adhesion and an attractive fabric modulus. The dipping units required to make "Kevlar" rubber receptive are not locally available at this time.

Other carcass constructions : Cables of "Kevlar" are being evaluated as direct replacements for steel cables in conveyor belts. When commercially available, this development will increase the range of belt tensions that can be met with "Kevlar", bringing the advantages of "Kevlar" to users of ultra high tension belts. Excellent fatigue resistance is one of the advantages cables of "Kevlar" offer. For example, when equal strength and diameter cables of steel and "Kevlar" are embedded in rubber, tensioned under high load, and cycled as in a conveyor over a drum, the cable of "Kevlar" outlasts the steel cable by a substantial margin (Table III).

Table III

Cycling Tests with Experimental Rubber Belts
Steel Cables and Cables of "Kevlar" Vulcanized into Rubber

Drum diameter	Load on	Number of Cycles	
(mm)	Cable (kN)	Cable of "Kevlar"	Steel Cable
620	16	686,000 1)	380,000 1)
	10.5	1,000,000 2)	1,000,000 2)
1000	16	2,000,000 3)	926,000 3)

1) Cables cut through rubber
2) Test stopped without noticable damage to cables
3) Cables of "Kevlar" without noticable damage after test; steel cable destroyed through fatigue

Cable of "Kevlar" : 6 x 19 construction, 86.5 kN, 11.3 mm diameter
Steel cable : 6 x 19 construction, 79.2 kN, 9.5 mm diameter
For futher details see reference 4.

Traditional, plain-weave designs are among the carcass types used in speciality belting. The unique properties of "Kevlar" allow it to replace asbestos, glass, steel, polyester, and nylon in belting applications where - rather than high strength- heat, chemical, fatigue and cut resistance, non-combustibility, and good electrical insulating properties are primary design criteria.

4. Advantages of "Kevlar" in Conveyor Belts

4.1 Compared to Steel Reinforcement

"Kevlar" offers the user of steel cord belts the potential to improve performance while reducing costs. Every conveyor installation is unique. In what follows, benefits derived from using "Kevlar" are summarized. One needs to consider for each installation, existing or now being planned, what advantages "Kevlar" might offer.

Corrosion-free belts of "Kevlar" will reduce maintenance costs where corrosion is a problem. If covers are accidentally cut, damage is limited to the immediate area. Repairs can be scheduled, and then made easily using conventional repair techniques.

Impact, Penetration, and Slit Resistance

Belts of "Kevlar" demonstrate better resilience under impact than conventional steel cord belts. Under most any type of impact: unexpected, high-energy drops, or continuous pounding from material transfer, "Kevlar" distributes impact energy across the belt, minimizing peak stresses and damage.

In contrast to widely spaced steel cables, the closely spaced cords in belts of "Kevlar" provide an almost continuous barrier to penetrating objects.

No belt is slit-proof. However, a carcass of "Kevlar" provides better resistance to slitting than widely spaced steel cords.

Wear Resistance : The uniform load support in a carcass of "Kevlar" is credited with providing the lower rates of cover wear (compared with similarly compounded covers on steel cord belts) observed in high impact applications; first in field service (see Table IV) and now being confirmed in controlled university tests (6).

Table IV

Comparison in Cover Wear of Bucket Wheel Reclaimer Belts

Belt Type	Duration of Test (month)	Cover Wear (mm)	Cover Wear (mm/month)
Steel Cord Belt 1	5	3	0.6
Steel Cord Belt 2	12	10	0.83
Belt Reinforced with "Kevlar"	5.5	0.5 - 1.0	< 0.18

Source : VDI - Nachrichten - Reference 5

Reduced Weight for Energy Savings or Increased Capacity : Belts of "Kevlar" are typically 20 to 45 % lighter than comparable steel belts. Weight savings are achieved in both carcass and cover.

The carcass is lighter because "Kevlar" is one-fifth the weight of steel and, unlike a steel cord belt, very little rubber is required to fill voids and distribute shear between cords.

Top covers can be thinner, and therefore lighter, while providing equal wear life. (Naturally, covers of equal thickness to those on a steel cord belt can be specified to give greater cover life). Top cover thickness can be specified considering wear requirements only rather than providing the extra thickness required for steel cord belts to minimize cover cracks that can lead to cable corrosion.

With "Kevlar", bottom covers can be thinner, providing good load support with no danger of cords slicing through to pulleys.

How significant are the weight savings ? For a 1.5 Km long installation reduced energy consumption of 20,000 German Marks/year have been reported (7). Of course, the weight savings can also be used to increase belt capacity often with no conveyor modifications.

Deep Troughing, True Running : Belts of "Kevlar" are more flexible than steel cord belts, allowing deep troughing even with narrow belts. Use with 45 degree idlers is possible. Sufficient transverse rigidity is maintained to provide good load support and protection against creasing at idler junctions.

Flexibility for good idler contact, combined with a reinforcement that more easily allows equalization of tensions, results in belts that run true.

Excellent Flex Fatigue Resistance : "Kevlar" has excellent flex fatigue resistance, inherently better than that of steel. "Kevlar" is ideally suited, therefore, for high fatigue applications such as feeder and stacker-reclaimer belts.

Smaller Pulley Diameters : Flexible, fatigue resistant, single ply belts of "Kevlar" allow the use of smaller diameter pulleys, achieving good wrap for efficient power transmission with no danger of ply delamination.

Personnel and Fire Safety

"Kevlar" can improve the safety of your operation. Where belts are used in potentially hazardous environments, "Kevlar" has the advantage over steel cord by being non-sparking and non-conductive. The danger associated with catastrophic belt breaks is reduced where undetected corrosion of steel cables is a concern and "Kevlar" eliminates risk to personnel from broken, protruding cables.

And Many Others....

Shorter transition and turning distances, for example, can be part of new conveyor system designs, as can metal detectors, for tramp iron removal with no belt interference.

Thinner, lighter belts of "Kevlar" allow shipment of longer belt sections requiring fewer splices. Faster installation is possible.

4.2 Advantages Over Textile Reinforcement

The benefits of "Kevlar" compared to steel have been covered in the previous section in some detail. It is therefore not difficult to envisage the benefits of "Kevlar" over conventional textile reinforcements. Without labouring them, these advantages may be summarized as follows :

4.2.1. Higher Strength

- Stronger belts
- Reduced number of plies (usually single ply) and therefore thinner belts and lighter weight
- Increased section belt length, therefore fewer joints
- Lower installation cost

4.2.2. Lighter Weight

- Reduced energy consumption
- Easier handling
- More flexible belts, excellent troughing

4.2.3. Lower Elongation, Lower Creep

- Longer belts
- Fewer, or even no resets
- Reduced take-up requirements

4.2.4. Improved Non-Flammability, Improved Safety

- Inherently fire resistant
- Will not support combustion
- Belts reinforced with "Kevlar" pass Tremonia gallery test
- Pass "self-rescue" breathing filter test

5. Current Limitations of "Kevlar" in Belting

As with most new product developments, some limitations exist which need further development efforts. Currently, three such areas are Dynamic Splice Strength, the Drum Friction Test, and the Cable Development (covered above). For South Africa the non-availability of dipping units required to make fabrics "Kevlar" receptive to rubber imposes a further restriction.

5.1 Splicing

Belts reinforced with "Kevlar" in all three carcass types can be made endless using vulcanized finger splices. Strong, durable splices can be prepared following procedures developed by belt manufacturers for these single ply constructions. Simple, vulcanized, overlap splices can be substituted for finger splices in some applications. Even cold-glued splices show good life.

However, the dynamic splice strength of belts reinforced with "Kevlar" is still lower that that of comparable steel cord belts, even though it already exceeds that of conventional textile reinforced belts (7). Du Pont has undertaken mathematical computer modelling of splices and has identified leads to improve the dynamic performance (8). Practical tests are currently under way to confirm the theoretical results.

5.2 Drum Friction Test

Belts reinforced with "Kevlar" will not pass the drum friction test when required to meet temperature limits of less than 325 ^{o}C (as in the U.K.).

However, when the permissible temperature is as high as 500 ^{o}C (as for example in Germany) both rubber, and also PVC and PVG belts have passed successfully. The temperature evolution during the test has been described for a type 1250 (N/mm) rubber belt reinforced with "Kevlar" as follows (3) :

"For a type 1250/1 belt as a result of the frictional heat, the temperature reaches after about 2 hours and 15 minutes approximately 415 °C, the temperature then drops again to about 255 °C. The belt does not break". It may be added that the belt does not burn and therefore passes the German drum friction test.

The South African Drum Friction Test requirements (as laid down by S.A.B.S.) differ from those in UK and Germany. No maximum temperature specifications are laid down. As "Kevlar" does not melt or support combustion, we do not expect any problems in meeting S.A.B.S. requirements.

6. Trade Experience

Eight European conveyor belt manufacturers have developed products reinforced with "Kevlar". More than 100,000 metres of belts with carcasses of "Kevlar" aramid are now in operation. Table V gives a summary of the installations by year, by length and by strength range. Since 1982 a substantial increase in installations has been witnessed. Following are typical case histories of how belts reinforced with "Kevlar" are being used today and it is shown how these installations compare to similar S.A. installations. Furthermore, the first S.A. installation is described.

Table V

CONVEYOR BELTS REINFORCED WITH

"KEVLAR" ARAMID

INSTALLATIONS

YEAR	TOTAL LENGTH (m)	STRENGTH RANGE (N/mm)
1975	600	630-1000
1976	700	1250-2000
1977	2500	400-2500
1978	7300	1000-4000
1979	5600	1000-3150
1980	8500	1250-2000
1981	6700	1250-4000
1982	12000	1250-1600
1983	37000	630-4000
1984	22000	630-2500

6.1 Case History : Iron Ore Mine

The A/S Sydvaranger Company operates one of the most remote taconite mines in the world. Its open pit mine in Kirkenes, Norway, lies 480 km north of the Arctic Circle, where winter temperatures of -40 °C are common. Harsh conditions and difficult access to the facility make dependability a principal selection criterion for their equipment.

In 1979, the company sought to increase mine capacity by 20 %. The mine was already operating 24 hours per day, so the increase meant removing the bottleneck in their operation : the 530 metre long, 67 metre lift, main conveyor that carries ore of size up to 150mm diameter from the primary crusher. It was determined that small increases in belt speed and width, combined with an increase in troughing angle to 45 degrees, would allow them to meet their production goal of 4000 tons per hour. Selection of the proper belt to replace the existing, lower strength EP belt was critical.

Rail and stockpile capacity allows a maximum 20 hour production stop at the mine before ship loading is interrupted 14 km away. Long splicing times for steel cord belts contributed to their being excluded from consideration as a replacement belt. Good transverse flexibility was required for deep troughing in the new, high tension, relatively narrow belt.

A type 3150 (N/mm), 1200 mm wide, cord belt of "Kevlar" met the company's strength and flexibility needs. A durable, vulcanized splice could be made in the short time allotted. Nylon breakers were provided to cushion the impact of the 2 metre drop from the primary crusher to the belt.

The A/S Sydvaranger Company accomplished their capacity increase. And they found the cord belt of "Kevlar" to be dependable in service. In 1983 they ordered additional lengths of this belt for the conveyors following the original one.

Although there is no direct parallel in this country, the advantage of shorter splicing times on high tension belts must be of interest to all, especially those in remote areas.

6.2 Case History - Coal Underground

Saarbergwerke AG produces 10 million tons of coal per year from 6 mines in Germany. They move an estimated 20 million tons of material annually on 345 belt conveyors having a combined belt length of 260 km. Conveyor belts in the strength range 2500 N/mm to 4500 N/mm account for 15 % of the total length installed. Once all steel cord, more than half of these high tension belts are now reinforced with "Kevlar".

Saarbergwerke became interested in "Kevlar" when one of the main belts in their Warndt mine had to be replaced after 6 1/2 years, half the expected life, because of extensive steel cord corrosion. Additionally, the belt was damaged at the edges as a result of alignment problems. EP belts could not be considered for the 4000 N/mm tension application because their lateral stiffness provided insufficient troughing.

Saarbergwerke installed a trial belt of "Kevlar" in 1977; a 2.7 km, type 2000 (N/mm), solid woven belt carrying 10,000 tons of coal per day. Their experience with this belt has been very positive. After the first 1000 hours in use, elastic elongation was measured at 0.15 %, permanent elongation at 0.8 %. Splices were made by both hot vulcanization and cold glueing. Vulcanized splices are typically the more durable, yet the average life for the combination of splices was reported to be 4 years. The belt displayed good tracking and troughing, good edge stability and no corrosion.

This positive experience led Saarbergwerke to begin a steady program of replacing steel cord belts with "Kevlar". By 1984, more than 19 km of solid woven belts reinforced with "Kevlar" were installed. Covers include both PVC and rubber (PVG).

Saarbergwerke's single longest belt is a type 4000 solid woven belt of "Kevlar" in the main gallery of the Ensdorf mine. This 1200 mm wide, PVC-covered belt has an inter-axis length of 3.5 km. The installation has 1050 kW power. Running at 3.0 m/s with a troughing angle of 40 degrees, the belt carries 1800 tons per hour.

"Kevlar" brought Saarbergwerke the reduced maintenance and repair costs they originally sought. Additionally, they have reduced down time by using mechanical fasteners routinely for belts up to type 2000 and, when necessary, for higher strength belts for up to 5 days.

Saarbergwerke also reports the use of smaller diameter pulleys with "Kevlar", making savings possible in space and capital.

Corrosion of steel reinforced belts is not generally regarded as a problem in our climate. Corrosion has been identified at a number of installations, however, and could be the cause of premature failure.

The failure of steel belts due to slitting is more widely reported. High tensile strength belts reinforced with "Kevlar" should be of great benefit to local users, where slitting is a problem.

However, the requirements of increased carrying capacity over longer distances will make belts reinforced with "Kevlar" more and more attractive. A number of installations are facing power problems. Incumbent steel belts are too heavy. The ability to increase carrying capacity without increased power requirements is an obvious advantage of using a conveyor belt reinforced with "Kevlar".

6.3 Case History - Port

The EMO port facility in Rotterdam is one of the largest trans-shipment terminals in the world, handling 100,000 tons of coal and iron ore per day. 22 km of conveyor belts are in service here.

EMO experienced extensive maintenance and reliability problems with their steel cord belts for 8 years. These included damage from tramp material on their main, sea quay belts, and rapid cover wear on their stacker-reclaimer belts. Steel cord corrosion resulted from even small cover cracks and damaged large sections of the belts.

Following tests in 1982, EMO began a programme of replacing their steel cord belts with belts of "Kevlar" as replacement became necessary. By 1984, 15 km of belts reinforced with "Kevlar" were in operation.

EMO has realized many benefits from "Kevlar". Better resistance to damage. Easier repairs that can be made in as little as one quarter of the time required for steel cord belts. No corrosion and a dramatic demonstration of longer belt life : covers wear at a rate one-third of those on steel cord belts in the same stacker-reclaimer service at EMO.

6.4 Richards Bay

The parallel of the EMO installation and Richards Bay Coal Terminal (RBCT) is obvious. RBCT is unique among world coal terminals for two notable reasons : (1) it is now the largest single coal export terminal in the world (2) it has reached its present size only 9 years after the first coal passed through the terminal.

Current capacity is 44 million tons annually (mta), and 42 km of conveyor belt are in constant service. Total train unloading capacity is 19,000 tons per hour (tph) through three tandem rotary tipplers and one random wagon tippler. The rail yard can receive 200-wagon unit trains and tipple 100 wagon trains with all rail movement within the terminal handled by RBCT locomotives. Total reclaim capacity is 36,000 tph through five stacker reclaimers and one reclaimer from a stockyard with a total storage capacity of over 5 mt. Total shiploading capacity is 26,000 tph over 3 shiploaders operating on 4 berths.

Further expansions, which will increase throughput capacity even more, are being planned. Projections for the final future capacity of RBCT have gone as high as 100 mta. However, no dates or throughput levels have yet been finalised.

The first local installation of a conveyor belt reinforced with "Kevlar" is at RBTC. Belt no. 411 is a type 1000 (N/mm), cord construction, 1800 mm wide, 312 metre long, inclined belt from an underground tippler carrying coal to yard belts. The performance of this imported belt, installed in mid-1985, will be closely watched not only by those at RBCT but also by all belt users and manufacturers throughout the country.

7. Conclusion

"Kevlar" is the proven, high strength reinforcing fibre. Its outstanding mechanical, thermal, and chemical properties deliver unique performance characteristics, which allow "Kevlar" to replace steel cord and traditional textile reinforcements in demanding conveyor belt applications. Light weight, durability, non-corrosion, ease of maintenance and installation - all add up to saving in cost and improved performance.

"Kevlar" is now used in more than 100,000 metres of conveyor belting in hard rock and soft coal, in overland applications, in quarries, ports, and underground mines throughout 13 countries.

The potential for conveyor belts reinforced with "Kevlar" is beginning to be recognised here. Potential installations where wear rates can be reduced (such as stacker - reclaimers) and where power limitations are restricting expansion, have been identified. European experience will be proven valid in South Africa as results from initial installations become available.

References

1) Pulvermacher, B., "Kevlar" Aramid as Reinforcing Material for Conveyor Belts, Proceedings of Seminar on "Kevlar" for S.A. Mining Industrie, Johannesburg, 1982.

2) Pulvermacher, B., "Kevlar" Aramid - A New Fibre Reinforcement for Conveyor Belting.
- Proceedings of Beltcon II, Johannesburg, May 1983
- The South African Mechanical Engineer, June 1983, Vol. 33, No 6, p. 144-149.

3) Jugel, R.J.W., Development of Conveyor Belts with Cord Construction of "Kevlar" from Viewpoint of Belt Manufacturer,
- Proceedings of Seminar on "Kevlar" in Conveyor Belts held in Geneva, June 7, 1984.

4) Pulvermacher, B., Entwicklungen und Tendenzen auf dem Gebiet von Foerdergurten verstaerkt mit "Kevlar" Aramid
- Proceedings of Transmatic 85, Karlsruhe, April 1985, p. 398-405

5) VDI-Nachrichten, Dec. 1982, No 51, p.9

6) Tessmann, U., Aufbau und Pruefkonzept eines Impact-Gurtpruefstandes
- Proceedings of Transmatic 85, Karlsruhe, April 1985, pg 462-469

7) Spinka, H., Conveyor Belts Reinforced with "Kevlar", - Introduction, Use and Experience at Ruhrbergbau, Proceedings of Seminar on "Kevlar" in Conveyor Belts held in Geneva, June 7, 1984.

8) Khan, S., Mathematical Modelling of Splices for Conveyor Belts - Cord and Straight Warp Structures Reinforced with "Kevlar",
- Proceedings of Seminar on "Kevlar" in Conveyor Belts held in Geneva,June 7, 1984.