CASE STUDY: ARAMID REINFORCED CONVEYOR BELT IN MARITSA ISTOK 2 POWER PLANT

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INTRODUCTION

Large conveyor belts are often made of rubber and a reinforcing carcass. These carcasses are produced from either steel or textile. Aramid is a very strong man-made fiber that combines advantages of both steel and regular textile. Using aramid can give some advantages over steel and other textiles for the user of the conveyor belt. All over the world several belts are already using aramid as a reinforcing carcass. This document describes a conveyor belt set up that is based on a pipe conveyor belt reinforced with an aramid carcass, which runs in the Maritsa Istok-2 power plant in Bulgaria.

Maritsa Istok-2 is the largest thermal power plant in the Balkans. It is located 60 km from Stara Zagora in the vicinity of the village of Radetski and the dam lake Ovcharitsa. The construction of Maritsa Istok-2 started on 7 May 1962; it was inaugurated on 10 November 1966. Between 1979 and 1995 the power station was expanded by four additional units. Maritsa Istok-2 has a total installed capacity of 1,465 MW and generates 30% of Bulgaria's electricity. It consists of eight generating units, two of which are equipped with flue gas desulphurisation plants. The rehabilitation of the older power units, including construction of FGD plants for units 1 to 6, is in progress.

In the year 2000 the first investments in re-equipping and reconstruction of the power plants started in Bulgaria. In this process also a conveyor system to transport the waste of the lignite combustion has been installed.

The power supplied by the Maritsa power plants is generated by the combustion of lignite. This process produces, besides the energy, copious quantities of ash. This ash is taken out from the plant by means of a water stream to big pools. The water penetrates through the pool’s bottom leaving the ash behind. When a pool is full, the ash dries. To re-use these pools the ash needs to be removed.

The task for this conveying system was to link the ash pools and the conventional belt conveyors that transport the ash to the dump. The focus in this document is on the reinforcement carcasses.

DESIGN CHOICES

For the transport of the ash a closed system was preferred to guarantee pollution free transport. First it was planned to include several encapsulated conventional conveyors. This means a large numbe of separate conveyors all with separate drives. The other option was to integrate a so called pipe conveyor for the long distance transport of the ash. In Figure 1 principle sketch of this type of conveyor is given. A pipe conveyor only opens at the loading and unloading area. When it is closed the two sides of the belt overlap each other, causing a true closed pipe.

The main reason for finally choosing a pipe conveyor belt is that this type of belt is a single curved conveyor line, which also encapsulates the ash. The encapsulation of the ash means that there will be no spillage along the conveyor line, which was seen as a big advantage of this option. The lifetime of this belt is also estimated to be longer due to fewer transfer points.

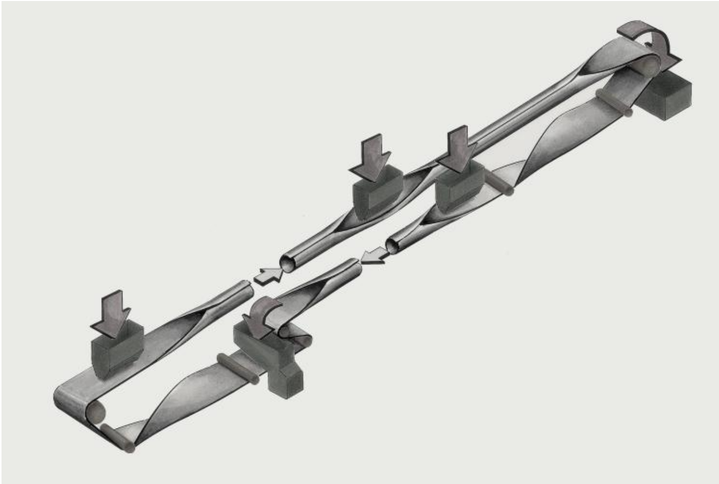

Figure 1: Principle Pipe Conveyor

The conveyor system was split into two parts. The first part (taken into service in 2000) consists of a bucket chain excavator, a movable conveyor, a collecting conveyor and a pipe conveyor with a length of 2,5 kilometers. The bucket chain excavator takes the ash out of the pool. This ash is dumped onto a movable conveyor which transports the ash via a collecting conveyor to the pipe conveyor belt to be transported it to the tip.

The diameter of the pipe of this conveyor is 425 mm and it was designed with a 1000 kW head (single pulley) and a 315 kW tail drive. The speed of the belt is 4 m/s and the belt strength 1600 N/mm. Belts of this length require an elongation as low as possible to reduce the take-up length. The maximum take-up length for this belt was only 10 m. This will limit the choice of carcass material. Some indications for take up lengths for different carcasses are shown in Figure 2. In case of a low take-up, often steel is used, but as the diagram shows aramid is also a possibility.

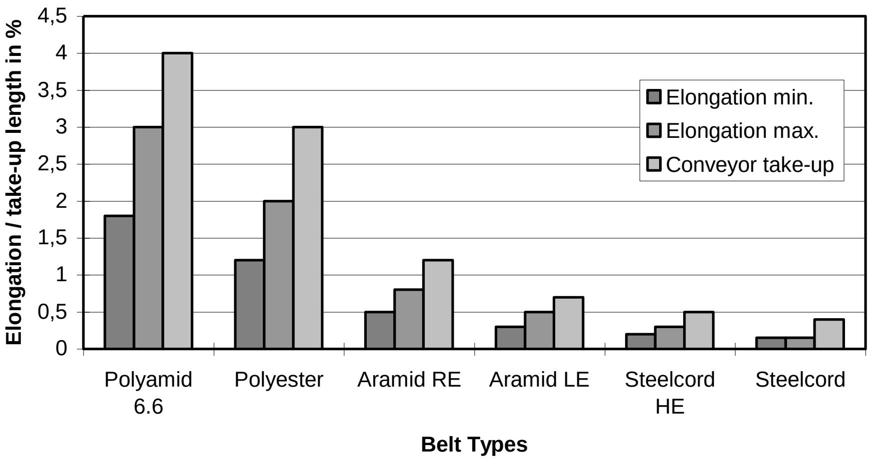

Figure 2: Elongation and recommended take-up in % of center distance

The carcass of this conveyor belt is a straight warp construction (Figure 3) made from aramid with a strength of 1600 N/mm. On the bottom of the straight warp carcass, a steel breaker, and in the top rubber layer, a textile breaker is applied.

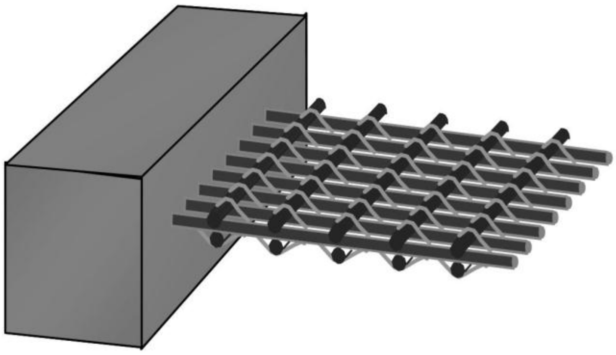

Figure 3: Straight warp fabric

The main reason for the choice of a straight warp aramid carcass was the reduced weight compared to steel reinforced belt, since power consumption was an essential point of the design. In Figure 4 a comparison is shown to give an indication of difference in power consumption between steel and aramid reinforcement. The data for this calculation are from a comparable conveyor belt.

Conveyor Data

Center distance	m	2500
Lift height	m	0
Bulk density	t/m³	1,0 (coal)
Capacity	t/h	3000
Belt speed	m/s	4,2
Belt width	mm	1400

Belt type

		ST 1800 8/4 Y	D 1600 8/3 Y (LE)
Belt weight	kg/m	37,0	20,7
Max. continuus load T_1	kN	306	270
Power consumption	kW	731	658
Pulley diameter	mm	800	630
Conveyor take-up	m	10	17,5
Belt length per 10 t	m	268	370
Number of splices		19	14

Figure 4: Comparison steel vs aramid

The weight reduction can be obtained because of two reasons. Firstly aramid is approximately 5 times lighter than steel (Figure 5). The other reason is that the belt could be designed thinner. This is because the aramid cords in the fabric are placed closer to each other compared to steel cords and thus more, but thinner yarns could be used. All together this resulted in a belt that was 35% lighter compared to a steel cord reinforced belt. The reason for applying a steel breaker in the bottom (outer) rubber layer is that this gives sufficient stiffness to create and maintain a good pipe-shape for the belt. The reason for using a textile breaker on top is that in the case of steel, this would create far to high compressive forces on the top breaker.

		Polyamid 6.6	Polyester	Aramid	Steel
Breaking Strength	N/mm^2	910	1100	2710	2360
Specific Density	Kg/dm^3	1.14	1.12	1.44	7.85
Tenacity	mN/tex	780	820	1940	330
Lase 1%	mN/tex	30	80	440	150
EAB	%	20	13	3.5	2.0
E-modulus	GPa	7	14	70	180
Melting Point	^oC	260	260	>500	1540
Continous use	^oC	180	180	300	800
Heat resistance (48h, 200 ^oC)	%	45	55	90	100
Heat shrinkage (160 ^oC)	%	4	3	0	0

Table 1: Comparison reinforcing materials

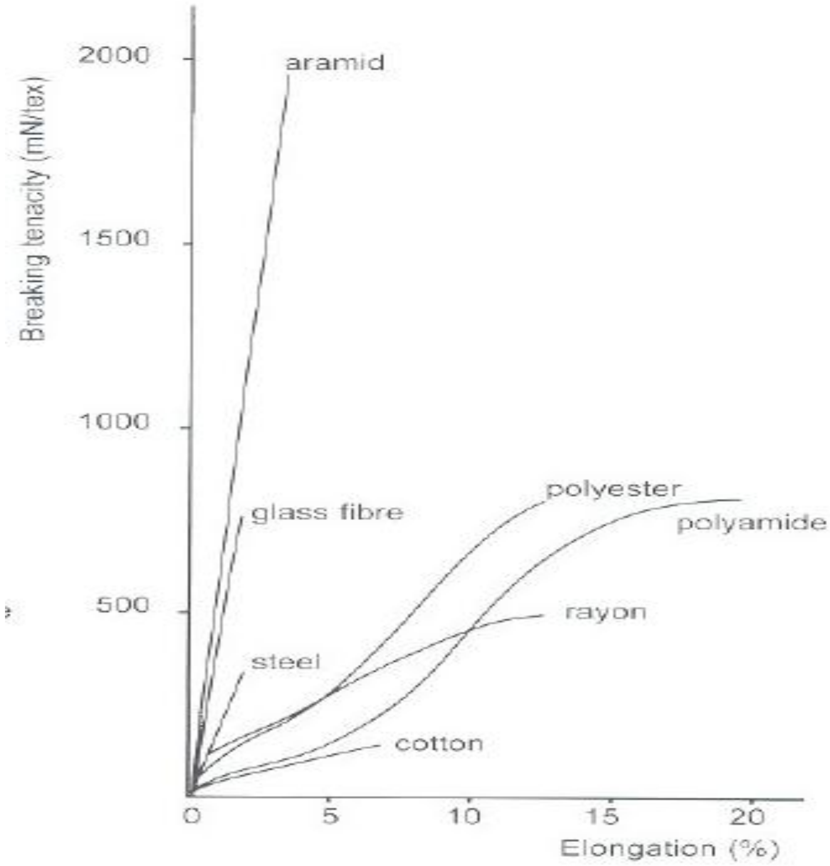

Figure 5: Stress-strain curve reinforcement materials

The start-up of the belt revealed even more power savings than expected. Because the head drive delivered enough power to drive the belt, it led to the decision that the planned tail drive of 315 kW would not be installed!

Besides the weight, also the higher flexibility of an aramid reinforced belt was an important consideration in determining the carcass material. The minimum curve diameter of the aramid reinforced pipe conveyor belt can be 20 to 25% lower than the one with a steel carcass. This gives fewer restrictions to the routing of the conveyor belt.

When specifying an aramid carcass, the three options are a cord fabric, a straight warp fabric and single aramid cords (like steel cords). These constructions use the strength of the aramid in the optimal way. Since the cords lie as straight as possible, these carcasses will result in a low elongation of the belt, resulting in a low dynamic growth. The dynamic growth from aramid-reinforced belts can be influenced via the construction of the aramid cords in the fabric.

A solid woven carcass (Figure 6) is also often used for conveyor belts, but these carcasses will not be a favourable construction for aramid. This is because of the low compressive strength of aramid. In solid woven constructions the compressive forces are significant, resulting in strength loss of the carcass.

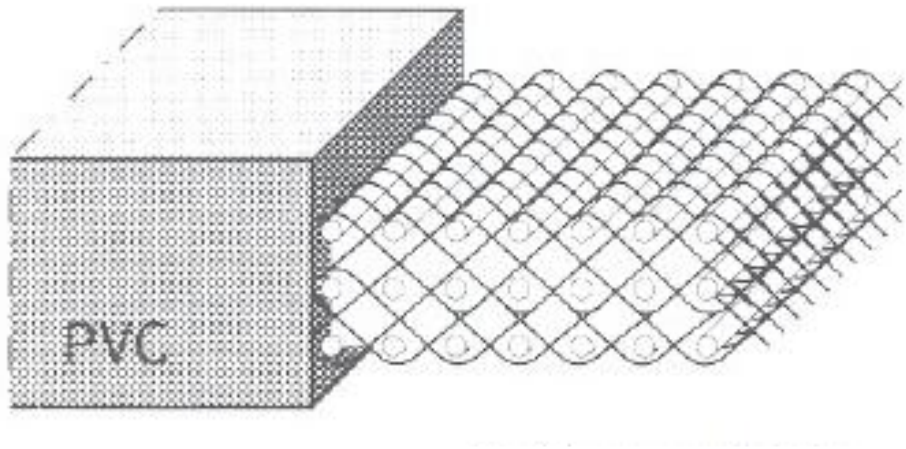

Figure 6: Solid woven carcass

The decision for a straight warp carcass (the warp is constructed from aramid and a polyamide binder and the weft consists of a polyamide yarn) in this pipe conveyor belt was taken based low reinforcement thickness and the additional transverse stiffness which is provided by the weft cords. An additional advantage of this carcass type is its slit resistance. It is comparable with that of a 4- or 5-ply EP belt or a Fleximat belt.

After several years of service it appeared that the installed pipe conveyor belt has shown no permanent elongation! This is still the case after 10 years of problem free service.

In 2007 it was decided that an additional belt would be installed in the Maritsa Istok -2 power plant. Because of the excellent performance of the first installed tubular conveyor, the decision for a second, much longer, stretch (5806 metres) was made, using an aramid carcass as well. The lay out of this second stretch is shown in Figure 7 (top view) and Figure 8 (longitudinal profile). Since this belt is more than double the length of the first stretch, the decisive points were again the reduced weight and flexibility of the belt compared to a steel cord belt. For the newly installed belt, the mass that needed to be transported with this conveyor belt was calculated to be 1700 tons of material per hour. This resulted in a design of a straight warp fabric of 2500 N/mm. This fabric was covered with 8mm NR/BR rubber on both sides (including breakers).

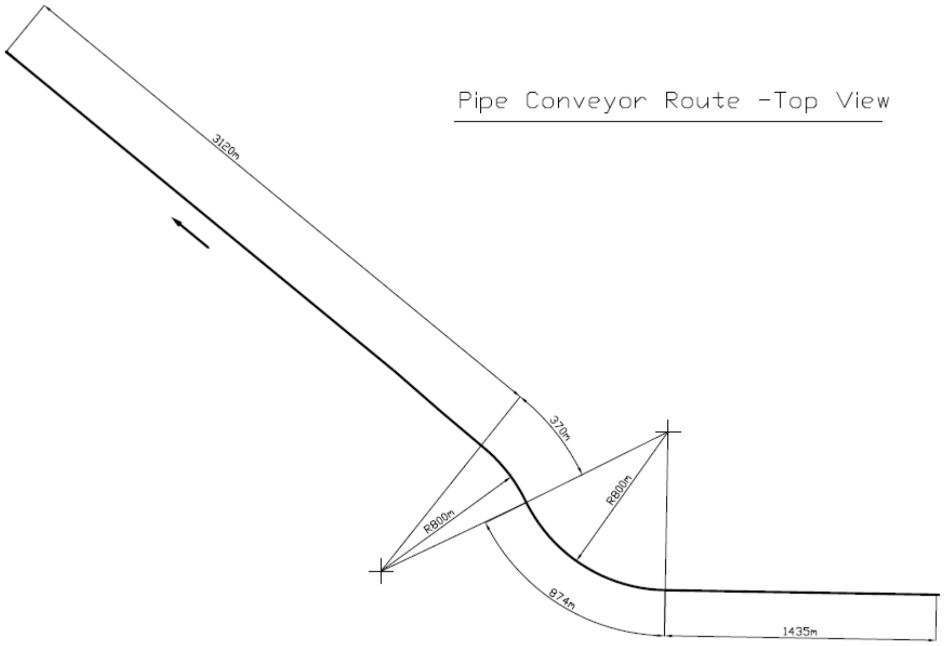

Figure 7: Pipe conveyor route – top view

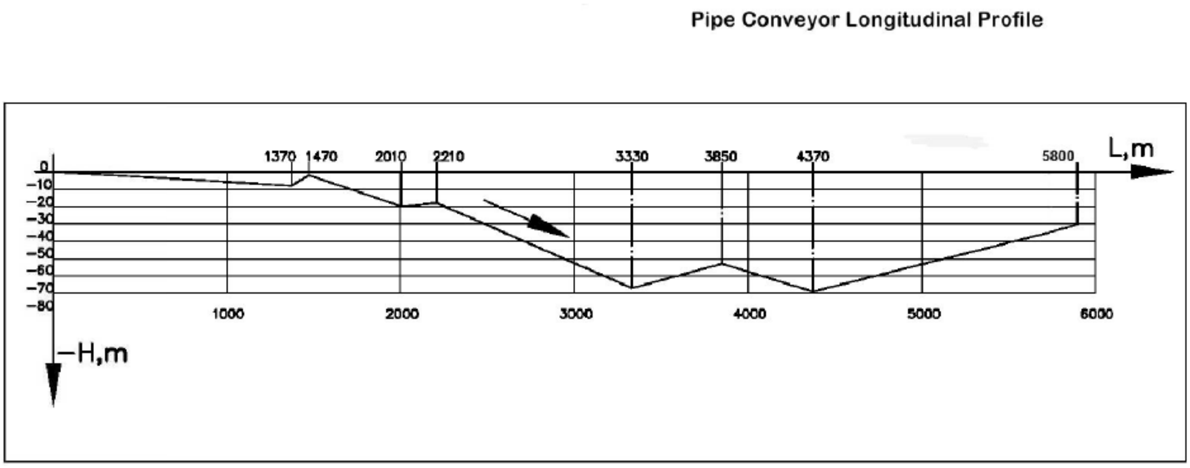

Figure 8: Pipe conveyor route – longitudinal profile

INSTALLATION

The reliability of a conveyor belt is largely determined by the quality of the splice. Since the aramid conveyor belt only contains one layer of reinforcement material, not all conventional splicing methods are suitable. There are three methods that can be used for an aramid belt. These are the finger splice, a double overlap splice and a single overlap splice. The latter is the fastest and easiest to use, but it is only useful when the aramid cords have a high twist level (higher elongation). The maximum belt strength for this splice is 1600 N/mm. The most commonly used splicing method for aramid reinforced belts is the finger splice.

For the installation of the in total 34 belt rollers in the Maritsa Istok plant a finger splice is used. In Figure 9 a drawing of the finger splice is given. It is important for a pipe conveyor that the finger splice has no splice angle (needs to be rectangular). When a splice angle is introduced, this will cause an uneven behaviour in the pipe shape.

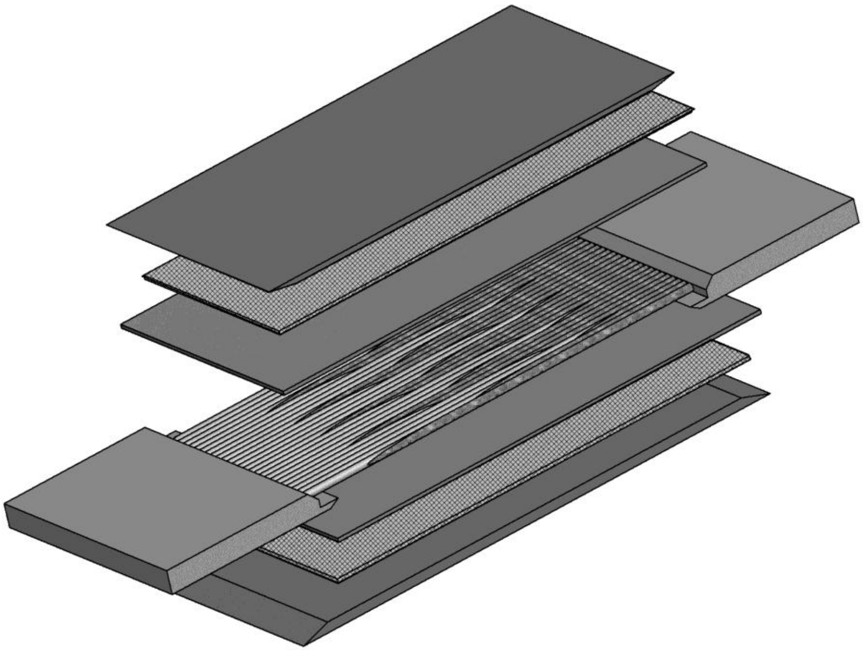

Figure 9: Finger splice

The first step of this splice is to remove the rubber layers from the aramid fabric. The next step is that the aramid fabric has to be zig zag cut to create the fingers. The fingers from both sides need to be fitted together precisely. It is very important that the alignment of the conveyor belts (and thus the fitting of the fingers) is done very accurately, since the high modulus aramid does not forgive bad splices! This process is time consuming. It is important that the cutting apart and jointing is carried out in one level (guarantees long durability). If this is performed in the right way, it guarantees that the forces are transmitted through the surfaces lying between the fingers.

After joining the fingers together, the breaker-fabrics need to be installed while renewing the rubber covering. To be able to create a good pipe shape in the conveyor belt a high transversal stiffness is necessary. Because of this, the choice of material for the breakers has been textile for the top-breaker and steel for the bottom one. To obtain a maximum strength of the splice, the breakers are designed as such that the load/tension transmission is in the length direction.

Aramid itself does not adhere to rubber without the right treatment. By cutting the fingers, the aramid in the cross-section is revealed. To guarantee the maximum strength of the splice, it is necessary to use the right bonding system that connects the rubber to the aramid again.

The time for drawing in and vulcanising of the belts in these two projects was estimated to be more than two days per splice, but during the process it was reduced to 14 working hours. The total installation was finished within the forecasted twelve weeks.

In the beginning of 2009 the second belt started service. The result of this installation is shown in Figure 10. This picture shows the construction of the framework and the pipe conveyor belt running inside this. The first stage, has been in use since 2000 and no problems have occurred since then.

Figure 10: Conveyor picture

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AUTHOR'S CV

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