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# BELTCON 3

Lowering of Safety Factors in Steel Cord Belt Conveyors/
Economical Transport using Belt Conveyors

A J Barbero

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*The S.A. Institute of Materials Handling*
*The S.A. Institution of Mechanical Engineers*
*The Materials Handling Research Group (University of the Witwatersrand)*

# THE ECONOMIC TRANSPORTATION OF BULK MATERIAL OVER LONG DISTANCES USING BELT CONVEYORS

BY : MESSRS H.M. BOCCHIETTI/A.J. BARBERO

## 1. SELECTION OF TRANSPORTATION SYSTEM

The selection of the optimum transportation system is difficult, and often complicated by the over emphasis on the need for system flexibility to reduce management risks. For this reason a number of conservative decisions were made in the past, in favour of systems such as trucks, which are regarded as being more flexible than systems such as conveyors. In recent years with the relative surge in the cost of trucking versus conveying, more detailed assessments have been made with a corresponding trend towards conveying.

Goodyear, in the USA, manufactured the first steel cord belt in 1942. This first application was very successful and worked for several years. The belt was even re-used on another installation. However, the very powerful US automobile industry, with its worldwide domination, gave the American users absolute confidence in trucking, and trucks were therefore seldom compared objectively with conveying. The result was a slow development of the conveying industry in the USA. In the USA, around 1970, although truck loading capacities increased substantially, some US industries turned towards conveying due to its savings on operating costs.

In Germany the truck industry was destroyed during World War II, and this situation promoted the development of the conveying systems in the large open pit lignite mines. Germany therefore became the leader in Bulk Materials Conveying.

The competitive materials market led to a more responsible choice of transportation system, and as conveyor specialists we have noticed an ever increasing demand for conveying systems. This, we believe, is a very good sign for the future development towards more economic long distance bulk transportation.

Before considering other continuous handling systems we would like to comment on railways.

For the transportation of personnel as well as bulk materials the railway will clearly be more suitable, although man riding conveying systems are being employed. The future in the transportation field is becoming more and more specialised. Systems are being designed for particular rather than general applications. A good example is the world's fastest train called TGV which is for transporting people only.

For bulk material transportation, in most cases, the rail operating cost per ton transported would be between 150% and 300% higher than for a straight or curved belt conveyor if :

- the annual output is more than 2 million tons;
- the transporting distance is less than 20 km. This should also apply to distances up to 80 km.

## 2. OVERLAND CONTINUOUS TRANSPORTATION SYSTEMS

Continuous transportation systems for bulk materials, with a yearly output exceeding 2 million tons, and over distances reaching 100 km, are limited to three basic types :

1. Rope - ropeways and cable conveyors.
2. Hydraulic - slurry lines.
3. Belt - belt conveyors.

Ropeways for the time being are generally limited to economical outputs of about 400 t/h and therefore can only be considered for a maximum annual output of about 3 million tons. Their main advantage is the long spans between pylons, and the consequent low cost of civil works, particularly in mountainous areas.

It should, however, be noted that the belt conveyor system, developed by REI, using a suspended pipe frame can reach a 300 m span and still remain price competitive. The 300 m span became acceptable as the "Curvoduc" (REI curved conveyor) can accommodate the curve radius generated by high speed winds on the flexible pipe frame.

Cable conveyors exist for 8 million tons per year, but are limited to about 20 million tons per year.

Hydraulic systems exist for 10 million tons per year.

Belt conveyors are feasible at 150 million tons per year, and are without doubt the most universal.

In fact a 3,15 m wide belt conveyor is already handling 40 000 t/h of bulk material. If a speed of 8 m/s the belt speed of the Selby "Stereoduc" (REI straight conveyor) were applied to such a belt, the output could reach 100 000 t/h.

Another major advantage for the belt conveyor is that it can handle very large boulders weighing several tons. This is not possible for the pipe system and cable conveyor which are limited to about 20 kg and 200 kg lumps respectively.

Regarding horizontal curves, the hydraulic system of course can accommodate the lowest radius, whilst the belt conveyor can accept :

| | | |
|---|---|---|
| equipped with textile belt | - | 200 m |
| equipped with steel cord belt | - | 500 m |

Using a belt conveyor system belt lift can be prevented even if the starting time is short (3 minutes). This is an important advantage which substantially increases the efficiency coefficient versus the cable conveyor system, where the starting time may have to be as long as 45 minutes.

## 3. BELT CONVEYOR CALCULATION

During the years 1950 to 1970, Germany invested most in conveyor research and testing. Simultaneously, the German industry started conveyor component standardisation in order to reduce production and maintenance costs. Technical norms were selected and applied, and standard calculation methods were published.

Unfortunately these calculation methods quickly became restrictive, because they were based on experience which is now outdated. They are still considered as a basis, and have inspired the European norms as well as those of the USA and UK.

The result is that the norms, not having followed the latest experience and developments, remain very conservative and have an adverse effect on capital costs, especially.

It should be noted that the cable conveyor is not hampered by these norms as it has not been standardised by an external authority.

In view of this REI took the lead to promote more realistic standards and safety factors which are based on the last 15 years of worldwide experience.

The main points which are applied in the field by REI are described below :

1. The calculation method is completely reconsidered and revised taking into account new parameters based on actual data of belt conveyors which have been operating for several years in very different conditions.

2. The use of precise measurements of friction coefficients (factors) not only for the rotation resistance, but also for belt sliding on fixed sheet or rotating rollers.

3. Belt safety factors lower than those recommended by belt manufacturers.

4. The total engineering concept oriented towards the lowest operating cost per ton handled.

It should be emphasised that REI operates in the very specialised field of Continuous Handling Equipment for Bulk Materials and have therefore devoted their entire attention to the development of the technology. This is not the case for most engineering companies which have to study complete plants or mines (turnkey projects) where the capital cost is very often the only factor under consideration, and where the transportation means represents only a few per cent of the total investment. It has been noted that the major consideration being ignored is generally that of the operating costs.

## 4. MORE ACCURATE CALCULATION METHODS AND FRICTION COEFFICIENTS

As explained above, since 1962 we have considered measured results on long overland belt conveyors in order to improve existing factors included in calculation formulae.

The Rankine formula has been valid for two centuries and still is. However, most designers, not having the opportunity to obtain actual full scale measured results of plant operating for several years, have no way of refining the factors contained in standard established formulae for power and tension.

The importance of these factors increases tremendously on curved conveyors, because they directly affect the belt stability which if incorrect creates major problems.

It is our experience that :

- the friction coefficient from the load is not constant or uniform. The same coefficient should not be applied to the load and to the belt;
- the deformation coefficient of the belt on the rollers is different to that for the cables on the "polyrim" lined pulley;
- the theoretical coefficients often applied to long conveyor lengths (for example 5 km) are not close to reality;

Some companies suggest a fixed friction coefficient of 0,014. However, in reality it must be recognised that the coefficient is dependent not only on the component but also on the temperature variations, even when very small. On the other hand, based on several installations operating in winter at -50° celsius, it is noted that the friction coefficient variation is lower than the one recommended officially in the international norms.

More difference exists for the frictions between the drive drum and the belt.

In conclusion we are insisting on the fact that if we follow blindly the calculation methods given by the norms, we will never obtain the up-to-date technique. Worse still we will never operate at the lowest operating and capital cost.

THE STANDARDISATION OF CALCULATION METHODS HAS BEEN AND STILL IS A MAJOR HINDRANCE TO CONVEYOR DEVELOPMENT.

## 5. LOWER BELT SAFETY FACTORS

As in the case of the calculation methods and the choice of several coefficients, the belt safety factor is also a coefficient of uncertainty.

This factor has been evaluated by the belt manufacturers and published in all specialised magazines.

Belt manufacturers seeking direct sales to the final users, offered help to calculate the belt specifications. Naturally they wanted to protect themselves for the belt warranty in order to reduce the risk. Very high safety factors were therefore employed in order to compensate for eventual error in the component quality, or incorrect erection and belt vulcanisation. The accumulation of all these factors led to the exaggeration of the belt price. In some cases the belt cost alone represented 40% of the total investment. In addition, due to the fact that the belt weight is higher than it should be, the energy consumption is higher and therefore more expensive. This largely explains the slow development of the belt conveyor system.

The NCB for the Selby South Drift has accepted a belt safety factor of 5. Such acceptance represents important progress on this issue. A large gap, however, still exists. Cable conveyors not subjected to the same constraints, are being based on safety factors slightly below 3, and this safety factor is used on cables which are not protected against rain, sun, etc.

Too often we have to face an over investment in belt class.

In the Selby case a steel cord belt ST 7100 has been chosen because the NCB accepted a safety factor of 5.

With a more realistic safety factor the Selby steel cord belt would have been ST 4500. Today in 1985 the investment savings on the belt alone would be close to R300 per metre for the total length (30 km) - R9 million.

## 6. COST COMPARISON BETWEEN BELT CONVEYORS AND OTHER SYSTEMS

Many comparative studies have been carried out, particularly by university students and engineering companies. The results of the studies carried out by the student teams have generally been published. Unfortunately, very seldom have comparisons been made of actual equipment operating for several years.

REI has performed a number of such studies and some examples are quoted. For these studies all the savings calculations were carried out by the users and based on several operating years.

First of all we had the opportunity to substitute the trucking system at the Potasas De Navarra in Spain.

In 1963 it was the longest belt conveyor - 4 km with an output of 620 t/h. In 1969 the output was increased to 1 000 t/h.

The installed power for the conveyor is 400 hp compared to 1 750 hp for the trucks, which represents an energy saving of 77%. In 1969 with the increased output the energy saving became 85%, and operating and maintenance personnel savings 90%.

The capital cost comparison is also interesting.

At the starting date, when the conveying system was running at 620 t/h, the conveyor capital cost was 15% higher than that of the trucks. But when later the output was increased to 1 000 t/h the conveyor capital cost was 13% lower than that of the trucks.

These price comparisons are based on 1970 price indices. Today even for the output of 620 t/h the capital cost of the belt conveyor would be lower than that of the trucks. The lowest output limit for a breakeven on capital cost today would be 350 t/h, and this excludes the operating cost with the high increase in the price of oil.

In another similar case 3 years later the capital cost for the belt conveyor was only 4% higher than that of the trucks at an output of 1 000 t/h.

Several years later the truck investment was 37% higher than the conveyors, whilst the conveyor provided energy and personnel cost savings of 94% and 90%, respectively.

Another very interesting example is worth considering :

The Selby Mine - South Yorkshire, UK

Firstly we would comment on the cable conveyor.

As is well known, the cable conveyor involves several studies and patents, but only one manufacturer has developed it.

Conceived in 1949 the British cable conveyor uses external cables, which are traction components carrying the special belt with two grooves, one for each cable.

The two functions traction and loading are separated. This widely contributed to its UK development, and was not really influenced by the continental steel cord belt development. The first installation started in 1951 and permitted the modernisation of British coal mines. The first ten orders were placed by the NCB, and of the first 30, 23 were ordered by the NCB. In a 7 year period the NCB represented 70% of the total market.

It was generally accepted that for the Selby coal mine only a cable conveyor would be used; it was even published as such in the press in July 1976.

As is now well known, the technical progress in belt conveyors was so profound between 1949 and 1976 that finally the NCB placed one order for a cable conveyor (North Drift) to Cable Belt and one order for a belt conveyor ("Stereoduc") to ASL/REI (South Drift).

The "Stereoduc" of ASL/REI was commissioned in June 1983.

The cable conveyor started to operate two years later in June 1985.

The comparative data at this stage cannot draw operating cost comparisons as the results are not yet available, but in October 1978 the British newspapers published the amount of the two orders placed simultaneously :

- £16 million for the cable conveyor
- £20 million for the belt conveyor

The requested output from the first drift i.e. nearest the head end is :

- 2 800 t/h for the cable conveyor
- 3 200 t/h for the belt conveyor

The long life warranty has been given by each manufacturer company for the belt rollers and power unit drive components.

On the belt conveyor "Stereoduc", satisfactory tests have been made at 8,4 m/s on the belt, and for two years it has been operating satisfactorily. During the period 1983 - 1985 the stereoduc has handled not only coal but also waste material coming from the tunnel drills.

A very precise and objective comparison of the two systems will be made presently, not only for the operating cost but also the energy consumption. It was claimed that the cable conveyor system required less power than any other system. The longevity of the main components, such as the belt and rollers, will also be a major consideration in the operating cost development.

The NCB choice for such an important order represents a significant show of confidence in steelcord belt conveyors, coming from the largest European coal producer. Indeed the NCB will get several important, technical and economic results, for the benefit of themselves and all belt conveyor users.

This very modern installation contributed substantially to achieve 30 world records.

## 7. USE OF DESIGNERS WITH RELEVANT EXPERIENCE

There is never a unique technical solution to a transportation problem. For that reason many competent and skilled engineers working in specialised companies are always bringing original and economical solutions.

On that subject we can give a lot of examples but will limit these to only two.

As explained at the beginning of this lecture trucks have, for years, been the leading transportation means in earth moving.

It must also be recognised that the manager of a large earth moving working site, who had never used conveyors before, would prefer to use dumpers or large trucks based on two main ideas :

a) Flexibility.

b) Short conveyor working life for the investment recoupment.

For flexibility the conveying system has already proven, worldwide, that it can easily be adapted in a large scale wherever bulk material with a high output has to be moved.

Generally, in contracting works or earth moving projects the duration of the job very seldom exceeds four years. For such a short period all the investment must be recovered, even if, after such a short time, the conveying system is re-usable.

REI has delivered a curved conveyor, for example, for tunnel waste removal which would have an operation life of only one year. Of course this conveyor was studied with the special concept of simplicity, in order to make the investment justified for such a short period.

Another installation was provided to transport a total of 7 million tons of construction material over 6,7 km in 3 years, although it seems abnormal to invest a complete overland curvoduc for such a limited duty.

This was what our REI curvoduc has done for the runway construction of the new Djakarta (Indonesia) Airport.

In this case the concept was based on two main considerations :

a) Investment repayment in 3 years.

b) Short delivery time.

## 8. CONCLUDING REMARKS

Conveyors are being employed increasingly in long overland bulk transportation systems. We should always try to adapt the belt conveyor concept to the final needs based on three objectives.

a) Lowest total cost per ton of bulk material transported.

b) High reliability or work efficiency coefficient (close to 98% in our main references).

c) Use of appropriate safety factors and design coefficients for the optimum life rating, maintenance protection and economics.

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