CONVEYOR CHAIN EXPERIENCE AT MALELANE MILL

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Abstract

A practical approach was adopted in the selection and design of conveyor chain links in various materials, the emphasis being on long life, cost reduction and improved time efficiency. Roller chains are compared with rollerless chains, particularly with regard to maintenance, and results from service experiments at Malelane are presented.

Introduction

In a sugar factory maintenance costs and time efficiency have an important bearing on overall efficiency.

Any stoppage in the factory e.g. a faulty conveyor, causes a front end stoppage which has an adverse effect on production and may entail, if it persists, the added expense of burning coal. At Malelane, stoppages due to slat conveyor chain failures accounted for more than 10% of lost time.

Investigation

It was decided that there was no alternative to the use of slat conveyors for carrying shredded cane and bagasse and after examining the problems associated with the use of the roller chains it was concluded that —

(a) there are too many wearing parts in roller chain;
(b) dirt and sand cause the chain to seize and the resultant skidding causes roller wear;
(c) inconsistent quality of chain parts causes early failure;
(d) pin failures are largely due to excessive hardness i.e. lack of quality control during the hardening process;
(e) excessive wearing of the bushes causes side plates to skid on the mild steel liners so that both wear down rapidly.
(f) replacement of a broken pin in a roller requires a special tool and is a lengthy operation.

Most of the chains at Malelane were being replaced twice a season, at great cost.

Design

It is considered that a good chain should :—

(a) last at least two seasons;
(b) be reasonably priced i.e. considerably cheaper than existing chains;
(c) be of good quality and reliability so as to ensure good time efficiency;
(d) be designed so as to ensure easy renewal of pins and links;
(e) have a weight to strength ratio that at least matches that of present chains so that existing drive units can be used;

It was also decided that the strong chain required for the greater load on the de-watering mill feed conveyor should be the standard chain for the other front end slat conveyors.

Selection

The rollerless chains used on elevators in the cement and fertilizer industry appeared suitable provided it was possible to design a link with an attachment for fitting slats.

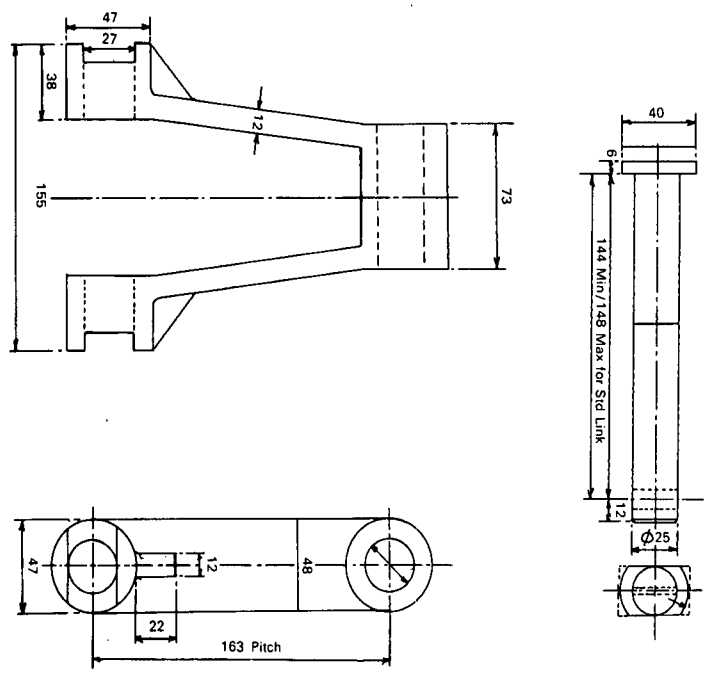

FIGURE 1 Apex 6 Plain Link

It was thought that if the chains could stand up to the abrasive nature of cement they should be successful on bagasse conveyors which contain 2 to 3% sand.

A trial was carried out on the dewatering mill feed slat conveyor using this type of chain, cast in alloy steel (trade name Apex 6).

In order to use the chain it was necessary to modify the tail sprocket tooth profile so as to give it a saw tooth profile to accommodate uneven stretching of the chain.

Material

The first chain used was cast in a material consisting of 1% chrome and chemically matched EN18A with forged pins of EN57 hardened to 325 Brinell Hardness (BH).

The links were hardened to 350 BH and the weight of the chain was 13,2% lighter than the roller chain. Increased load on the drive motor at maximum crushing rate was less than 5%.

Discussion

Serious pin failure causing several lengthy production delays, was experienced after conveying approximately 350 000 tons of cane.

The type of fracture was consistent with brittle fracture and the EN57 pins, which showed very slight wear, were replaced by forged pins manufactured from EN24, hardened to 285BH.

These pins were far more successful but the next problem was the excessive stretching of the chains. This appeared to be caused by wear in the roughly cored pin holes as cast. The uneven stretching often caused downtime when the slack chain fouled on the head sprocket.

To avoid these problems continuous attention had to be given to tensioning the chain but it was used to the end of the crushing season.

The next season Apex 6 chain was installed on the mill feed slat conveyor, but with new pins, again EN24 but hardened to 285BH, and there was a considerable decrease in downtime due to chain failure. However, links that did fracture showed excessive porosity and evidence of underfilling during casting.

There were far less failures and stoppages on the shorter diffuser slat conveyor even though a second-hand chain was used but this could have been due to a lighter load on the chain (shredded cane as opposed to saturated bagasse on the de-watering mill conveyor.

To reduce wear and frictional resistance between slat and mild steel wearing strip, the mild steel wearing pad on the slat was replaced with a pad cast in SG70 iron (see Figure 2), giving cast iron on mild steel instead of steel on steel.

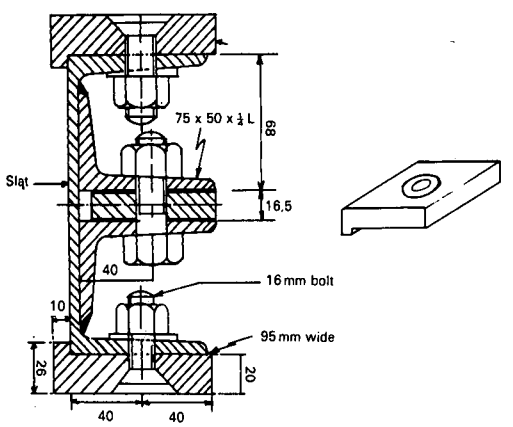

FIGURE 2 Cast Wear Pad TMF SG 70

The result was most successful and resulted in a saving in maintenance costs as wearing strips are no longer replaced each season, having a life of two to two and a half seasons.

Link failures were rather excessive due to poor quality. Many fractures showed serious porosity and in several instances the links were extremely hard (400 to 430 BH). Because of the inconsistent quality, it was decided to change to a different material and spheroidal graphite grade 70 iron was suggested because of the success experienced with the wearing pads i.e. good abrasive resistance, which for a drag type chain is a major consideration. Further more, SG iron castings were likely to be cheaper.

In order to run an experiment concurrently with the Apex 6 links, sixty five links were cast in SG 70 iron to a design similar to the existing Apex 6 links.

Because of the lower ultimate tensile strength of the SG iron as opposed to the alloy steel, the cross sectional area of the SG 70 iron links was increased so that a chain consisting of SG iron was now only 5% lighter than the original roller chain.

Two links of both the Apex 6 and the SG 70 iron were submitted to the National Physical Research Laboratory of the CSIR[1] by the foundry with a specific request to compare the abrasive resistance of both materials and to carry out metallurgical examination and mechanical testing.

Results of Tests

Mechanical Tests

Both chain links were tested to determine tensile strength, yield strength, % elongation, % reduction of area and Charpy impact strength. (See Table 2).

The SG iron met the mechanical requirements of the high tensile grade BS 2789 — 700/2, the test indicating that the alloy steel links were low on elongation. The ratio of yield strength to tensile strength was 90% which again indicated that the material was low in ductility.

These tests showed that the yield strength of the SG iron was approximately 30% lower than that of the alloy steel and therefore it was necessary to alter the sectional dimensions of the link to accommodate lower yield strength.

Abrasion Tests

The samples were abraded for a given number of cycles and at a fixed load against a bonded abrasive paper. Both samples were tested under identical conditions.

TABLE 1
CHEMICAL TESTS

	% C	% Si	% Mn	% S	% P	% Ni	% Cr	% Mo
Cast Iron	3,68	2,68	0,24	0,010	0,037	N/A	N/A	N/A
Alloy Steel	0,28	0,25	0,55	0,012	0,032	0,61	1,12	0,20

TABLE 2
MECHANICAL TESTS

Material	Sample Number	Tensile strength (MPa)	Yield strength (MPa)	Elongation (%)	Reduction of area (%)	Charpy (J)
SG iron	1	787	555	4,0	2,9	3,0
Chain	2	852	561	5,7	4,2	2,5
Link	3	—	—	—	—	2,0
BS 2789	Spec	700	—	2,0	—	—
700/2	—	Min	—	Min	—	—
Alloy steel	4	1,021	922	10,0	25,3	29,0
Chain	5	1,031	948	10,3	25,6	38,0
Link	6	—	—	—	—	31,0

The average weight loss of the test run was 24,75 μg/mm² for the SG iron and 144,3 μg/mm² for the alloy steel.

Therefore, it is clear that the abrasive wear resistance of the SG iron is considerably higher than the alloy steel, probably due to the lubrication effect of the graphite.

Trials With the SG Iron Links

The following season sixty links cast in SG 70 iron were included in the diffuser slat conveyor, the balance being Apex 6 links (See Figure 3). The SG iron links were cast with cored holes but it was decided that the holes should be drilled out to provide a better fit for the pins. Forged pins were used made in EN 24 and hardened to 285 BH, machined down from a standard 25 mm diameter pin to 23,8 mm diameter.

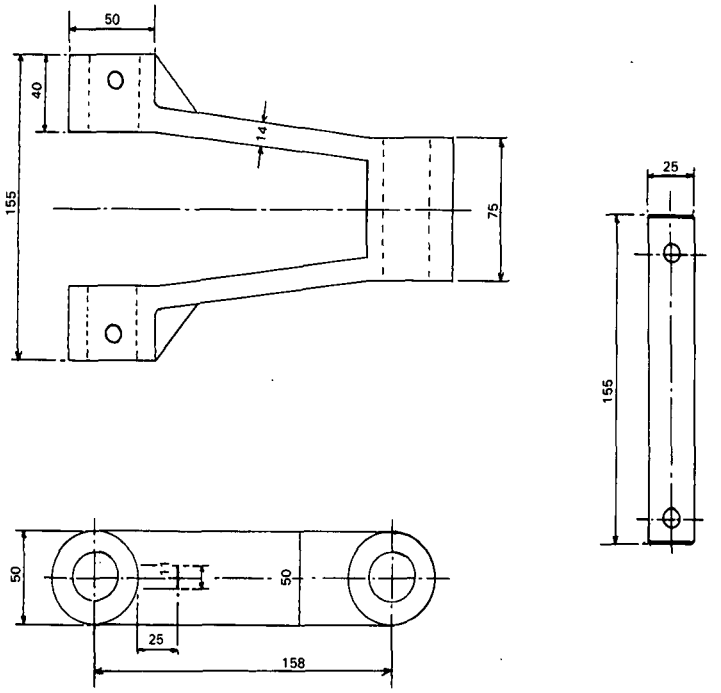

FIGURE 3 TMF SG 70 Plain Link

During that season, there were several fractures of the Apex 6 links but not one failure of the SG iron links. At the end of the season, the SG iron links were only slightly worn and these links were used in the diffuser discharge slat conveyor together with Apex 6 links. Again no failure occurred — these links had now been used to convey a total of 3 070 000 tons of cane.

It was now decided to proceed with the testing of an entire chain cast in SG 70 iron.

All the links were cast without cored holes and all the holes were drilled in our own workshop using a double head attachment ensuring that the chain would have a perfect pitch and with the desired tolerance between pin and hole. Once again the forged pin machined down to 23,8 mm diameter was used, hardened to 285 BH.

There was an absolutely trouble-free run during the crushing of the first 750 000 tons of cane, but then pin failures were experienced consistent with hydrogen embrittlement fractures. However, even this caused only a few hours actual production delay because most of the broken pins were picked up on the weekly inspections and replaced with EN 24 pins, unhardened. These pins gave no further problems and 1 681 965 tons of cane were successfully crushed and downtime due to chain failure was reduced quite considerably.

Slat Conveyor Downtime

Prior to 1978/79, there was no break down of slat-conveyor stoppages. In the 1978/79 season, the downtime due to FE slat conveyors amounted to 85,8 hours which represented 10,7% of the total mechanical stoppages.

In the 1979/80 season, the downtime due to FE slat conveyors amounted to 41,1 hours which represents 5,2% when referred to the base year, 1978/79.

In the 1980/81 season, the downtime due to FE slat conveyors amounted to 69,4 hours which represents 8,6% when referred to the base year 1978/79.

In the 1981/82 season, the downtime due to FE slat conveyors amounted to 32,5 hours which represents 4,0% when referred to the base year, 1978/79.

Thus, the total improvement in FE slat conveyor downtime was 62% from the 1978/79 season to the end of the 1981/82 season. (See Figure 4).

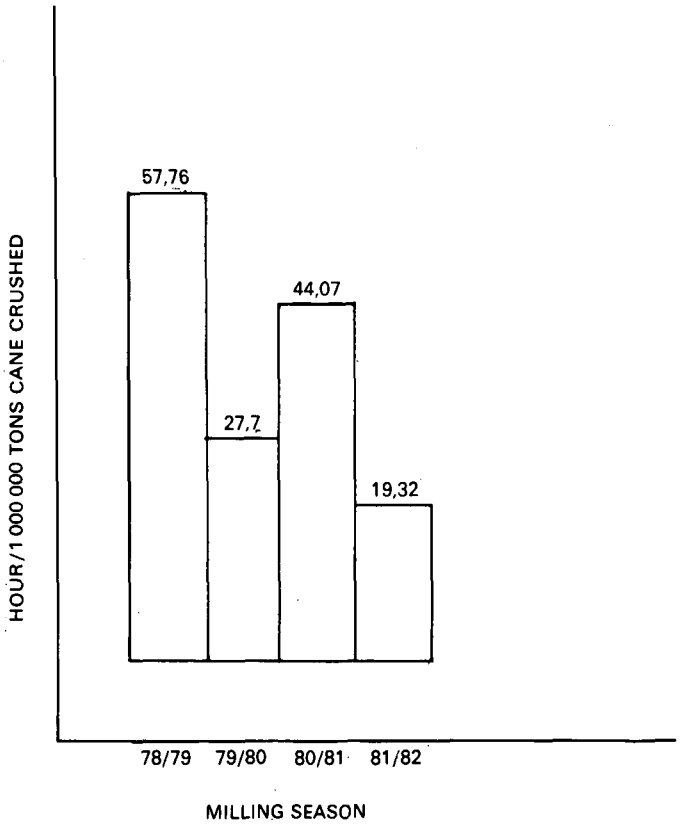

FIGURE 4 Slat Conveyor Downtime per 1 000 000 Tons Cane Crushed

Costs

Price index of various chains :	*Index-number*
Roller chains as originally used.	200
Apex 6 chain.	176
SG 70 iron.	152

Total Savings Effected on Slat Conveyor Chains by Using SG 70 Iron Links Instead of Roller Chains

	R	%
De-watering mill feed conveyor.	9 813	44,3
Diffuser feed conveyor.	5 747	44,3
Diffuser discharge conveyor.	7 155	44,3
Main carrier.	18 000	42,8

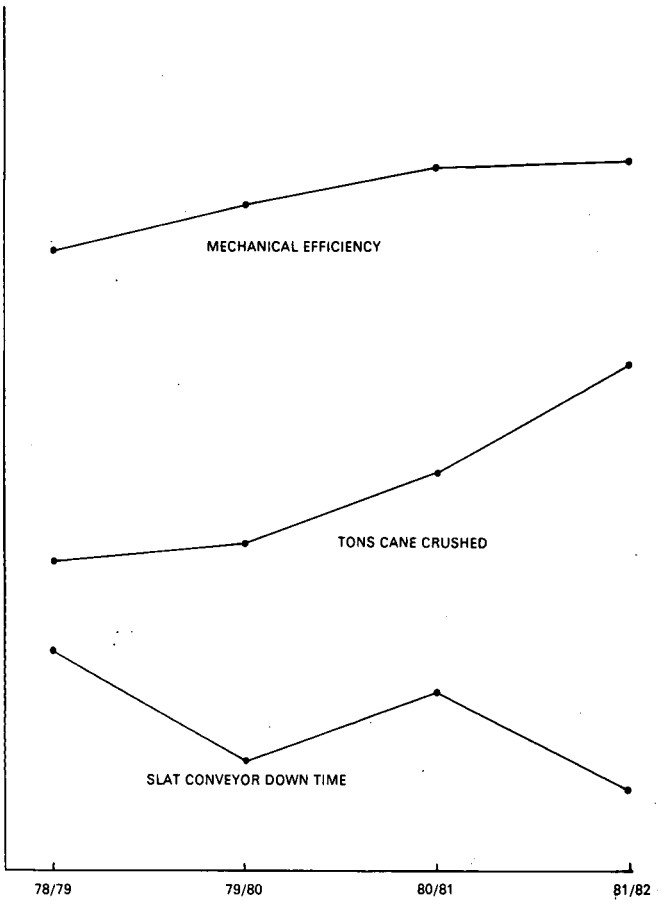

FIGURE 5 Reduction in Downtime

Conclusion

It has been decided to fit SG 70 iron link chains to all slat conveyors on the front end this year and to replace the main carrier chain with an SG 70 iron link (see Figure 6). Much more research is required into pin failure but it seems certain that the right path is being pursued and that the initial objectives have been achieved — namely:—

1. reduction in downtime. (See Figure 5);
2. a cheaper and more reliable chain;
3. a chain which is easy to maintain and repair;
4. a chain which is more suitable for use where sand and dirt are present.

A slightly heavier chain link has been designed which will be fitted with a bush in SG 70 iron, so that the chains can be refurbished at the end of the season in our own workshop and so achieve a much longer life span at a cost of approximately 60% less than the price of two new chains.

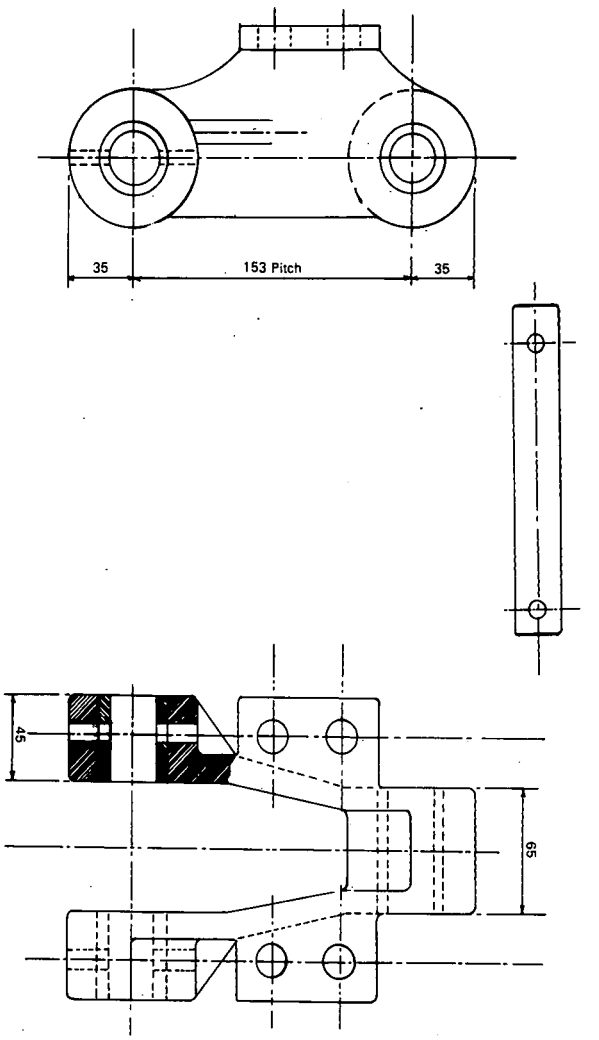

FIGURE 6 TMF Main Carrier Design TMF SG 70

Acknowledgements

I want to thank my management for making it possible for me to present this paper.

I also wish to express my thanks to my engineering staff and the foundry who so willingly assisted with the experiments.

REFERENCE

1. National Physical Research Laboratory. Report on metallurgical investigations of SG iron and alloy steel chain links, project No. 400/49991/63.