

MILL ROLL ARCING IN THE SOUTH AFRICAN SUGAR INDUSTRY

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Abstract

The arcing of mill rolls in the South African sugar industry is discussed. In particular the use of arcing equipment and welding rods and manpower are investigated, milling tandems and diffusers being dealt with separately. Finally the effect of arcing on final bagasse moistures is considered.

Introduction

The South African sugar mills have done extremely well over the years. As far as the front end of the factory is concerned, both extraction and bagasse moistures have been improving all the time. This is even more commendable when considering that there has been a steady increase in cane and fibre throughput. This good performance is the result of a combination of factors of which the most important are increasing imbibition, the replacement of milling tandems by diffusers and improved arcing. The industrial averages of some of the parameters describing the front end of the factory are given in Table 1. They are given for the 1969/70 season and for the 1991/92 season.

Table 1

Some front end parameters

	1969/70	1991/92
Cane throughput (t/h)	159,70	275,87
Fibre throughput (t/h)	24,00	41,18
Imbibition % fibre (%)	274,00	375,08
Extraction (%)	94,98	97,95
Moisture % bagasse (%)	53,30	51,18

It is not easy to find a measure of the effectiveness of roller arcing. Extraction certainly does not qualify as being particularly affected by the level of imbibition. The moisture % bagasse is also not ideal since it depends on a combination of factors but it is the best measure available. Figure 1 shows the final bagasse moistures for the industry from 1969 until 1991.

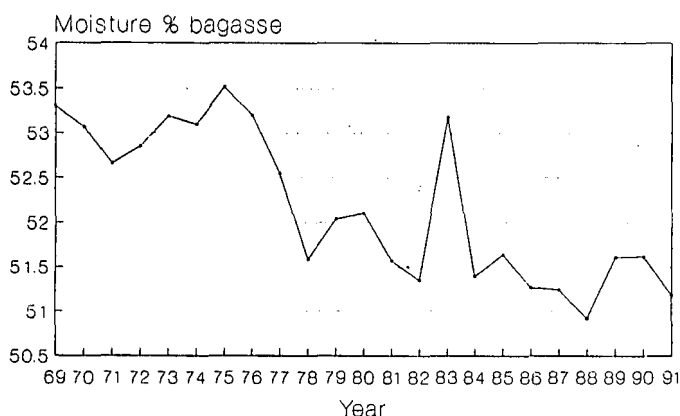


FIGURE 1 Bagasse moistures for the industry from 1969 to 1991.

The effect of arcing on bagasse moistures is particularly prominent from 1975 to 1978 when the industry changed from the old carbon arcing to arc welding and the moisture dropped by almost two points from 53,5% to 51,6%. In the latter roughening of the rolls is done by adding material to the rollers rather than removing material from them. The new method has the additional advantage of less roll wear and therefore a longer life. The high bagasse moisture of 53,2% in the 1983 season coincides with a severe drought and must be attributed to that.

Arcing Procedures

In the South African sugar industry arc welding is generally adopted as the method for roller roughening. The arcing with hardfacing rods is applied to the tips and flanks of the roller grooving. The welding rods used are Transarc CR70 (AZUCAR 80) from Afrox and Sugararc 100 from Selrod. Both are chromium based electrodes. Just recently Afrox brought out a new rod, the Transarc CR70 MR (MR standing for Mill Roughening) in which the high chrome has been replaced by ferro chrome which is said to be much cheaper. The Sugararc 100 comes in two different lengths. The short one was put on the market to minimize rod losses due to overheating at high currents. Apart from its length there is no difference in the short and long Sugararc rods and there are basically three from which to choose. The dimensions of these rods are given in Table 2.

Table 2

Rod dimensions

	CR70	CR70 MR	SA100
Core diameter (mm)	4,0	4,0	4,0
Overall diameter (mm)	8,4	8,4	7,6
Length (mm)	450	450	450
Core mass (g)	43,7	43,7	43,7
Overall mass (g)	104,0	104,0	?

The core wire is mild steel while the various additives are in the coating or flux. The main additive is chrome which forms an austenitic matrix of chromium carbides with a high resistance to wear together with good impact resistance. The chromium deposit gives a hardness of about 58 HRC. The chemical composition of the deposit as given by the manufacturers is shown in Table 3.

Table 3

Chemical composition of deposit

	CR70	CR70 MR	SA100
Carbon	3,01	3,00	3,13
Manganese	1,71	2,00	0,51
Silicon	1,08	1,20	1,22
Chromium	27,01	22,00	17,20
Niobium	0,03	0,30	0,01
Vanadium	0,05	0,05	0,05

Arc welding can be done using alternating current (AC) or direct current (DC). When using DC the electrode can be negative (DC- or straight polarity) or positive (DC+ or reverse polarity). The choice between AC, DC- and DC+ depends on the application, the metal to be arced and the welding rod. An important consideration is the fact that the heat generated at the positive pole is normally not the same as the heat generated at the negative pole. The difference accounts for the difference in burning off rate and penetration depth depending on the polarity. Heat at the electrode favours a high burning off rate while heat at the workpiece favours high penetration or dilution. For the hardfacing of mill rollers made of cast iron the suppliers of the above rods recommend the use of DC+ or AC with a preference for the former, a current of between 140 and 190 amps and a minimum open circuit (OC) voltage of 70 volts.

Many factories do not follow these recommendations and arcing tests were carried out to evaluate their importance. These tests were done at the SMRI on a rotating disk of cast iron similar to that of the mill shells. The diameter of the disk was 300 mm and the thickness 35 mm. The surface speed was approximately 9 m/s. During the tests water was sprayed onto the surface of the disk in an attempt to simulate welding conditions at the factory. The tests were aimed in particular at the effect of rod make, arcing current and polarity on such aspects as burn off rate, deposition efficiency, arcability and surface appearance. The results were rather disappointing in that the differences were not all that clear or were difficult to measure. An exception was the burn off rate which is an important indicator of where and how much heat generation takes place. This in turn determines the quality of the arcing. Table 4 shows the burn off rates in seconds at a current of 190 amps for the various makes and polarities. Irrespective of the polarity Sugararc 100 had the fastest burn off time while CR70 MR was slightly faster than CR70. For all makes the use of AC had the fastest burn off time. This was contrary to expectations and could not be explained. Both CR70 and CR70 MR were slightly faster at DC+ than at DC- while this was the opposite for the Sugararc 100.

Table 4

Polarity versus make (burn off rate in seconds)

Current 190 amps	CR70	CR70 MR	SA100
Polarity DC+	198	192	145
Polarity AC	170	156	110
Polarity DC-	209	202	124

Table 5

Current versus polarity (burn off rate in seconds)

Make CR 70	Polarity DC+	Polarity AC	Polarity DC-
Current 140 amps	265	220	275
Current 190 amps	198	170	209
Current 300 amps	134	110	142

Table 6

Make versus current (burn off rate in seconds)

Polarity DC+	Current 140	Current 190	Current 300
CR70	265	198	134
CR70 MR	260	192	130
SA100	228	145	98

Table 5 shows burn off rates in seconds for CR70 at the various currents and polarities. The burn off times decreased with increasing current, as expected. At a low current of 140 amps the arc was unstable especially at DC+ and DC-. The rods were sticking to the disk and the adhesion of the arcing material to the disk was markedly less. Irrespective of polarity, at 300 amps there was much spatter and the deposit was less rough and more globular. At all currents AC burns off the fastest while DC+ is only marginally faster than DC-. The latter appears to be in contradiction with the supplier's documentation on hardfacing electrodes.

Table 6 shows burning off rates in seconds using DC+ with the various makes and currents. Irrespective of the current the Sugararc 100 burnt off the fastest with CR70 MR slightly faster than CR70. For each make the burn off rate or heat generation increases with the current, as expected. While 140 amps appears to be too low for CR70 and CR70 MR it was not that bad for the Sugararc 100. A current of 300 amps seems to be too high especially on the Sugararc 100.

The findings of the tests could be summarized as follows. No significant differences were found between CR70 and CR70 MR. The Sugararc 100 on the other hand has a much higher burn off rate and could be used at a lower current. There does not appear to be a great difference between DC+ and DC- and in Australia both are used. AC generates much more heat and could again be used at a lower current. A current of 140 amps seems to be in order when using AC and/or Sugararc 100 but is otherwise a little low. A current of 300 amps on the other hand appears to be too high irrespective of make or polarity. Even at such a high current however the rod never overheated to the point that it could not be fully used. Table 7 gives the arcing rod used plus the electrical arcing details for the various factories during the 1991/92 season. The factories are divided into two groups. The first group consists of five factories having milling tandems while the others have diffusers. In each group the factories are listed in the order of their ascending bagasse moistures.

Table 7

Electrical arcing details

	Make	Polarity*	Current	OC volt
Gledhow Mount Edgemombe Darnall Maidstone Noodsberg	CR70	AC	140-160	90
	CR70	HWDC+	130-150	45
	SA100/CR70	HWDC+	200-?	53
	CR70	AC	300-400	80
	SA100	AC	260-380	?
Pongola Sezela Illovo Amatikulu Gledhow Felixton Glendale Union Co-op Umfolozi Umzimkulu Maidstone	CR70	AC/DC+	180-200	80/70
	SA100/CR70	AC	280	80
	CR70	DC+	180	?
	SA100	AC	150	80
	CR70	AC	140-160	90
	SA100	AC	?	70/80
	CR70	DC+	170	85
	SA100/CR70	AC	120-140	90
	SA100	AC	240	?
	?	AC	?	83
CR70	AC	300-400	80	

* HWDC+ = half wave rectified DC+

During the 1991/92 season CR70 MR was not yet on the market and the choice was between CR70 and Sugararc 100. This choice appears to be a very personal one with most factories using CR70 shifting towards Sugararc 100. Only in the 1992/93 season have people been trying the CR70 MR electrode. Most mills are using AC current simply because

it is cheaper. Only Pongola, Illovo and Glendale are using DC+. Darnall and Mount Edgecombe are using a standard 500 KVA, three-phase distribution transformer for their arcing power supply. A diode in the circuit changes the AC current to half rectified DC+. This type of arrangement is very inefficient and gives little or no current and/or voltage control. The current varies from factory to factory and within a factory from mill to mill and from arcer to arcer. Maidstone tops the scale with a current between 300 and 400 amps. Other users of a high current (above 200 amps) are Darnall, Noodsberg, Sezela and Umfolozi. Apart from Sezela all these factories have high bagasse moistures. Most factories have an open circuit voltage between 70 and 90 volts except for Mount Edgecombe and Darnall which operate with voltages of 45 and 53 volts respectively. This low voltage must surely cause arcing difficulties and is most likely the reason for Darnall's use of a high current.

Arcing Labour and Consumables

With the hard facing welding rods in use for more than 15 years one would expect some kind of standard in the use of labour and consumables. Nothing is further from the truth. There are great differences in both manhours and welding rods used among the various factories. The latter is to a lesser extent also true for the same factory over a period of years. Table 8 shows, for milling tandems, the use of welding rods in relation to the cane throughput, fibre throughput and manhours as supplied by the factories for the 1991/92 season. In addition it shows the fibre throughput per hour and the moisture percent bagasse for that season. As the number of manhours arced is not well recorded, the consumption of arcing rods per manhour can therefore only be a very rough estimate and should be used with care. It is however an interesting figure not only from an arcer's productivity point of view but also because it should relate to arcing current. The factories are listed in order of their ascending bagasse moisture.

Table 8
Arcing labour and consumables for milling tandems

	Rod/cane kg/1 000 t	Rod/fibre kg/1 000 t	Rod/ labour kg/mh	Fibre t/h	Moisture %
Gledhow	11,94	77,91	1,82	29,62	48,26
Mount Edgecombe	11,58	80,26	1,07	30,53	49,89
Darnall	14,26	94,39	1,25	47,11	52,19
Maidstone	6,35	41,16	0,52	26,72	52,44
Noodsberg	18,23	130,85	1,88	42,04	52,83

Maidstone stands out because of a very low consumption of welding rods. With only 41,16 kg/1 000 t of fibre its consumption is far below average. This low use of electrodes in combination with a high current must have a detrimental effect on bagasse moistures. The low consumption per manhour is particularly strange in view of the high currents. Noodsberg is, at 130,85 kg/1 000 t fibre the greatest user of welding rods. In spite of this high figure, bagasse moistures are high, possibly due to a high fibre throughput and a high arcing current. Noodsberg has a problem in running the mills slowly and could therefore justify a slightly higher current but a current of above 260 amps seems to be excessive. Darnall does a great deal of arcing per ton of fibre but has at 47,11 t/h the highest fibre throughput in the industry. This high throughput combined with a high current could very well be the reason for the high bagasse moistures. Both Gledhow and Mount Edgecombe are doing a fair amount of arc-

ing while having a relatively low throughput and current resulting in good bagasse moistures. The use of arcing rods per manhour varies from 0,52 for Maidstone to 1,88 for Noodsberg. Both these factories have a high current and there does not seem to be any relationship between rod consumption per manhour and arcing current.

Table 9
Arcing labour and consumables for diffusers

	Rod/cane kg/1 000 t	Rod/fibre kg/1 000 t	Rod/ labour kg/mh	Fibre t/h	Moisture %
Pongola	6,62	47,02	1,07	13,97	44,92
Sezela	3,76	23,32	0,25	14,89	48,74
Illovo	3,07	20,33	0,59	14,51	49,38
Amatikulu	1,70	11,21	0,86	27,12	49,98
Gledhow	2,31	14,68	1,82	13,22	50,23
Felixton	2,27	14,15	1,90	22,10	51,87
Glendale	2,15	14,74	0,44	5,98	52,16
Union Co-op	14,28	115,23	1,35	8,19	52,49
Umfolozi	3,92	28,84	1,02	12,70	53,14
Umzimkulu	4,86	31,13	0,61	10,31	53,43
Maidstone	1,11	7,50	0,35	30,16	54,00

Table 9 gives the arcing labour and consumables for diffusers. Again the factories are listed in order of ascending bagasse moistures. The differences in arcing consumables and manhours between milling tandems and diffusers are of course mainly due to the reduction in mills and mill rolls. The higher temperature of the bagasse and the higher percentage ash should however also affect the wear on the rolls and the use of welding rods. It is never easy to compare figures from different factories but with respect to the fibre throughput it is even more difficult because of the parallel milling versus series milling. Although not completely satisfactory this is dealt with by using the fibre throughput per mill irrespective of the number of mills and the way they are arranged. It is interesting to note that the fibre throughputs calculated that way are much lower for diffusers than those for milling tandems. Pongola is, at 47,02 kg/1 000 t fibre, the second largest user of arcing rods amongst the diffuser factories but has the lowest bagasse moisture of 44,92% to show for it. Maidstone on the other hand has, at 7,5 kg/1 000 t fibre, the lowest arcing consumables while it has the highest fibre throughput at 30,16 t/h. This together with a high arcing current could well be the reason for the fact that Maidstone has the highest bagasse moisture (54%) in the industry. The other factories have bagasse moistures in between these extremes almost inversely proportional to the consumption of arcing materials, as evident in the graph in Figure 2.

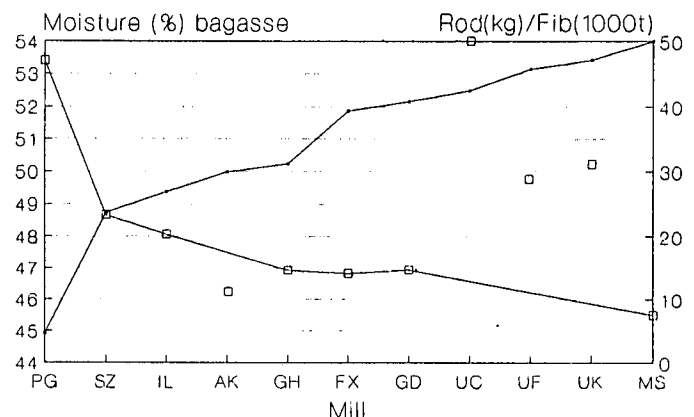


FIGURE 2 Bagasse moisture (●) versus arcing consumables in kg/1 000 t fibre (□).

An exception is found at Amatikulu, Union Co-op, Umfolozi and Umzimkulu. Amatikulu is doing very well in that it does not arc a great deal but still obtains good bagasse moistures. This is even more remarkable when taking into consideration an above average fibre throughput. Union Co-op stands out with by far the highest arcing consumables of 115,23 kg/1 000 t fibre. There does not appear to be any reason for this other than that Union Co-op has small mills but so has Glendale. Both have very low throughputs to compensate for this. Umfolozi and Umzimkulu are, after Union Co-op and Pongola, the biggest users of arcing electrodes and although their throughput is low, their bagasse moistures are high. One wonders if this has anything to do with the fact that both factories recently changed from a milling tandem to a diffuser. The use of arcing rods per manhour varies from 0,25 for Sezela to 1,90 for Felixton. Again there does not seem to be any relationship between rod consumption per manhour and arcing current. This is

rather a reflection on the accuracy of the data, in particular the manhours, than on anything else.

Conclusions

Since their introduction in the mid seventies, the chromium based hardfacing electrodes have served the industry well. It is however remarkable that after more than 15 years the use of these rods does not show any uniformity or standard. The consumption of arcing rods per ton of cane, per ton of fibre and per manhour varies enormously. On the electrical side it is particularly the arcing current that shows vast differences from factory to factory. It appears that there is a relationship between electrode consumption and the current on the one hand and bagasse moistures on the other. This means that there is room for improvement resulting not only in lower bagasse moistures but also in a higher extraction and the better utilisation of consumables and manpower.