

IMPACT OF ULTIMA[®] ROLL USAGE ON TCO DEVELOPMENT IN VARIOUS ROD AND BAR MILL CONFIGURATIONS *

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Abstract

ULTIMA[®] are high performance, centrifugal cast, double poured (CC duplex) work rolls. This paper describes the principle of the ULTIMA[®] roll concept and its wide range of usability. The ULTIMA[®] concept provides a solution for rod and bar mills to increase performance and output, even under harsh rolling conditions. The main focus is on highly loaded mill stands that require both high wear resistance and resistance against thermal fatigue, like pre-dog bone, dog bone, slitler. Specific case studies of quite different mill configurations and rolled product mix prove the positive impact on production yield, mill and roll shop operations, and profitability in terms of TCO (total cost of ownership).

Keywords: rod and bar mills; case studies; roll performance; TCO.

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1. INTRODUCTION

ULTIMA[®] is a highly alloyed non-graphitic cast iron grade. The flexibility of its alloying system allows us to cover a wide range of applications, just by adopting specific features like carbide content and hardness to the working conditions of each mill stand. 5 years ago, the ULTIMA[®] system has been presented at the ABM conference, with all metallurgical details. In the meantime, nearly 5000 ULTIMA[®] rolls and rings have been delivered to more than 150 mills in 40 countries all over the world.

Not all mills keep extensive records of rolls in service, but we have received feedback from around 80 mills. As these mills cover a huge variety of product range and rolling conditions, we are now in a position to clearly identify the main working parameters for successful ULTIMA[®] application.

Depending on pass shape, and cooling parameters, we need a specific minimum rolling speed in order to guarantee best ULTIMA[®] performance (Fig. 1):

pass shape	Pressure of cooling water			
	2 - 3 bar	3- 4 bar	4- 6 bar	>6 bar
round	4 m/s	3 m/s	3 m/s	2 m/s
oval	5 m/s	4 m/s	4 m/s	3 m/s
dog bone and slit		4 m/s		
rebar finishing		2 m/s		
flat		4 m/s	3 m/s	
angles		7 m/s	5 m/s	4 m/s

Figure 1: min. rolling speed required for operation of ULTIMA[®] rolls based on pass shape and pressure of cooling water (at referenced flow rate of 350 l/min and roll)

Main application of ULTIMA[®] is pre-finishing and finishing of rebar (Fig. 2). Our customers have successfully used ULTIMA[®] for a wide size range of products, outperforming standard roll grades in these stands up to 8 times!

Imperial bar size	Metric barsize (soft)	FLUTED								
		RD	OV	FLAT	SQUARE	DB	SL	OV	FIN	
#2	8	Y	Y	Y	-	3, 4	3, 4	Y	Y	
#3	10	Y	Y	Y	Y	2, 3, 4	2, 3, 4	Y	Y	
#4	13	Y	Y	Y	Y	2, 3, 4	2, 3, 4	Y	Y	
#5	16	Y	Y	Y	Y	2, 3, 4	2, 3, 4	Y	Y	
#6	19	Y	Y	-	Y	2	2	Y	Y	
#7	22	-	-	-	-	-	-	Y	Y	
#8	25	-	-	-	-	-	-	Y	Y	
#9	29	-	-	-	Y	2	2	Y	Y	
#10	32	-	-	-	-	-	-	Y	Y	
#11	36	-	-	-	-	-	-	Y	Y	
#14	43	-	-	-	-	-	-	-	-	
#18	57	-	-	-	-	-	-	-	-	
18J	(57)							Y	Y	



Figure 2: rolling application ULTIMA[®] successfully has been tested

For many of our customers, rolling rebar was just the start for ULTIMA[®] application. Now they also use these rolls for rolling rounds up to 40 mm diameter, squares and hexagons, and narrow flats as well. Due to its superior wear resistance, ULTIMA[®] has proven to be the best solution for rolling stainless angles up to 2", and carbon steel angles up to 2,5".

2. CASE STUDIES

The following case studies are comparing campaign length and roll performance achieved with ULTIMA[®] against conventional grades, such as NCI (Nodular Cast Iron) and AIC (Alloyed Indefinite Chill). We have chosen mills operating under very different conditions, in order to show the flexibility of ULTIMA[®] rolls in operation. All comparison data relate to the use of BRC rolls.

2.1. CASE A: 2 strand slitting of 3/4 inch (ca. 19mm) bar

- 500 ktpa 18 stands wire rod mill (8 cantilever + 4 two-high stands + 2 parallel operating 6 stands rod blocks) producing mainly rebar (3/8, 1/2 and 3/4 inch).
- Billet size is square 127mm; in stand 8 a fluted square is rolled which is feeding the dog bone stand 9 by a 45° twisted bar – slitting is done in stand 9, in stands 10 and 11 an OV/RD sequence is rolled providing a 3/4" bar to the rod blocks, where further sizing and rebar finishing is done.



Figure 3: 500 ktpa wire rod mill

- 1 MILL LAYOUT
- 2 PASS SEQUENCE
- 3 STAND CONFIGURATION
- 4 ROLL DIMENSION
- 5 ORIGINAL ROLL SPECIFICATION
- 6 1st TRIAL PHASE (2014)
- 7 2nd TRIAL PHASE (2016)

In 2014 in a first trial phase SGA rolls of stands 9 to 12 were replaced by ULTIMA[®] rolls. In the dog bone and slitting stands 9/10 ULTIMA[®] returned 3.2x the pass life of NCI rolls which were in use that time – the average redressing was reduced by 32%. In total ULTIMA[®] rolls in terms of t/mm performed 4.5 times better than cast irons. In the oval/round passes of stands 11 and 12 the increase of pass life was ca. 1.8x, where required redressing was reduced by 38 to 52% – expected total tonnage which can be rolled in stands 11 and 12 is 3.6 to 4.7 times higher compared to NCI.

In a second trial phase in 2016, the cantilever rings in stand 8 rolling a fluted square were replaced by ULTIMA[®]. Pass life for the fluted square geometry

increased from 3520 tons to 12800 tons, so that ULTIMA[®] cantilever rings of stand 8 now can operate a full week of production. More than that, redressing is only half and in consequence evaluated in tons/mm the performance is 7.8x higher compared to NCI in use before. More detailed trial feedback is summarized in figure 4.

stand	8		9		10		11		12	
roll size	D475/435x160		D340/280x500		D340/280x500		D340/280x500		D340/280x500	
pass	fluted square 36.9		DB 2 x 3/4"		SL 2 x 3/4"		OV 15.5 x 29.6		RD 18.8 x 18.8	
roll grade	SGP	ULT	SGA	ULT	SGA	ULT	SGA	ULT	SGA	ULT
tons/pass	3,520	12,800	1,500	4,800	1,500	4,800	1,140	2,120	1,760	3,110
average redressing [mm]	6.0	3.0	6.0	4.1	6.0	4.1	5.0	2.6	6.5	2.5
tons / pass / mm	587	4,267	250	1,171	250	1,171	228	815	271	7,464
passes on barrel	1	1	6	6	6	6	6	6	6	6
tons / trip to mill	3,520	12,800	9,000	28,800	9,000	28,800	6,840	12,720	10,560	18,660
NEW to SOD [mm]	40	40	60	60	60	60	60	60	60	60
campaigns per roll life	6	13	10	14	10	14	12	23	9	24
total tons	21,120	166,400	90,000	403,200	90,000	403,200	82,080	292,560	95,040	447,840
ULTIMA performance benefit	-	7.8 x	-	4.5 x	-	4.5 x	-	3.6 x	-	4.7 x

Figure 4: setup of ULTIMA[®] trial and mill feedback of a 500 ktpa wire rod mill producing mainly rebar

For an annual production of 500.000 tons, this leads to significant savings for this specific mill – as shown in figure 5:

- 293 hours saved for pass and roll changes gaining additional production time in the mill to increase mill utilization output
- 234 less ring/roll changes means less workload in the roll shop for machining and roll stand assemblies

stand	8		9		10		11		12	
roll size	D475/435x160		D340/280x500		D340/280x500		D340/280x500		D340/280x500	
pass	fluted square 36.9		DB 2 x 3/4"		SL 2 x 3/4"		OV 15.5 x 29.6		RD 18.8 x 18.8	
no. of pass changes	-	-	333	104	333	104	439	236	284	161
no. of roll changes	142	39	56	17	56	17	73	39	47	27
changing time (h)	59	16	106	33	106	33	140	75	91	51
theoretical savings in mill downtime in hours (h)	-	43	-	73	-	73	-	65	-	39
theoretical roll consumption	47.3	6.0	11.1	2.5	11.1	2.5	12.2	3.4	10.5	2.2

Figure 5: possible time savings with ULTIMA[®] for a 500 ktpa wire rod mill producing mainly rebar

- (*) time consumption for pass & roll changes (pass: 15 Min, roll: 25 Min)

In addition to the cost saving potential, also an improvement in product quality due to less wear and improved surface quality can be seen – differences in surface finishing even after long campaigns are obvious; see figure 6.

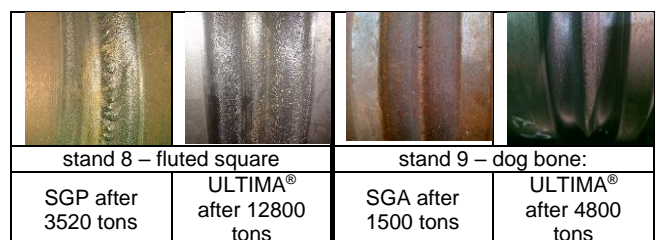


Figure 6: pictures of pass grooves 8 and 9 after rolling different tonnages

The mill now is also running more stable so that the cobble rate could be reduced by around 30% reducing the number of lost bars and downtime of the mill in consequence as well.

2.2. CASE B: 4 strand slitting of \varnothing 3/8 inch (ca. 10mm) bar

- 500 ktpa 18 stands bar mill producing mainly rebar 3/8 to 1 inch
- Billet size is square 170mm; for 4 strand slitting of 3/8 inch rebar a flat-flat-dog-bone-slitter-leader-finisher pass sequence is rolled in the finishing train

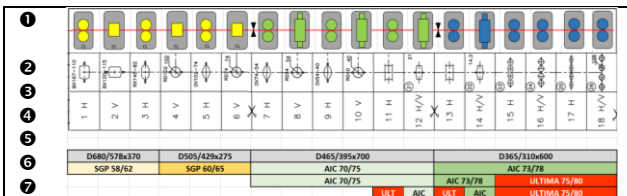


Figure 5: 500 ktpa bar mill

- 1 MILL LAYOUT
- 2 PASS SEQUENCE
- 3 STAND CONFIGURATION
- 4 ROLL DIMENSION
- 5 ORIGINAL ROLL SPECIFICATION
- 6 1st TRIAL PHASE (2014)
- 7 2nd TRIAL PHASE (2016)

In 2014 in a trial first phase AIC rolls of stands 15 to 18 (= dog bone – slitter – leader – finisher) were replaced by ULTIMA® rolls.

With this first attempt pass life in these 4 stands was increased by a factor 2.4 to 3.0 times with ca. 30 to 40% less redressing. This result was already good, but not satisfying.

stand	11		13		15		16		17		18	
	roll size		roll size		roll size		roll size		roll size		roll size	
pass	D465/395 x 700		D365/310 x 600		D365/310 x 600		D365/310 x 600		D365/310 x 600		D365/310 x 600	
roll grade	AIC	ULT	AIC	ULT	AIC	ULT	AIC	ULT	AIC	ULT	AIC	ULT
tons/pass	3,000	-	2,000	-	900	2,200	900	2,200	900	2,200	300	900
average redressing [mm]	5,3	-	4,5	-	4,0	3,0	3,5	2,5	3,4	2,0	3,5	3,5
tons / pass / mm	566	-	444	-	225	733	257	880	265	8,800	86	2,693
passes on barrel	10	-	13	-	8	8	8	8	8	8	8	8
tons / trip to mill	30,000	-	26,000	-	7,200	17,600	7,200	17,600	7,200	17,600	2,400	7,200
NEW to SOD [mm]	70	-	55	-	55	55	55	55	55	55	55	55
campaigns per roll life	13	-	13	-	13	18	15	22	16	27	15	15
total tons	390,000	-	312,000	-	93,600	316,800	108,000	387,200	115,200	475,200	36,000	108,000
ULTIMA performance benefit	-	-	-	-	-	3,38 x	-	3,58 x	-	4,12 x	-	3 x

(*) Stand 18 : no saving on machining because before ribbing surface is totally cleaned.

Figure 6: 1st setup of ULTIMA® trial and mill feedback of a 500 ktpa bar mill from 2014

The pass grooves of ULTIMA® rolls after rolling a campaign of 2200 tons in pre-finishing stands (dog bone, slitter and leader) were analyzed in detail.

Figure 7 shows the dog bone pass previous to the 4 strand slitting operation of diameter 10mm bar. Although the 3 apices in the center of the pass still are looking very good in shape, the open sides show a higher wear rate. We concluded, that the dog bone pass was overfilled by the incoming section due to worn out profile of the previous flat passes. In a second phase AIC rolls from stands 11 and 13 were replaced by ULTIMA® to catch up with the longer campaign length which can be rolled using high performing roll grades like ULTIMA® in finishing stands.



Figure 7: dog bone pass of stand 15 after rolling 2200 tons 4x10mm rebar

Within a 2 years’ trial period, cooling conditions in the mill stands and roll handling in the machine shop were optimized based on the gained experience when using ULTIMA® rolls. Since begin of 2016 the campaign length for rolling diameter 10mm rebar in 4-strand slit operation significantly could be increased due to consecutive use of ULTIMA® rolls in the finishing stands 11, 13 and 15 to 18.

Tonnage which can be rolled with ULTIMA® in dog bone, slitting and leader pass is 5 times higher compared to SGA – in terms of tons/mm performance gets up to 9x. Benefit in the flat passes of stands 11 and 13 is less – longer campaigns could be rolled, but isn’t done in order to maintain the stability in the mill and to have an equalized campaign length of 4500 tons/pass.

stand	11		13		15		16		17		18	
	D465/795 x 700 FL		D365/510 x 600 FL		D365/510 x 600 D8 4 x 10		D365/510 x 600 D8 4 x 10		D365/510 x 600 LEADER		D365/510 x 600 FIN 10	
roll grade	AIC	ULT	AIC	ULT	AIC	ULT	AIC	ULT	AIC	ULT	AIC	ULT
tons/pass	3.000	4.500	2.000	4.500	900	4.500	900	4.500	900	4.500	300	1.200
average redressing [mm]	5,3	2,2	4,5	2,2	4,0	2,8	3,5	2,0	3,4	2,0	3,5	3,5**
tons / pass / min	566	1.875	444	2.045	225	1.607	257	2.250	265	18.000	86	2.743
passes on barrel	10	10	13	13	8	8	8	8	8	8	8	8
tons / trip to mill	30.000	45.000	26.000	58.500	7.200	36.000	7.200	36.000	7.200	36.000	2.400	9.600
NEW to SLD [mm]	70	70	55	55	55	55	55	55	55	55	55	55
campaigns per roll life	13	29	12	25	13	19	15	27	16	27	15	15
total tons	390.000	1.305.000	312.000	1.462.500	93.600	684.000	108.000	972.000	115.200	972.000	36.000	144.000
ULTIMA performance benefit	-	3,3 x	-	4,7 x	-	7,4 x	-	9,1 x	-	8,4 x	-	4 x

Figure 8: 2nd setup of ULTIMA® trial and mill feedback of a 500 ktpa bar mill from 2016

2.3. CASE STUDY C: 2 strand slitting Ø 3/8 inch (ca. 10mm) bar

- 300 ktpa 13 stands bar mill with 3 high roughing stand rolling 5 passes
- Billet size is square 130mm; in stand 9 a fluted square is rolled which is feeding the dog bone stand 10 – slitting is done in stand 11, in stands 12 and 13 a leader and rebar finishing sequence is rolled – see figure 11.

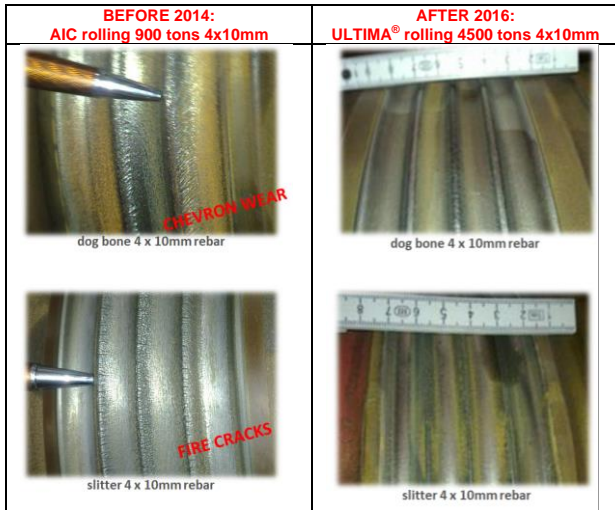


Figure 9: Pass groove of AIC rolls after rolling 900 tons D10mm in 4SS operation vs. ULTIMA® rolling 4500 tons per pass

In case of producing diameter 10mm rebar only, the benefit when using ULTIMA® rolls in the finishing train is outstanding. For a production of 500 ktpa the savings could be:

- 822 hours less time for pass and roll changes gaining additional production time in the mill to increase mill utilization output
- 340 less roll changes means less workload in the roll shop for machining and roll stand assemblies
- In theory inventory for finishing train work rolls could be reduced from 62 to 12 rolls only to produce 500 kt diameter 10 mm rebar in 4 strand slit operation

stand	11		13		15		16		17		18	
	D465/795 x 700 FL		D365/510 x 600 FL		D365/510 x 600 D8 4 x 10		D365/510 x 600 D8 4 x 10		D365/510 x 600 LEADER		D365/510 x 600 FIN 10	
no. of pass changes	167	111	250	111	556	111	556	111	556	111	1.567	417
no. of roll changes	17	11	19	9	69	14	69	14	69	14	208	52
changing time (1)	7	5	71	31	168	34	168	34	168	34	503	126
theoretical savings in mill downtime in hours	-	2	-	39	-	134	-	134	-	134	-	378
theoretical roll consumption	2,6	0,8	3,2	0,7	10,7	1,5	9,3	1,0	8,7	1,0	27,8	6,9

(1) time consumption for pass & roll changes (pass: 15 Min, roll: 25 Min)

Figure 10: theoretical time savings with ULTIMA® for a 500 ktpa bar mill when rolling 10mm rebar in 4 strand slit operation

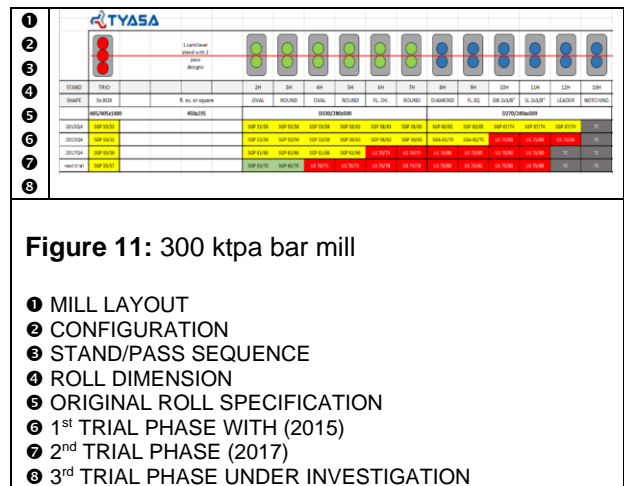


Figure 11: 300 ktpa bar mill

- 1 MILL LAYOUT
- 2 CONFIGURATION
- 3 STAND/PASS SEQUENCE
- 4 ROLL DIMENSION
- 5 ORIGINAL ROLL SPECIFICATION
- 6 1st TRIAL PHASE WITH (2015)
- 7 2nd TRIAL PHASE (2017)
- 8 3rd TRIAL PHASE UNDER INVESTIGATION

Until 2014, the mill used standard Nodular Iron rolls in all stands except stand 13, where the mill used Carbide for rebar finishing already.

The performance gap between the nodular iron rolls in dog bone, slitting, and leader pass, and the carbide rolls in finishing was huge. The mill operator and BRC made the decision to close this gap by introducing ULTIMA® in a multistep joint trial.

2.3.1. First Trial:

ULTIMA® introduction in stands 10 – dog bone, 11 – 2 strand slitting, and 12 – leader pass.

Before the trials started, the pass life of standard iron rolls in these stands was very short.

- In the dog bone stand 11, and slitting stand 12, pass life of SGA was 350 t per groove when rolling 3/8" rebar.

The goal of this first ULTIMA® trial was to achieve min. 3 times the pass life of SGA

in dog bone and slitting to equalize pass
life with the carbides in the finishing stand.

The result of this first ULTIMA[®] trial in September 2015 showed:

- ULTIMA[®] in dog bone and slitter showing significant improvement in pass life rolling 1340 t/pass (=3.8 x SGA)
- leader pass: ULTIMA[®] in oval leader pass can match campaign length of carbide in finishing 3/8" rebar
- The carbide rolls in stand 13 had a pass life of approx. 1200 tons 3/8" rebar

2.3.2. Second Trial:

- Extend ULTIMA[®] to stands 6 – oval pass, and stand 7 – round pass, stand 8 – diamond pass and stand 9 – fluted square, in order to significantly improve shape and surface quality of bar entering the dog bone pass.

Evaluation of 2nd trial results was done end of 2017:

In stands 6 to 9 with pass sequence oval – round – diamond – fluted square, the tonnage rolled with ULTIMA[®] is 4 times the tonnage rolled with conventional nodular cast iron rolls (NCI).

Pass shape and surface quality are excellent even after the much longer campaigns, as can be seen in the following figure 12:








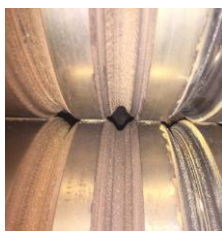
STAND PASS SHAPE ROLLING SPEED	BARREL DIMENSION AND NO. OF GROOVES	TONS PER ROLL CHANGE	TONS/PASS	MM OF REDRESSING	ULTIMA PASS GROOVE
		CAST IRON		ULTIMA	
#6 FLAT OVAL  2.8m/s	D330/ d280 x500 7 gr.	13 500 tons 1 929 t/pass 3mm	54 000 tons = 4x NCI 7 714 t/pass 4mm		
#7 RD  3.8 m/s	D330/ d280 x500 7 gr.	13 500 tons 1 929 t/pass 3mm	54 000 tons = 4x NCI 7 714 t/pass 4mm		
#8 DIA  5.1 m/s	D270/ d240 x500 8 gr.	5 184 tons 741 t/pass 3mm	20 736 tons = 4x NCI 2 592 t/pass 4mm		
#9 FL. SQ.  6.8 m/s	D270/ d240 x500 7 gr.	5 184 tons 741 t/pass 3mm	20 736 tons = 4x NCI 2 592 t/pass 3mm		

Figure 12: performance comparison between NCI and ULTIMA[®] rolling an - oval – round – diamond – fluted square - pass sequence

Dog bone and slitting in stands 10 and 11: ULTIMA[®] rolls are giving 5 times the performance of standard rolls – for more details have a look on figure 13:





STAND PASS SHAPE ROLLING SPEED	BARREL DIMENSION AND NO. OF GROOVES	TONS PER ROLL CHANGE	TONS/PASS	MM OF REDRESSING	ULTIMA PASS GROOVE
CAST IRON		ULTIMA			
#10 DOG BONE  7.5 m/s	D270/ d240 x500 11 gr.	6 480 tons	32 400 tons	4mm	
		589 t/pass	2 945 t/pass		
#11 SL  8.9 m/s	D270/ d240 x500 11 gr.	6 480 tons	32 400 tons	4mm	
		589 t/pass	2 945 t/pass		

Figure 13: performance comparison between NCI and ULTIMA rolling 2 x 3/8" in dog bone and splitter

Thanks to the use of ULTIMA® in the previous stands the excellent shape and surface of the slit bar allows the carbide leader to achieve very high tonnage (fig. 14).


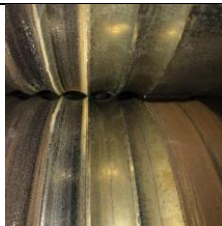


STAND PASS SHAPE ROLLING SPEED	BARREL DIMENSION AND NO. OF GROOVES	TONS PER ROLL CHANGE	TONS/PASS	MM OF REDRESSING	ULTIMA PASS GROOVE
CAST IRON		TC			
#12 OVAL  10.3 m/s	D270/ d240 x500 12 gr.	4 146 tons	54 432 tons	1.2-1.4mm	
		207 t/pass	4 536 t/pass		
#13 FIN  13.0 m/s	D270/ d240 x500 12 gr.	4 146 tons	18 144 tons	1.8-2.2mm	
		207 t/pass	1 512 t/pass		

Figure 14: performance comparison between NCI and TC rolling 3/8" rebar in leader and finisher

In figure 15 the setup and performance figures of the 2nd ULTIMA® trial phase from 2017 are summarized.

RODILLO		HIERRO NODULAR				ACERO ALTA VELOCIDAD (ULTIMA)				CARBURODE TUNGSTENO				INCREASE OF PERFORMANCE	
stand	profile	v _{roll} [m/s]	barrel dimension	no. of passes	rolled tons	cut	no. of passes	rolled tons	cut	no. of passes	rolled tons	cut	SGI - 100%		
CAJA 6	Caja Plana	2.8	330/280	7	13500	1929	3	7	54000	7714	4		400%		
CAJA 7	Redondo	3.8	500	7	13500	1929	3	7	54000	7714	4		400%		
CAJA 8	Diamante	5.1		8	5184	648	3	8	20736	2592	4		400%		
CAJA 9	Fluttaglin	6.8		7	5184	741	3	7	20736	2962	3		400%		
CAJA 10	Cacahuete	7.5	270/240	11	6480	589	3	11	32400	2945	4		500%		
CAJA 11	Separator (Slitting)	8.9	500	11	6480	589	3	11	32400	2945	3		500%		
CAJA 12	Ovalo (Lider)	10.3		20	4146	207	3				12	54432	4536	1.2-1.4	1313%
CAJA 13	Acabador	13.0		20	4146	207	3				11	18144	1512	1.8-2.2	428%

Figure 15: ULTIMA® performance feedback from 2nd trial phase in 2017

2.3.3. Positive effects of ULTIMA® use!

In addition to the huge increase in campaign length and tonnage performance of ULTIMA® rolls there are additional positive effects that have to be included in a total evaluation of cost versus benefits when evaluating TCO – total cost of ownership philosophy.

- Annual production increased by 16% (249 kt to 290 kt)
- Mill availability increased from 84 to 87% (cobble rate went down from 5 per day to 1 per day only)
- Less work load on mill and roll shop operations team:
 - Stands 6 and 7 changed every 15 days, when using ULTIMA® changed every 62 days!
 - Stands 8 and 9 changed every 6 days, when using ULTIMA® changed every 18 days!
 - Stands 10 and 11 changed every 7 days, when using ULTIMA® changed every 37 days!

3. SUMMARY

ULTIMA[®] rolls are high performance centrifugal cast double poured (CC duplex) work rolls. ULTIMA[®] provides a solution for rolling mills to increase performance and output, even under not so perfect rolling conditions. The use of ULTIMA[®] rolls has a positive impact on production yield, mill and roll shop operations, and profitability of the whole plant.

Today, nearly **5000 ULTIMA[®]** rolls have been delivered to long product mills. The general feedback from ULTIMA[®] rolls in rebar finishing compared to NCI / AIC in use:

- **3 – 5 x pass life!**
- **30 – 50 % less redressing!**
- **“application flexibility”**

This results in essential benefits for the rolling mill and its roll shop and inventory:

- significant gains in campaign length
- reduced down time → increase in mill utilization
- more stable rolling conditions → reduced no. of lost bars due to cobbles
- significant reduction of machining time and mill stand preparation
- reduced number of rolls on stock

All this was achieved by the outstanding productivity of ULTIMA[®], and helped the mill to

**REDUCE TOTAL COST
OF OWNERSHIP!**