Project Details

Project Title	**Achievement of highest brightness and whiteness in paper in a cost effective manner through selective addition of OWA at wet-end and size press**
Project Executed by	**IPMA & TNPL**
Participating Agency	**Avantha Centre for Industrial R & D (ACIRD), Yamuna Nagar (Haryana)** **Central Pulp & Paper Research Institute (CPPRI), Saharanpur (UP)**
Project Duration, Months	**30**
Date of Start	**September, 2014**
Date of Completion	**March, 2017**
Project Cost, Rs Lacs	**38.50 (ACIRD – 19.25, CPPRI – 19.25)**
Funds Released	**ACIRD: 15.24; CPPRI: 18.49**
Balance Funds to be Recieved	**ACIRD: 4.01; CPPRI: 0.76**

Objectives

- To study the chemistry of OWA compounds with papermaking furnish
- To decide the chemical addition sequence in wet-end to get the highest brightness/ whiteness of paper
- Screening of OWAs based on efficiency at wet end and size press
- Decreasing dose of OWAs for the target brightness level of paper and reducing cost

Quantified Deliverables of the Project

- **Reduction in dose of OWAs for the target paper brightness level**
- **Reduction in cost of application of OWA**
- **Improvement in optical properties of paper**
- **In-depth knowledge/data generation regarding the effect of different OWAs on optical properties of paper**

Technical Programme

- Effect of wet-end chemical addition sequence on optical properties of paper
- Application of varying doses of different OWAs (di and tetra) at optimized wet-end conditions and chemicals using different pulp furnishes[#] and fillers[@]
- Split addition of different OWAs* in wet end as well as in surface sizing using different pulp furnishes
- Addition of broke (5 to 30%) in the papermaking furnish and its effect on the efficiency of OWAs and effect of pH of pulp stock on optical properties of paper
- Effect of pH of pulp stock on optical properties of paper

 # mixed hardwood pulp, bagasse pulp, recycled pulp; @ Talc, GCC, PCC
**** commercially available di-, tetra- and hexa-sulfonic OWAs***

Technical Programme contd..

- Identification of impurities and interfering metals in OWAs and their effect on optical properties of paper
- Effect of cationic coagulant on affinity of OWAs with cellulosic fibers
- Identification of one or two new OWAs in place of commercially available OWAs and their effect on optical properties of paper
- Validation of findings at CPPRI
- Demonstration of results in the plant scale
- Compilation of data and preparation of report and plant trial

Result & Discussion

Different types of OWA's Used

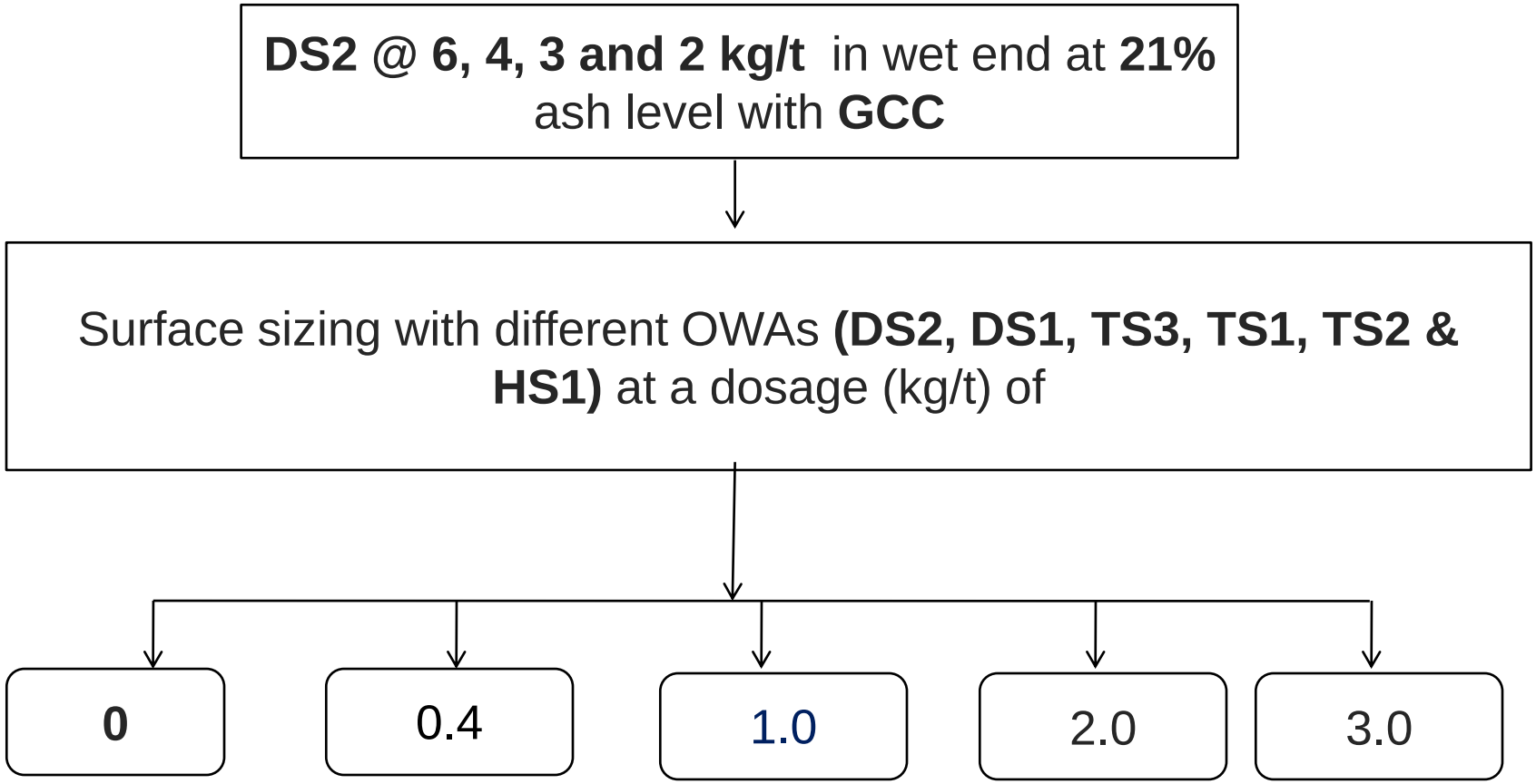
Name of OWA (% solids)	Type of OWA	E-value (1%/ 1 cm)	Cost, Rs/kg (as such)
DS1 (22.4)	Di- sulphonated	562	75
DS2 (99.9)	Di- sulphonated	493	255
TS1 (25.7)	Tetra-sulphonated	496	75
TS2 (22.6)	Tetra-sulphonated	327	55
TS3 (99.4)	Tetra-sulphonated	265	185
HS1 (20.7)	Hexa-sulphonated	374	70

Cost comparison of different OWAs addition at wet end for target paper brightness of 93.5 %ISO

OWA	Brightness, %ISO	Dose, kg/t	Cost, Rs./t
		As such basis	
DS1	93.2	26.8	2010
DS2	93.6	6.0	1530
TS1	94.0	42.8	5460
TS2	92.8	57.5	3163
TS3	93.7	11.0	2035

Mixed Hardwood furnish

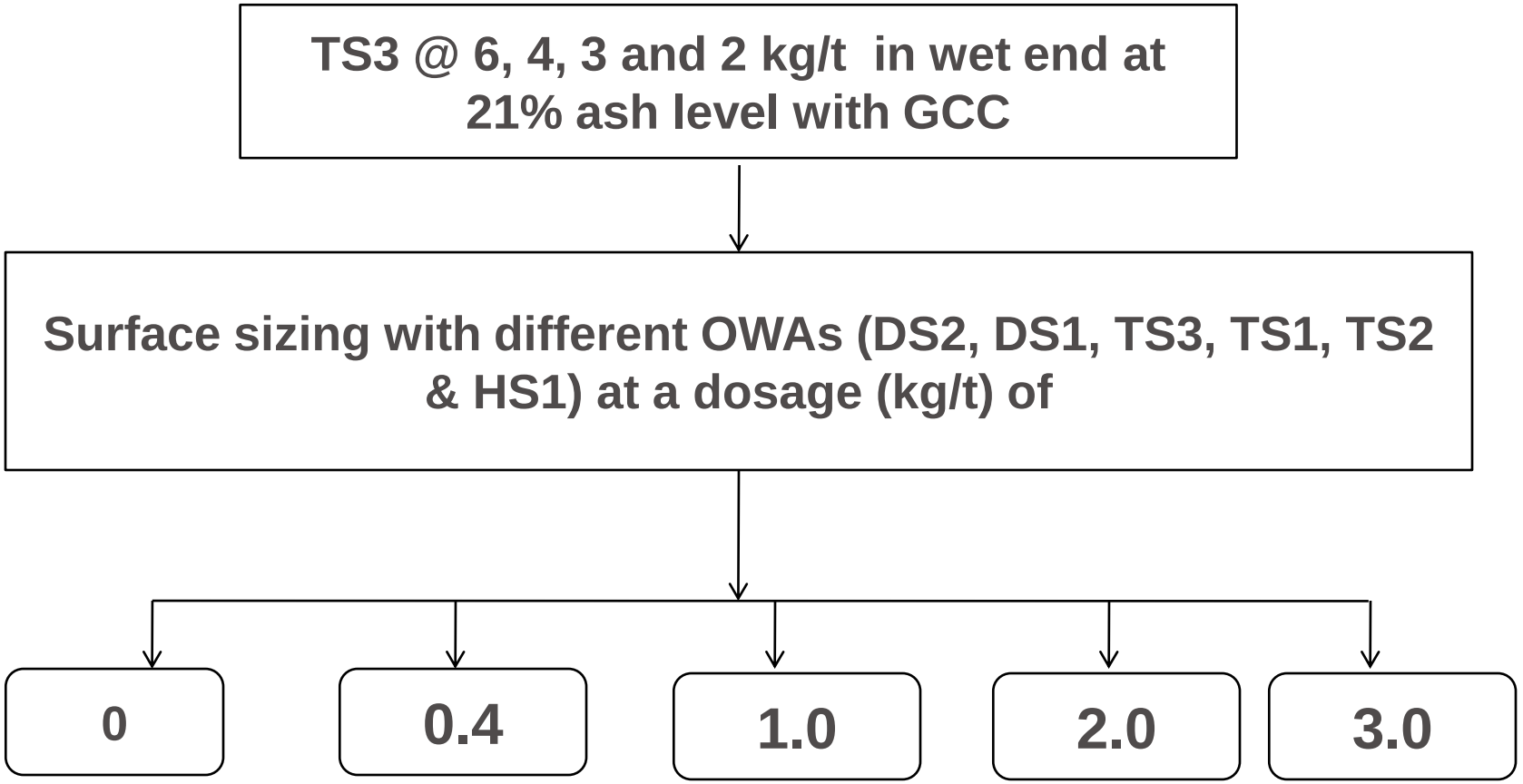
Split addition of different OWAs in wet end and surface sizing application



Best combinations

DS2 at wet-end, kg/t		6	3	4	3	4	4	4
At size press	OWA	--	DS2	DS1	TS1	TS3	TS2	HS1
	Dose, kg/t	--	2	2	2	2	2	2
Brightness, %ISO		94.4	94.8	95.4	94.6	95.2	95.6	95.1
Basic Brightness, %ISO		81.8	83.1	83.1	82.6	83.2	83.3	83.2
CIE Whiteness		138.3	141.8	142.5	141.8	143.2	141.8	142.5
Fluorescence		22.3	21.8	22.4	22.2	23.7	22.6	23.1
Fluorescence, C		11.2	11.7	12.3	12.0	12.0	12.3	11.9
Yellowness		-20.3	-21.3	-21.3	-21.3	-21.2	-22.1	-20.6
L*		95.3	95.8	95.3	95.6	95.8	95.8	95.5
a*		3.12	3.48	3.51	3.45	3.36	3.58	3.49
b*		-10.95	-12.1	-11.4	-12.2	-12.1	-11.7	-11.3
Opacity, %ISO		87.2	86.2	86.3	86.1	86.6	87.8	86.7

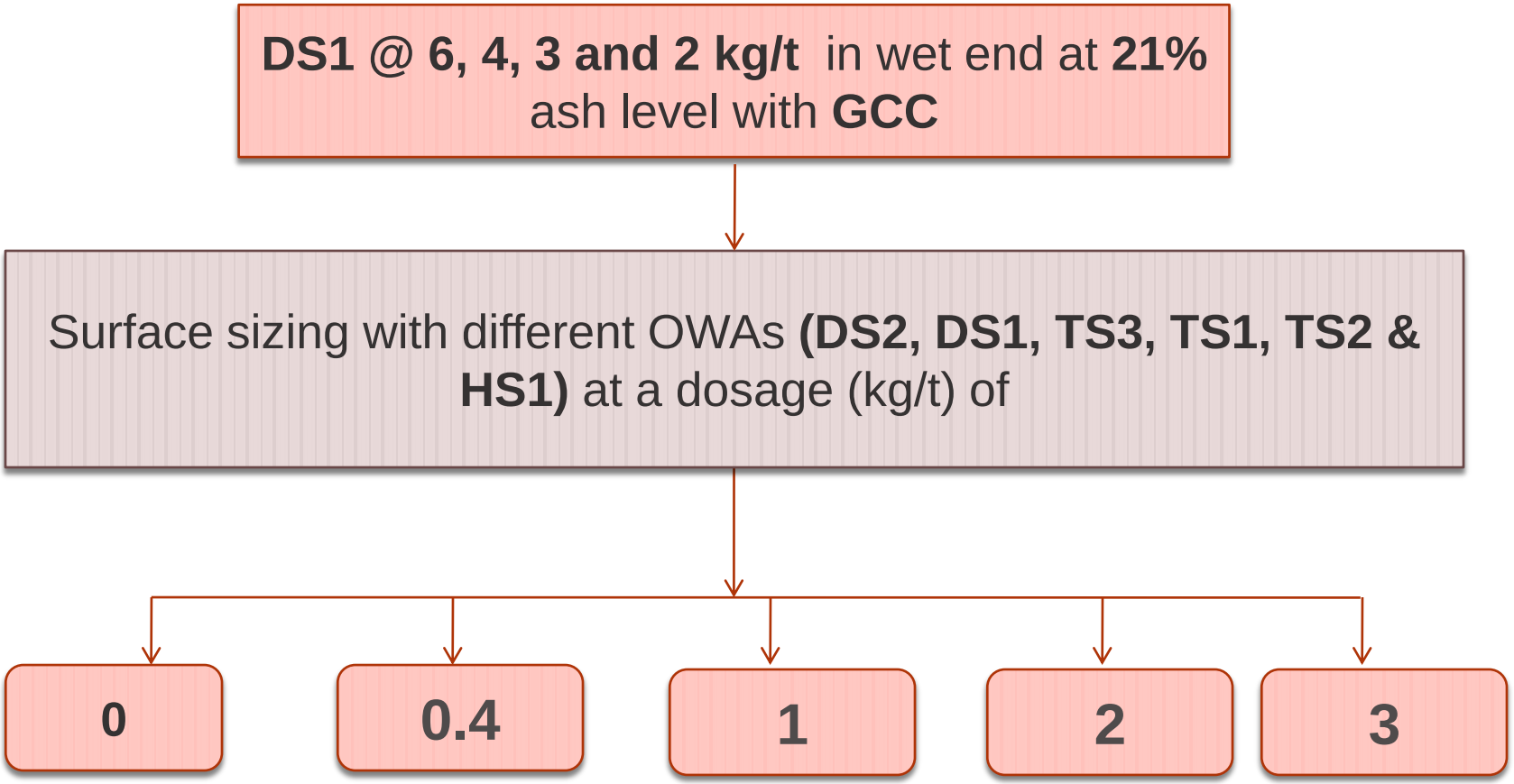
Split addition of different OWAs in wet end and surface sizing application



Best combinations

TS3 wet-end, kg/t		11	6	6	6	6	6	6
In surface sizing	OWA	--	DS2	DS1	TS1	TS3	TS2	HS1
	Dose, kg/t	--	2	0.4	1	1	2	2
Brightness, %ISO		93.7	94.6	94.3	94.1	94.7	94.5	94.0
Basic Brightness, %ISO		81.4	82.7	82.6	82.8	82.4	82.5	82.5
CIE Whiteness		141.4	142.9	143.3	143.1	142.3	142.2	142.6
Fluorescence		22.9	23.6	22.5	23.1	23.2	23.1	22.6
Fluorescence, C		12.3	11.9	11.7	11.3	12.0	12.0	11.5
Yellowness		-21.30	-21.34	-21.64	-21.82	-21.29	-22.12	-22.45
L*		95.7	95.4	95.4	95.1	95.1	95.5	95.5
a*		3.61	3.24	3.40	3.44	3.37	3.22	3.35
b*		-11.42	-11.74	-12.01	-12.16	-11.79	-11.61	-11.95
Opacity, %ISO		83.7	86.2	85.9	85.9	86.0	86.1	86.7

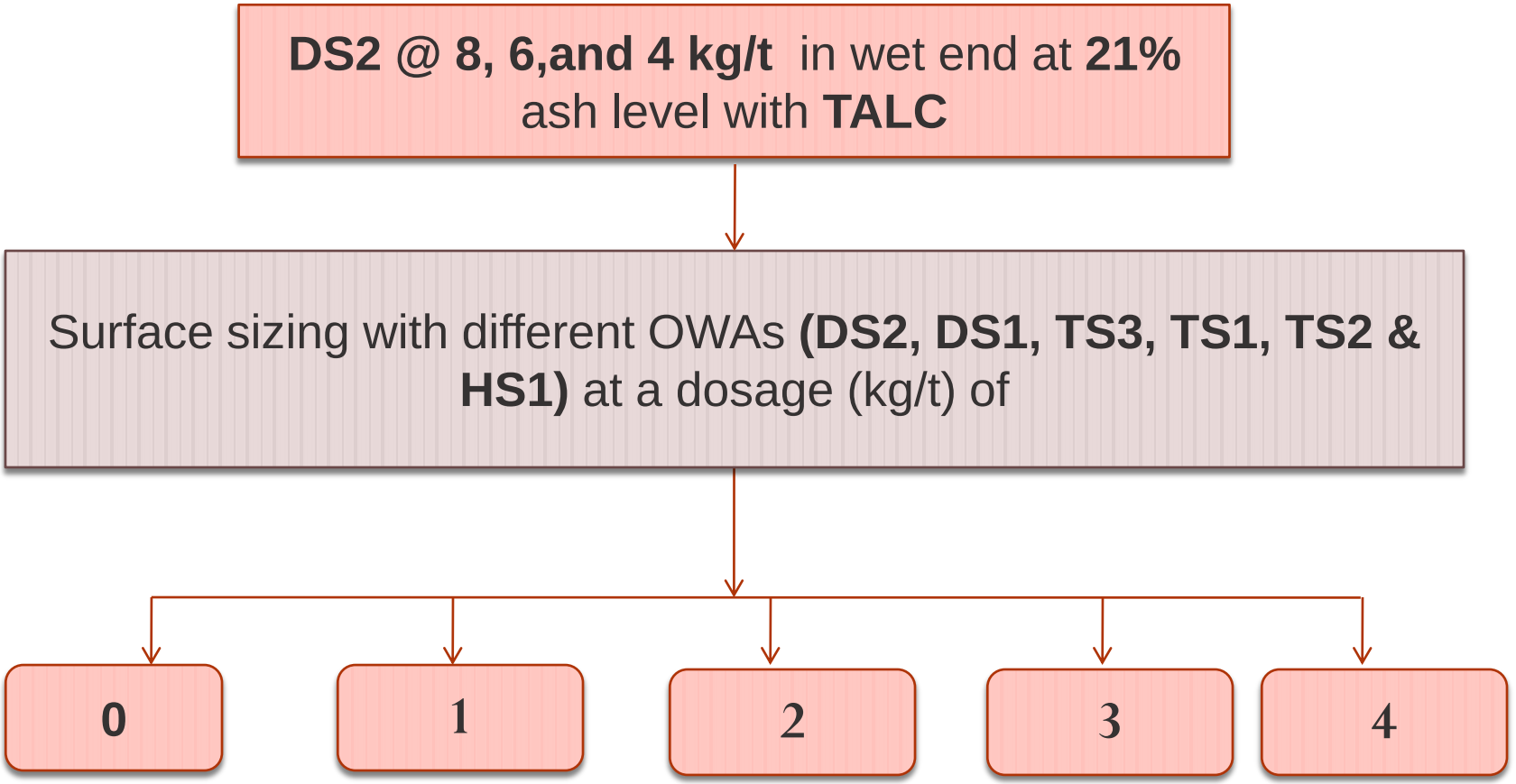
Split addition of different OWAs in wet end and surface sizing application



Best combinations

DS1 wet-end, kg/t		8	5	5	5	5	5	5
In surface sizing	OWA	--	DS2	DS1	TS1	TS3	TS2	HS1
	Dose, kg/t	--	2	2	2	3	2	2
Brightness, %ISO		93.7	93.8	93.9	93.5	94.0	93.4	93.3
Basic Brightness, %ISO		81.2	81.5	81.6	81.1	81.4	81.4	81.5
CIE Whiteness		142.6	144.2	142.6	143.1	143.2	142.5	142.5
Fluorescence		24.2	23.8	23.5	23.8	23.9	22.8	23.8
Fluorescence, C		12.5	12.3	12.3	12.4	12.6	12.0	11.8
Yellowness		-21.36	-21.11	-21.90	-21.64	-21.42	-20.70	-21.50
L*		95.5	95.1	95.5	95.8	95.5	95.7	95.6
a*		3.18	3.39	3.88	3.64	3.32	3.79	3.76
b*		-10.89	-12.16	-12.05	-12.00	-11.56	-11.93	-11.67
Opacity, %ISO		87.6	87.8	87.3	86.7	87.9	86.9	87.3

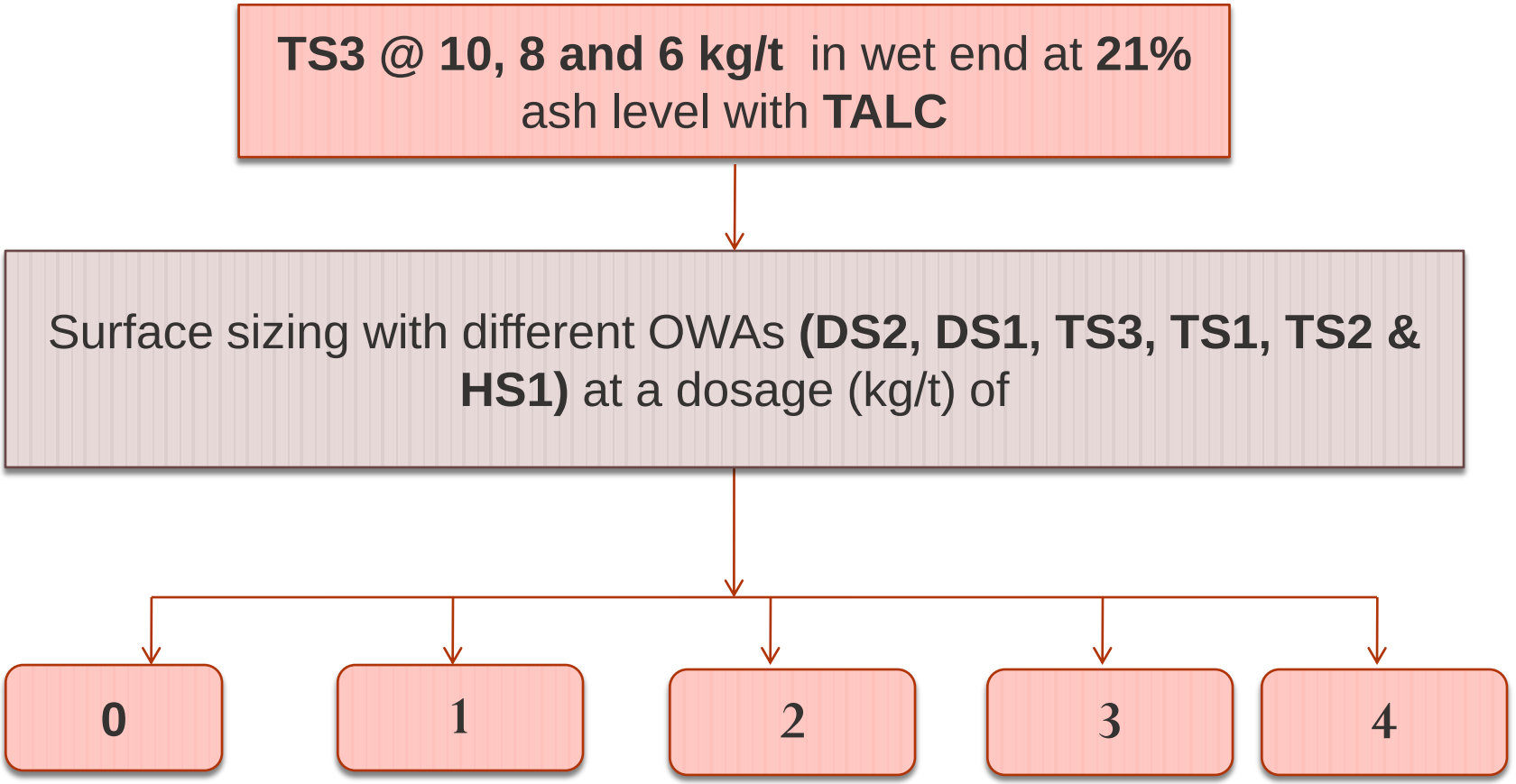
Split addition of different OWAs in wet end and surface sizing application



Best combinations

DS2 at wet-end, kg/t		8	6	8	6	8	8
In surface sizing	OWA	--	TS3	DS2	TS2	DS1	TS1
	Dose, kg/t	--	2	1	2	1	1
Brightness, %ISO		91.9	92.4	91.1	92.2	91.4	91.4
Basic Brightness, %ISO		79.0	78.5	78.2	78.1	78.4	78.6
CIE Whiteness		139.3	140.6	141.3	141.0	141.3	142.0
Fluorescence, C		25.2	13.9	23.4	14.1	13.0	12.8
Fluorescence		12.9	24.4	12.9	24.3	23.5	24.9
Yellowness		-20.63	-21.7	-18.8	-21.7	-19.0	-21.0
L*		94.3	94.1	94.4	94.1	94.2	94.2
a*		3.29	3.20	2.79	3.10	3.10	2.96
b*		-11.43	-12.05	-11.54	-12.02	-11.86	-12.13

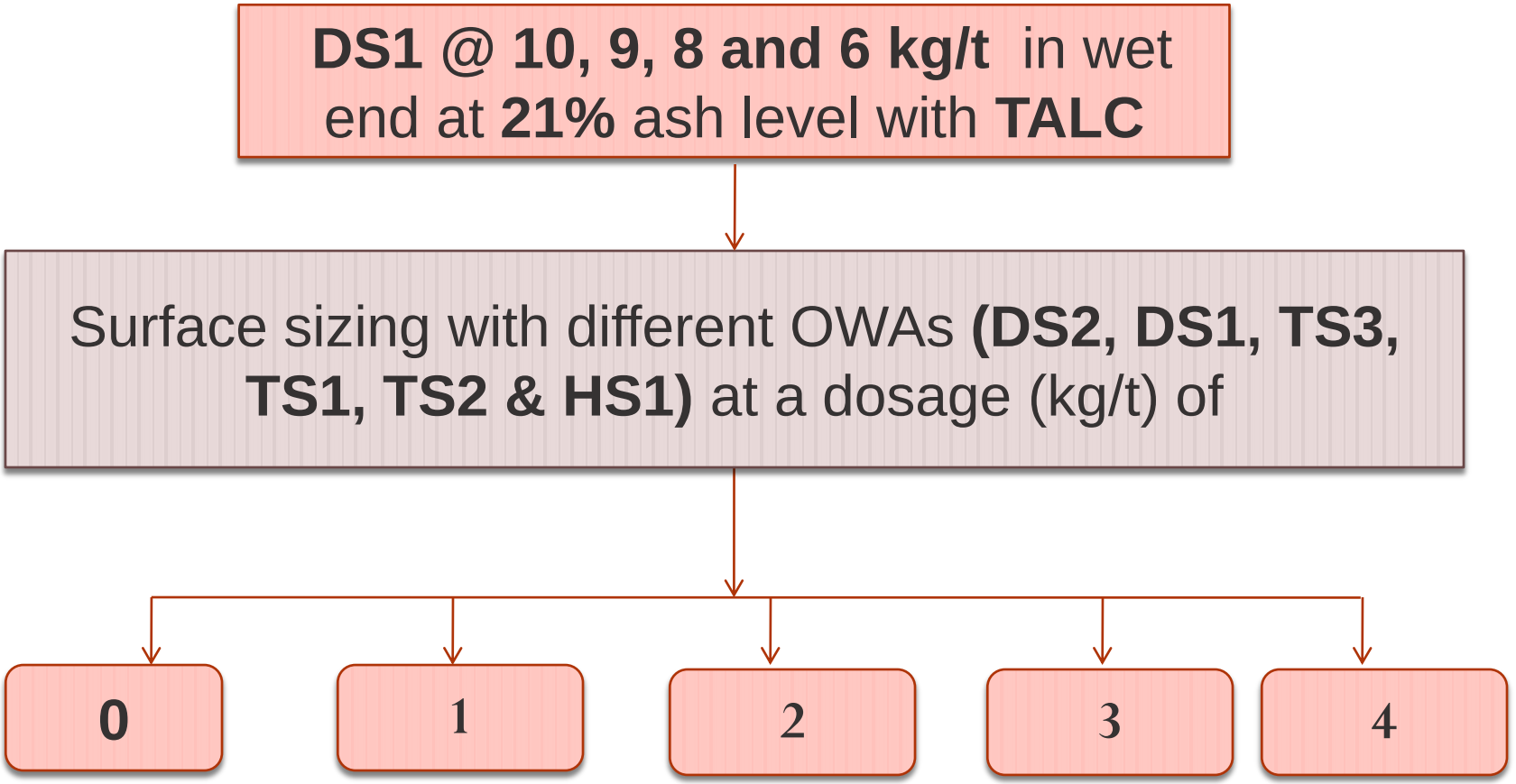
Split addition of different OWAs in wet end and surface sizing application



Best combinations

TS3 at wet-end, kg/t		16	10					
In surface sizing	OWA	--	TS3	DS2	TS1	TS2	DS1	HS1
	Dose, kg/t	--	2	1	1	2	1	1
Brightness, %ISO		91.9	91.9	91.2	91.2	92.0	91.4	91.4
Basic Brightness, %ISO		78.6	78.2	78.4	78.4	78.3	78.2	77.9
CIE Whiteness		142.5	144.8	145.0	145.0	144.3	145.5	144.6
Fluorescence		26.1	25.7	24.5	24.5	25.8	24.7	25.6
Fluorescence, C		13.3	13.7	12.8	12.8	13.7	13.2	13.5
Yellowness		-22.99	-25.93	-23.72	-23.72	-25.80	-23.82	-24.23
L*		94.6	94.4	94.1	94.1	94.1	94.0	94.4
a*		3.48	3.95	4.03	4.03	3.81	4.07	3.69
b*		-12.43	-12.95	-13.07	-13.07	-13.01	-13.07	-13.08

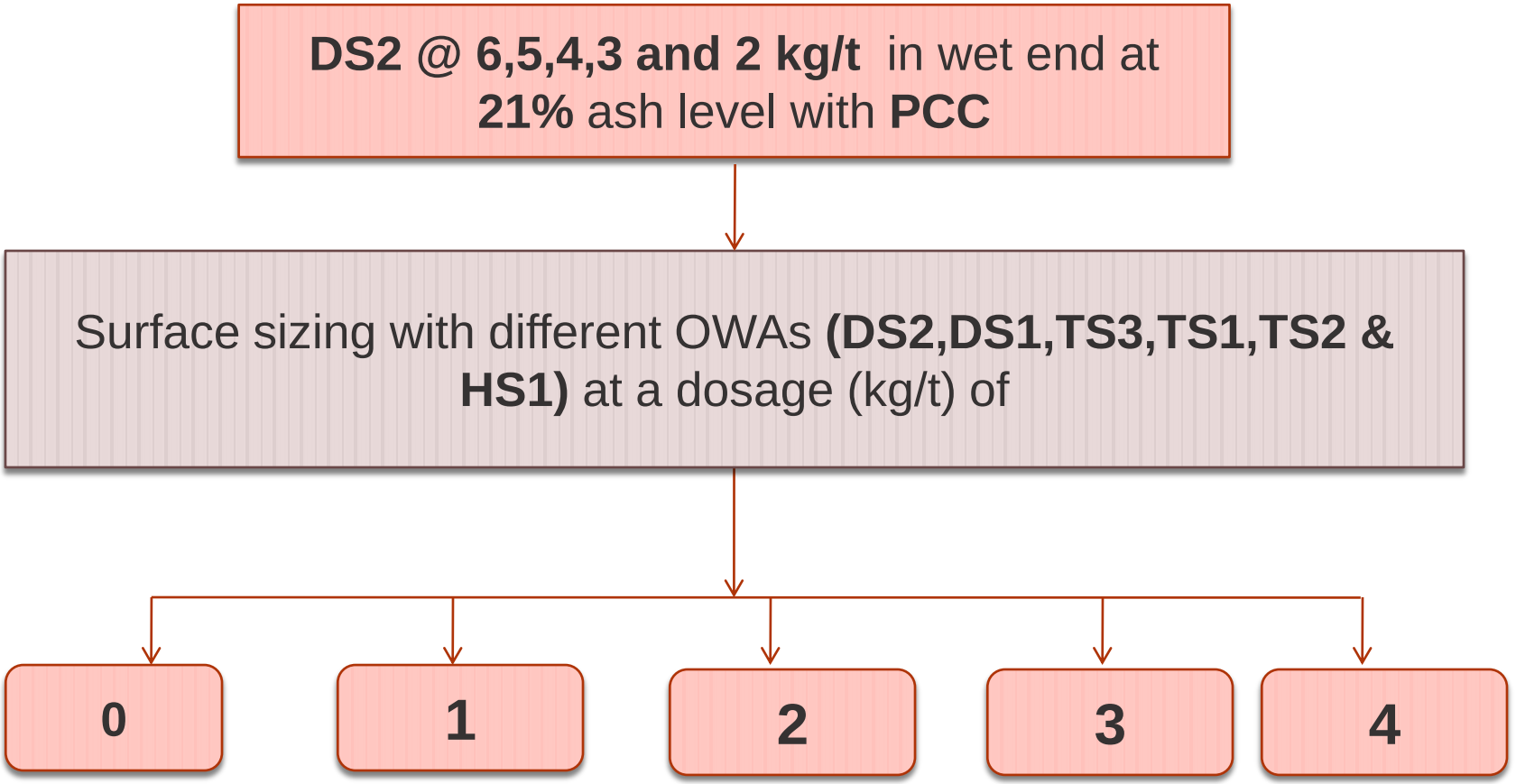
Split addition of different OWAs in wet end and surface sizing application



Best combinations

DS1 at wet-end, kg/t		12	9					
In surface sizing	OWA	--	TS3	DS2	TS1	TS2	DS1	HS1
	Dose, kg/t	--	2	1	1	2	1	1
Brightness, %ISO		91.6	92.1	91.4	91.6	92.2	91.6	91.7
Basic Brightness, %ISO		78.5	78.6	77.9	78.5	77.9	78.3	78.4
CIE Whiteness		136.6	145.7	145.5	144.5	145.4	146.1	145.8
Fluorescence		25.7	26.0	24.8	25.6	26.1	25.0	26.0
Fluorescence, C		13.1	13.5	13.5	13.1	14.3	13.3	13.3
Yellowness		-20.75	-26.33	-24.00	-25.26	-26.26	-24.11	-24.71
L*		94.9	94.3	94.1	94.1	94.3	120.0	94.4
a*		2.20	3.99	4.07	3.97	3.83	4.12	3.75
b*		-10.97	-13.15	-13.19	-13.20	-13.24	-13.20	-13.34

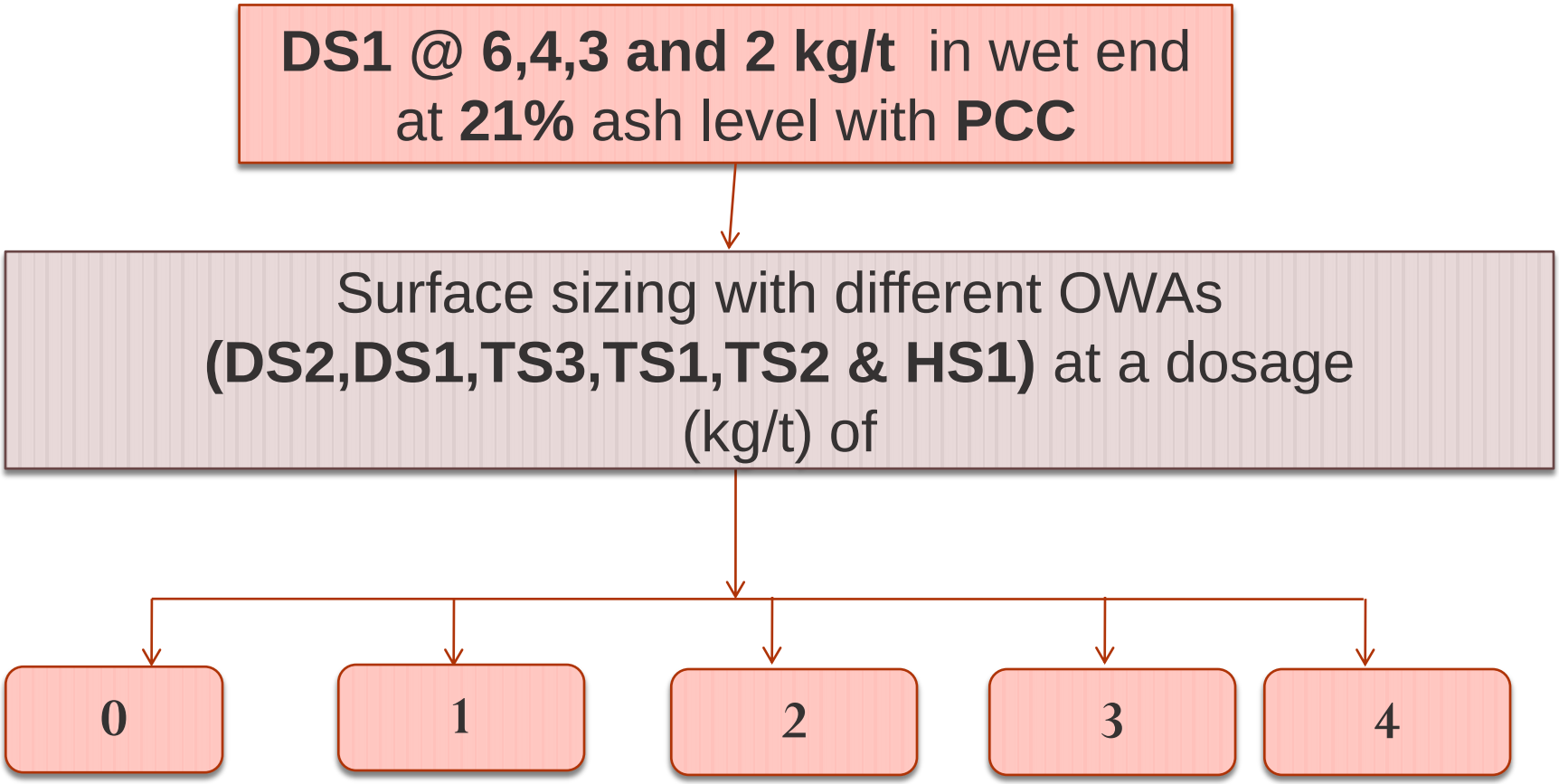
Split addition of different OWAs in wet end and surface sizing application



Best combinations

DS2 at wet-end, kg/t		**6**	**4**	**4**	**5**	**4**
In surface sizing	**OWA**	**--**	**TS3**	**TS1**	**DS1**	**TS2**
	Dose, kg/t	**--**	**3**	**3**	**3**	**3**
Brightness, %ISO		94.0	95.9	95.9	95.4	95.6
Basic Brightness, %ISO		84.0	83.9	84.1	83.8	83.5
CIE Whiteness		135.7	140.5	141.7	138.6	141.0
Fluorescence		20.1	23.8	23.5	22.8	22.9
Fluorescence, C		10.0	12.0	11.9	11.6	12.1
Yellowness		-18.20	-20.27	-22.24	-19.57	-20.69
L*		96.1	96.3	96.3	96.4	96.0
a*		3.31	2.69	3.26	2.99	3.42
b*		-12.00	-9.90	-10.60	-10.30	-11.50
Opacity, %ISO		91.4	91.8	92.0	90.8	90.5

Split addition of different OWAs in wet end and surface sizing application



Best combinations

DS1 in wet end, kg/t		8	6		
In surface sizing	OWA	--	DS1	TS2	HS1
	Dose, kg/t	--	1	2	3
Brightness, %ISO		96.3	95.5	96.4	96.1
B. Brightness, %ISO		84.2	84.4	84.1	84.1
CIE Whiteness		140.7	141.4	142.8	142.0
Fluorescence		23.6	22.6	22.9	22.6
Fluorescence, C		12.1	11.1	11.5	12
Yellowness		-20.30	-18.86	-19.23	-19.27
L*		96.3	96.0	96.0	96.2
a*		3.37	3.35	3.42	3.39
b*		-11.18	-11.30	-12.02	-12.12

Bagasse Furnish

Best combinations at 21% ash level with Talc

At wet end	OWA	DS2	DS2	TS3	TS3	DS1	DS1
	Dose, kg/t	10	6	10	6	12	8
At size press	OWA	nil	TS2	nil	TS2	Nil	TS2
	Dose, kg/t	nil	2	nil	2	nil	2
Brightness, %ISO		99.4	**98.7**	99.0	**97.8**	100.0	**98.2**
Basic Brightness, %ISO		84.3	**83.4**	85.1	**83.2**	85.1	**84.0**
CIE Whiteness		149.2	**154.4**	148.9	**147.9**	152.0	**152.7**
Fluorescence		26.5	**27.8**	26.4	**25.4**	27.8	**27.5**
Fluorescence, C		15.1	**15.3**	13.9	**14.6**	14.9	**14.1**
Yellowness		-23.42	**-26.89**	-23.32	**-23.40**	-24.82	**-26.52**
L*		96.2	**95.9**	96.5	**95.6**	97.4	**96.2**
a*		3.49	**3.62**	3.49	**3.51**	3.42	**3.63**
b*		-13.92	**-14.89**	-12.79	**-12.50**	-13.54	**-13.79**

Best combinations at 21% ash level with GCC

At wet end	OWA	DS2	DS2	TS3	TS3	DS1	DS1
	Dose, kg/t	10	7	14	9	10	6
At size press	OWA	Nil	TS2	Nil	HS1	Nil	SPPZ
	Dose, kg/t	Nil	2	Nil	3	Nil	3
Brightness, %ISO		102.3	**103.1**	101.1	**100.6**	101.1	**100.8**
Basic Brightness, %ISO		87.3	**87.5**	86.8	**85.7**	87.1	**85.3**
CIE Whiteness		155.3	**158.6**	154.3	**155.2**	154.2	**156.0**
Fluorescence		28.1	**28.12**	26.8	**26.2**	28.50	**28.91**
Fluorescence, C		15.0	**15.6**	14.3	**14.9**	14.0	**15.5**
Yellowness		-25.01	**-25.16**	-25.04	**-25.89**	-25.15	**-26.42**
L*		97.4	**97.0**	97.2	**97.0**	97.6	**97.3**
a*		3.81	**3.81**	4.15	**4.29**	3.42	**3.88**
b*		-13.89	**-13.82**	-13.67	**-14.99**	-13.72	**-14.42**

Best combinations at 21% ash level with PCC

At wet end	OWA	DS2	DS2	TS3	TS3	DS1	DS1
	Dose, kg/t	10	7	10	9	10	6
At size press	OWA	Nil	TS2	Nil	TS2	Nil	TS1
	Dose, kg/t	Nil	2	Nil	2	Nil	2
Brightness, %ISO		101.5	**101.9**	101.0	**101.7**	101.8	**101.4**
Basic Brightness, %ISO		87.9	**87.4**	87.1	**87.7**	88.2	**87.0**
CIE Whiteness		153.9	**157.7**	149.2	**157.6**	154.2	**154.2**
Fluorescence		26.4	**28.6**	23.4	**27.8**	26.4	**27.8**
Yellowness		-24.5	**-26.5**	-22.0	**-26.5**	-23.91	**-24.80**
L*		97.4	**97.6**	97.2	**97.6**	97.5	**97.6**
a*		4.12	**4.33**	4.02	**4.47**	3.95	**4.11**
b*		-13.72	**-14.66**	-11.90	**-14.60**	-13.25	**-13.49**

Recycled Furnish

Best combinations at 21% ash level with Talc

At wet end	OWA	DS2	DS2	TS3	TS3	DS1	DS1
	Dose, kg/t	9	6	9	6	11	7
At size press	OWA	Nil	HS1	Nil	HS1	Nil	SPPZH
	Dose, kg/t	Nil	2	Nil	4	Nil	3
Brightness, %ISO		87.3	**87.3**	86.8	**87.3**	88.2	**87.7**
Basic Brightness, %ISO		76.5	**74.6**	76.5	**77.2**	76.9	**76.4**
CIE Whiteness		138.8	**137.4**	138.6	**139.9**	137.6	**136.2**
Fluorescence		21.94	**24.69**	20.11	**25.17**	23.32	**25.36**
Yellowness		-20.68	**-23.02**	-18.94	**-24.45**	-21.68	**-23.03**
L*		93.2	**92.7**	93.0	**93.5**	93.7	**92.8**
a*		2.92	**2.90**	2.95	**3.11**	2.35	**2.32**
b*		-11.41	**-12.05**	-10.17	**-12.70**	-11.65	**-11.74**

Best combinations at 21% ash level with GCC

At wet end	OWA	DS2	DS2	TS3	TS3	DS1	DS1
	Dose, kg/t	8	5	8	5	11	7
At size press	OWA	Nil	HS1	Nil	HS1	Nil	HS1
	Dose, kg/t	Nil	4	Nil	4	Nil	3
Brightness, %ISO		91.0	**90.8**	89.9	**90.6**	91.3	**91.0**
Basic Brightness, %ISO		79.6	**79.30**	79.5	**78.6**	78.5	**79.1**
CIE Whiteness		139.2	**143.7**	139.4	**145.3**	142.8	**143.1**
Fluorescence		21.55	**26.18**	20.67	**26.24**	24.38	**26.85**
Yellowness		-21.35	**-25.09**	-19.85	**-25.84**	-22.84	**-24.10**
L*		94.20	**93.7**	95.2	**94.5**	94.4	**94.6**
a*		2.98	**2.83**	3.11	**3.24**	2.61	**2.71**
b*		-11.49	**-13.05**	-11.10	**-13.51**	-12.03	**-13.11**

Best combinations at 21% ash level with PCC

At wet end	OWA	DS2	DS2	TS3	TS3	DS1	DS1
	Dose, kg/t	9	6	9	6	11	7
At size press	OWA	Nil	HS1	Nil	HS1	Nil	HS1
	Dose, kg/t	Nil	4	Nil	4	Nil	3
Brightness, %ISO		91.8	**91.6**	91.4	**91.6**	91.9	**91.8**
Basic Brightness, %ISO		79.1	**79.2**	79.4	**79.2**	79.1	**79.1**
CIE Whiteness		140.5	**145.4**	141.6	**145.4**	142.1	**142.5**
Fluorescence		21.40	**26.10**	19.21	**26.10**	23.32	**24.90**
Yellowness		-21.40	**-24.88**	-21.10	**-24.88**	-22.10	**-23.10**
L*		94.6	**94.4**	94.4	**94.4**	94.8	**94.1**
a*		2.84	**3.34**	2.85	**3.34**	2.52	**2.65**
b*		-11.42	**-12.74**	-11.12	**-12.74**	-11.50	**-12.20**

Addition of broke in the papermaking furnish and its effect on the efficiency of OWAs

Effect of Broke addition in wet end with GCC at 21% ash level

DS2, kg/t	3	0	0	0	3	3
Broke addition, %	0	5	15	30	5	30
Brightness, %ISO	93.0	84.1	86.3	87.0	93.1	92.9
B. Brightness, %ISO	83.4	81.2	82.3	82.0	82.2	81.7
CIE Whiteness	136.4	91.1	99.9	106.7	138.3	140.1
Fluorescence	21.00	2.92	4.03	4.98	21.69	22.27
Yellowness	-20.41	-1.27	-4.29	-7.40	-19.96	-21.14
L*	95.6	94.3	94.8	94.5	95.3	95.0
a*	3.46	1.21	1.62	1.89	3.67	3.78
b*	-11.00	-1.14	-2.83	-4.47	-11.18	-11.73
Opacity, %ISO	86.7	87.1	86.5	86.2	86.1	85.3
S. Coeff., m^2/kg	47.8	47.1	45.9	46.2	46.9	47.1

Effect of broke addition during the split addition of OWAs in wet end and surface sizing

DS2 at wet end, kg/t	3	3	3	3	3
ABIZ in surface sizing, kg/t	2	0	0	2	2
Broke addition, %	0	5	30	5	30
Brightness, %ISO	94.6	93.1	92.9	93.6	93.5
B. Brightness, %ISO	82.6	82.2	81.7	82.3	82.1
CIE Whiteness	141.8	138.3	140.1	140.1	141.2
Fluorescence	22.20	21.69	22.27	21.80	22.02
Yellowness	-21.30	-19.96	-21.14	-20.42	-21.29
L*	95.6	95.3	95.0	95.6	95.1
a*	3.45	3.67	3.78	3.75	3.81
b*	-12.2	-11.18	-11.73	-11.28	-11.80
Opacity, %ISO	86.1	86.1	85.3	85.2	85.1
S. Coeff., m^2/kg	46.1	46.9	47.1	47.2	46.8

Effect of Broke addition in wet end with Talc at 21% ash level

DS2, kg/t	6	0	0	0	6	6
Broke addition, %	**0**	**5**	**15**	**30**	**5**	**30**
Brightness, %ISO	90.6	81.4	83.7	84.9	91.5	91.7
B. Brightness, %ISO	79.1	79.3	79.9	79.7	79.3	79.7
CIE Whiteness	137.5	81.6	94.2	104.2	140.1	140.8
Fluorescence	24.30	2.11	3.21	10.58	23.94	23.71
Yellowness	-20.52	-1.75	-2.86	-6.88	-21.87	-22.33
L*	94.2	93.6	93.9	93.8	94.4	94.7
a*	3.23	0.70	1.39	2.01	3.65	3.60
b*	-10.79	-0.60	-2.07	-4.24	-11.97	-12.15
Opacity, %ISO	83.9	83.2	83.1	84.0	83.2	84.1
S. Coeff., m^2/kg	35.9	39.8	40.1	40.2	40.2	40.1

Effect of broke addition during the split addition of OWAs in wet end and surface sizing with talc at 21% ash level at wet end

DS2, kg/t	6	6	6	6	6
TS2, kg/t	2	0	2	0	2
Broke addition, %	0	5	5	30	30
Brightness, %ISO	92.2	91.5	92.0	91.7	92.2
B. Brightness, %ISO	78.1	79.3	79.5	79.7	80.0
CIE Whiteness	141.0	140.1	141.2	140.8	142.0
Fluorescence	24.3	23.9	24.1	23.7	24.0
Yellowness	-21.7	-21.8	-21.9	-22.3	-23.0
L*	94.1	94.4	94.7	94.4	94.6
a*	3.10	3.65	3.85	3.60	3.87
b*	-12.02	-11.97	-12.30	-12.15	-12.52
Opacity, %ISO	83.1	83.2	83.5	84.1	84.3
S. Coeff., m^2/kg	35.3	40.2	39.4	40.1	39.9

Identification of new OWAs in place of commercially available OWAs and their effect on optical properties of paper

Characterization of different Identified OWAs

Name of OWA (% Solids)	Type of OWA	E-value (1%/1 cm)
AAMD (99.9)	Di- sulphonated	505
APOH (99.9)	Hexa- sulphonated	483

Optimization of AAMD in wet-end with GCC at 21% ash level

AAMD, kg/t	4	6	8
ISO Brightness, %	92.6	93.6	93.2
B. brightness, %	84.4	84.5	84.6
CIE Whiteness	136.6	139.5	139.1
Fluorescence	20.9	22.8	23.6
Fluorescence, C	10.2	11.3	11.6
Yellowness	-19.3	-20.5	-20.5
L*	95.3	95.6	95.7
a*	3.50	3.37	3.06
b*	-10.8	-11.3	-11.2
Opacity, %	88.5	88.6	88.8
S. Coeff., m^2/kg	55.7	56.2	57.2

Split addition of OWAs in wet-end surface sizing

AAMD, kg/t	4		
APOH, kg/t	Only starch	0.5	1
ISO Brightness, %	91.9	93.3	93.1
B. brightness, %	84.4	84.5	84.6
CIE Whiteness	136.9	139.0	139.1
Fluorescence	21.0	22.1	22.1
Fluorescence, C	10.	11.0	11.0
Yellowness	-19.9	-20.4	-20.1
L*	94.9	94.9	94.9
a*	3.60	3.63	3.62
b*	-4.08	-4.07	-4.08

Validation of the results carried out by CPPRI with selected OWA on mixed hard wood pulp and different fillers

Observations:

Addition of OWA (DS2) in wet-end application with GCC filler

- The B. brightness of control sample (mixed hard wood bleached pulp) taken for experiment at CPPRI was 76.8% ISO, whereas the pulp brightness of control sample was 81.8% at ACIRD.

- While addition of OWA (DS2) in wet-end @ 6.0 kg/t using GCC as filler maintaining 21% ash in paper achieved an increment of 17.4% brightness at CPPRI against 12.6% brightness at ACIRD.

Split addition of OWAs in wet-end and surface sizing application with GCC filler (DS2 at wet-end and TS1 at size press)

- The B. brightness of control sample (mixed hard wood bleached pulp) taken for experiment at CPPRI was 76.8 %, whereas the pulp brightness of control sample was 82.6% at ACIRD.

- While addition of OWA (DS2) in wet-end @ 3.0 kg/t and addition of OWA (TS1) in surface sizing application @ 2.0 kg/t using GCC as filler, maintaining 21% ash in paper achieved an increment of 17.05% brightness at CPPRI against 12.00% brightness at ACIRD along with cost reduction of 615 Rs/t of paper.

Addition of OWA (DS2) in wet-end application with talc filler

- The B. brightness of control sample (mixed hard wood bleached pulp) taken for experiment at CPPRI was 76.8%, whereas the pulp brightness of control sample was 79.0 % at ACIRD.

Observations:

- While addition of OWA (DS2) in wet-end @ 8.0 kg/t using talc as filler maintaining 21% ash in paper achieved an increment of 15.35% brightness at CPPRI against 12.9% brightness at ACIRD.

Split addition of OWAs in wet-end and surface sizing application with talc filler (DS2 at wet-end and TS2 at size press)

- The B. brightness of control sample (mixed hard wood bleached pulp) taken for experiment at CPPRI was 76.79% ISO, whereas the pulp brightness of control sample was 78.10% at ACIRD.
- While addition of OWA (DS2) in wet-end @ 6.0 kg/t and addition of OWA (TS2) in surface sizing application @ 2.0 kg/t using talc as filler maintaining 21% ash in paper achieved an increment of 17.37% brightness at CPPRI against 14.1% brightness at ACIRD along with cost reduction of 400 Rs/t of paper

RESULTS

- In all the four sets of experiments carried out at CPPRI showed better results than experiments carried out at ACIRD.

RECOMMENDATION

- It was recommended that the plant trial with the use of selected OWA with suitable filler may be carried out at TNPL/ BILT.

Demonstration of results in the plant scale

Plant scale trial in hardwood based mill

Paper M/c No. (Production) : 2 (40 TPD)

Pre trial Period: : February 07, 2017 (9 AM) to February 08, 2017 (9 AM) Total 24 hrs

Trial Period: : February 08, 2017 (12 Noon) to February 09, 2017 (11 PM) Total 35 hrs

Paper Product/ Grammage: : Paper grade 2/ 90 GSM

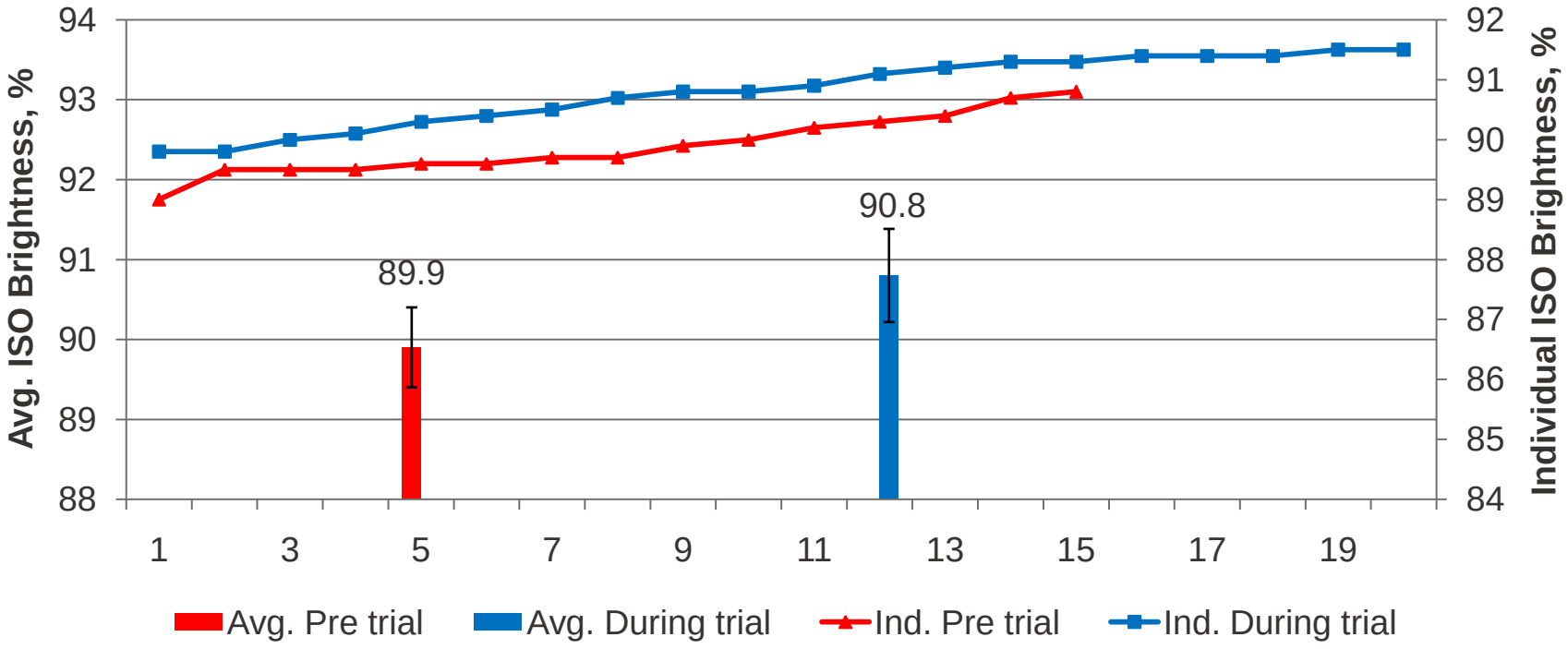
Chemical dosage during pre trial period : OWAs i.e. TS1 @ 3 kg/t at wet-end and 2 kg/t in size press. Rest of the conditions i.e. chemical, doses and dosing points are same

Chemical dosage during trial period : OWAs i.e. DS1 @ 3 kg/t at wet-end and HS1 @ 1.5 kg/t at size press (i.e. addition of 6 kg of DS1 in batch of 2T pulp at wet-end and 6 kg HS1 in a batch of 4T starch at size press on as such basis)

Observations:

Number of occurrence in brightness slabs

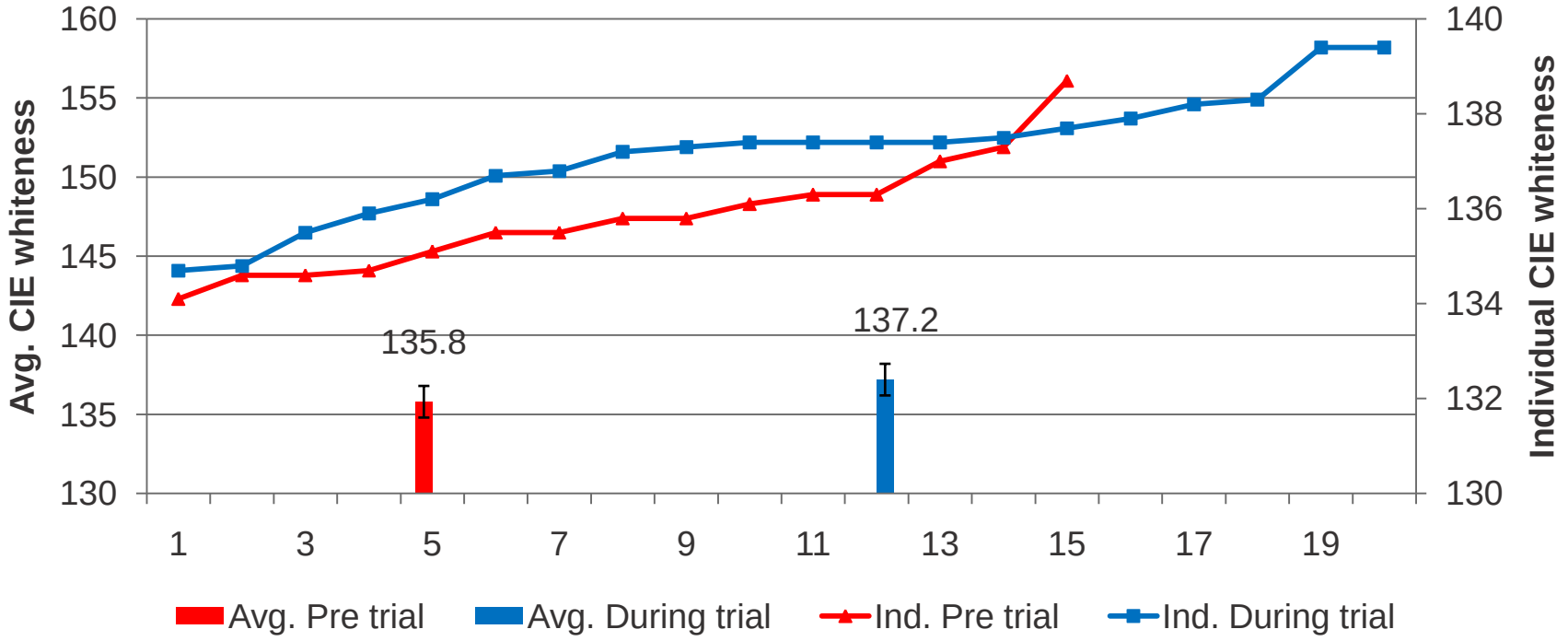
Brightness slabs	Pre trial	During trial
≥91	0	9 (45%)
≥90<91	6 (40%)	9 (45%)
≥89<90	9 (60%)	2 (10%)



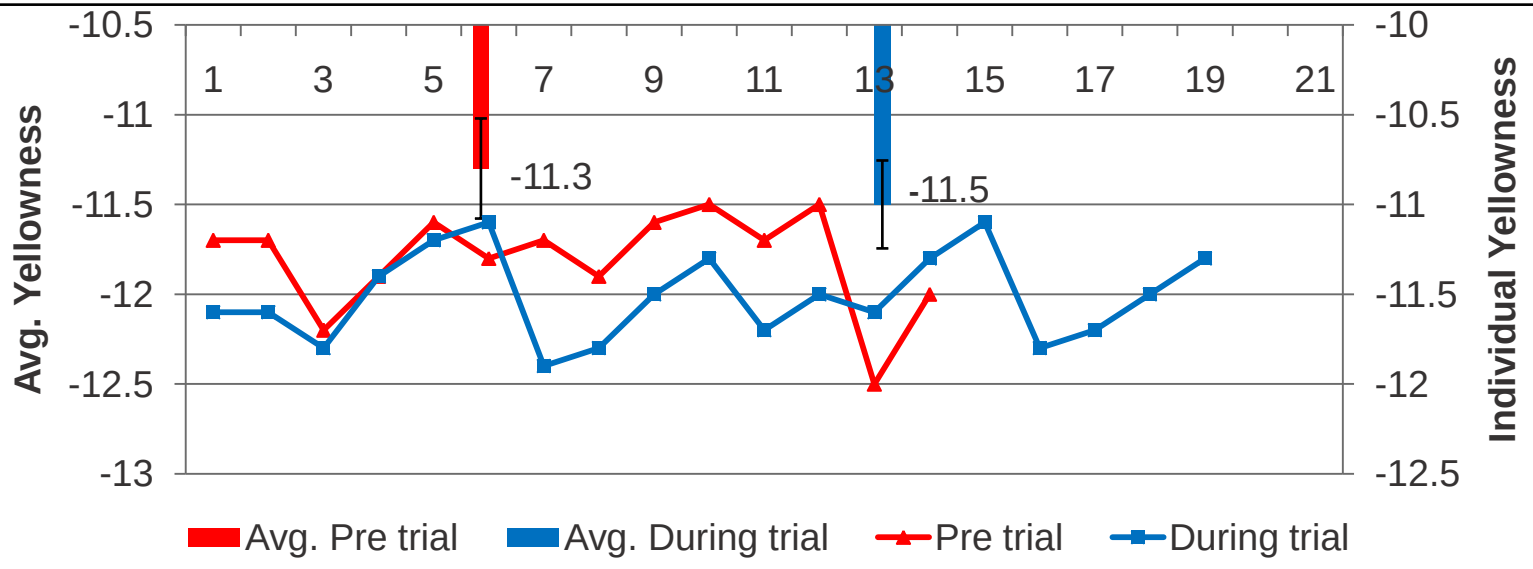
Effect on brightness of paper

Number of occurrence in CIE whiteness slabs

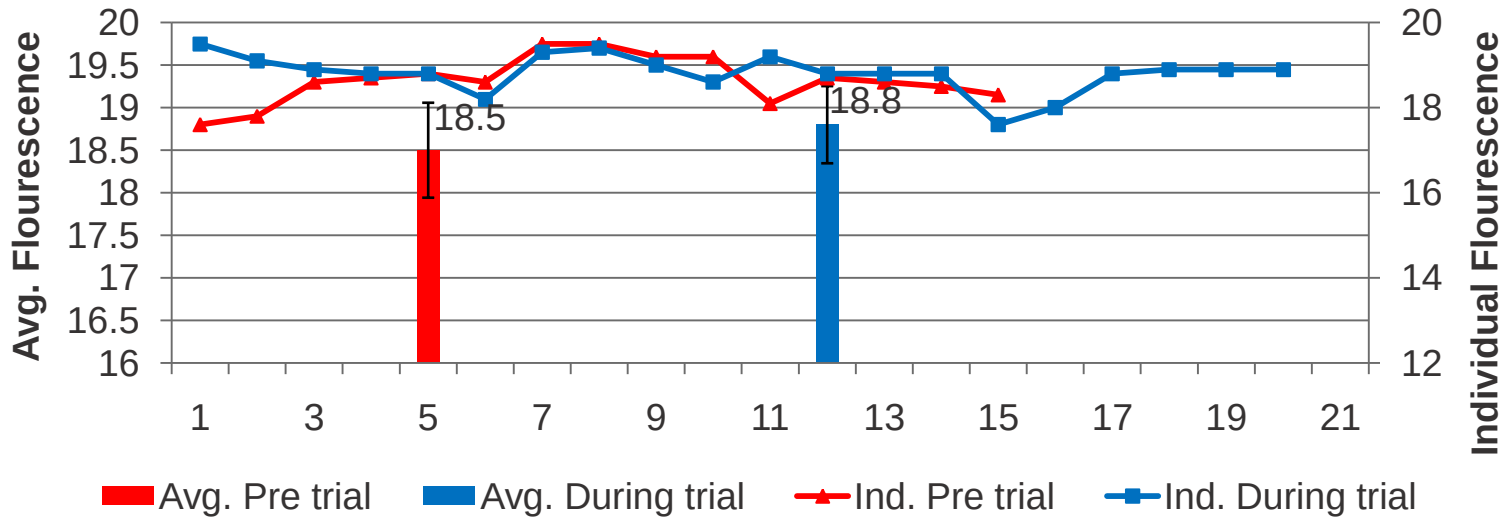
Whiteness slabs	Pre trial	During trial
≥139	0 (0%)	2 (10.0%)
≥138<139	1 (6.7%)	2 (10.0%)
≥137<138	2 (13.3%)	9 (45.0 %)
≥136<137	3 (20.0 %)	3 (15.0%)
≥134<136	9 (60.0%)	4 (20.0%)



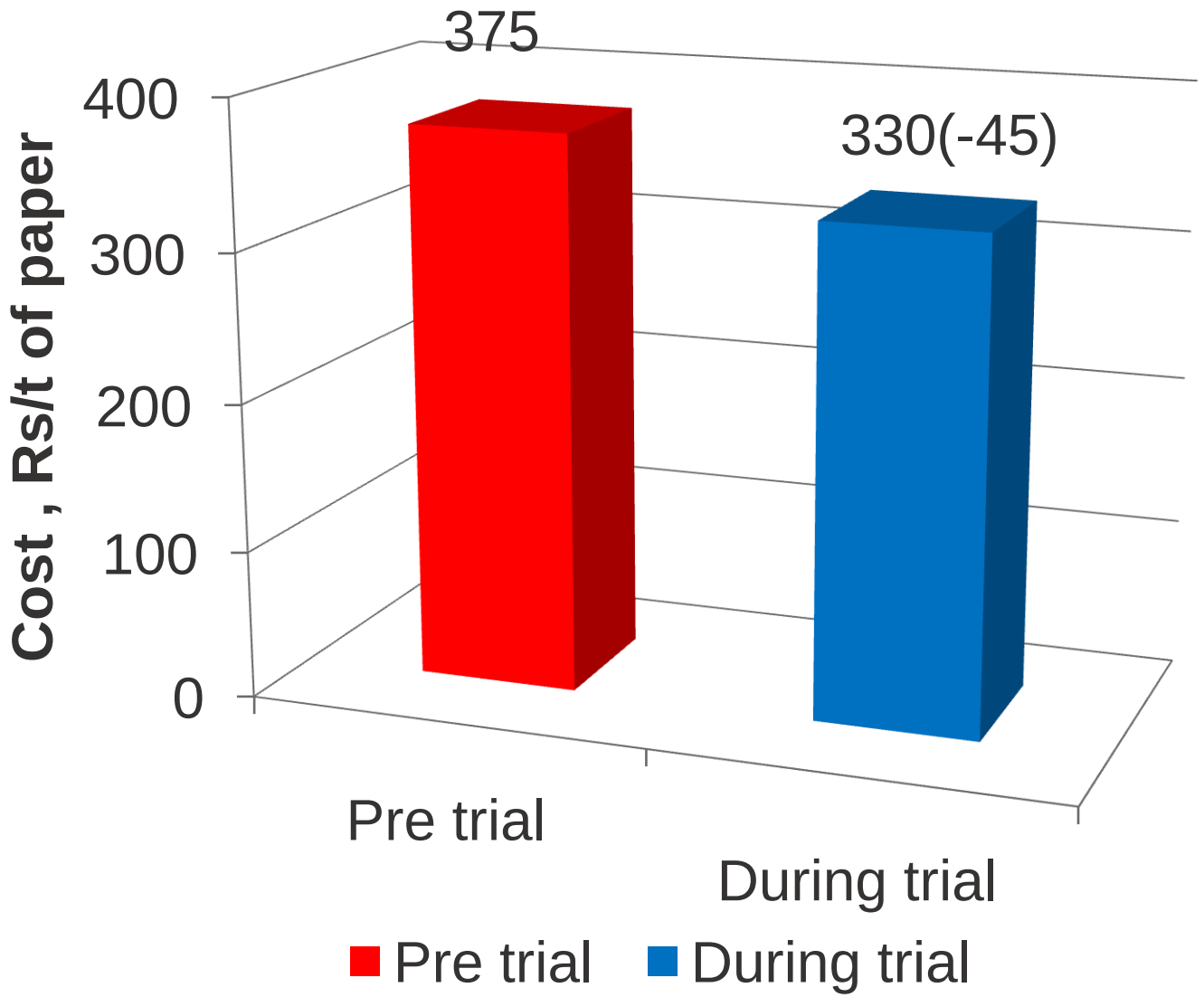
Effect on CIE whiteness of paper



Effect on yellowness of paper



Effect on fluorescence of paper



Effect on cost of OWAs

Plant scale for agro based mill

Paper M/c No. (Production) : 3 (150 TPD)

Trial Period: **:** March 30, 2017 (12 Noon to 6.30 PM) Total 6.5 hrs

Paper Product/ Grammage: **:** Writing and printing paper/ 64 GSM

Reduction in chemical dosage during trial period :Reduction in dose of OWAs i.e. from 3.5 kg/t to 3.1 kg/t in case of DS2 at wet end along with 4 kg/t of HS1 addition at size press (DS2 was added at a conc. of 75 gpl at wet end monitored by DCS. HS1 was added in size press by prereparing solution of 500 gpl and maintaining a flow of 1 lpm in starch slurry on the basis of paper draw of 7.5 t/hr)

Dosing points : DS2 in mixing chest at wet end, HS1 in size press

Optical properties of paper during trial period

DS2 dose at wet end, kg/t	**4.5**	**4.0**	**4.0**	**3.5**	**3.5**	**3.2**	**3.2**	**3.1**	**3.1**	**3.1**	**3.1**	**3.1**	**3.1**
HS1 dose at size press, kg/t	**2.0**	**4.0**	**4.0**	**4.0**	**4.0**	**4.0**	**4.0**	**4.0**	**4.0**	**4.0**	**4.0**	**4.0**	**4.0**
Brightness, %ISO	89.5	89.9	90.0	89.3	89.1	89.3	89.1	89.1	89.3	89.3	89.6	89.4	89.5
CIE Whiteness	145.1	145.8	146.2	144.0	144.1	143.8	145.4	145.1	144.1	144.6	146.2	145.2	145.0
Yellowness	-28.9	-29.0	-29.2	-29.2	-29.0	-28.8	-30.0	-29.0	-29.0	-29.4	-30.2	-30.1	-30.1
L*	89.0	89.1	89.0	89.5	89.5	89.5	89.3	89.4	89.6	89.6	89.6	89.6	89.6
a*	3.14	3.20	3.20	3.20	3.16	3.20	3.20	3.20	3.14	3.15	3.20	3.20	3.20
b*	-10.2	-10.4	-10.5	-10.3	-10.2	-10.1	-10.6	-10.5	-10.2	-10.3	-10.6	-10.5	-10.4

Average values of optical properties

Properties	Average	Standard deviation
Brightness, %ISO	89.4	0.30
CIE Whiteness	145.0	0.85
Yellowness	-29.4	0.53
L*	89.4	0.21
a*	3.19	0.02
b*	-10.38	0.16

Summary

Best combinations of OWA's at wet-end & size press

Filler/ furnish		Mixed Hard wood Pulp			Bagasse Pulp		
		Talc	GCC	PCC	Talc	GCC	PCC
At wet-end	OWA	TS3	DS2	DS2	DS2	TS3	DS2
	Dose, kg/t	10	3	4	6	9	7
In surface sizing	OWA	TS1	TS1	TS2	TS2	HS1	TS2
	Dose, kg/t	1	2	3	2	3	2
Brightness, %ISO		91.2	94.6	95.6	98.7	100.6	101.9
Basic Brightness, %ISO		78.4	82.6	83.5	83.4	85.7	87.4
CIE Whiteness		145.0	141.8	141.0	154.4	155.2	157.7
Fluorescence		24.5	22.2	22.9	27.8	26.2	28.6
Yellowness		-23.72	-21.3	-20.69	-26.89	-25.89	-26.5
L*		94.1	95.6	96.0	95.9	97.0	97.6
a*		4.03	3.45	3.42	3.62	4.29	4.33
b*		-13.07	-12.2	-11.50	-14.89	-14.99	-14.66

Best combinations of OWA's at wet-end & size press

Filler/ furnish		Recycled Pulp		
		Talc	GCC	PCC
At wet-end	OWA	DS2	DS2	DS2
	Dose, kg/t	6	5	6
In surface sizing	OWA	HS1	HS1	HS1
	Dose, kg/t	2	4	4
Brightness, %ISO		87.3	90.8	91.6
Basic Brightness, %ISO		74.6	79.30	79.2
CIE Whiteness		137.4	143.68	145.4
Fluorescence		24.69	26.18	26.10
Yellowness		-23.02	-25.09	-24.88
L*		92.74	93.69	94.42
a*		2.90	2.83	3.34
b*		-12.05	-13.05	-12.74

Major Achievements

- The choice of addition of several wet-end cationic additives after OWA had no change in optical properties of paper sheets.
- The brightness of paper sheets was increased with increase in dosage of OWA. But after a certain addition level of OWA, the brightness either remains constant or reduces due to the greening effect of OWA.
- The intrinsic brightness of filler also had significant impact on brightness of paper.
- At same dosage of OWA, the optical properties including basic brightness were higher with GCC as compared that with talc filler.
- The cost of OWAs can be reduced by 20-30% or more without compromising the optical properties of paper by using split addition of OWAs in wet end and size press in various combination with all three pulp furnishes.
- No adverse effect of broke addition on performance of OWA at wet-end was observed, while slight reduction in optical properties of paper were observed in case of surface sizing the sheets having broke %age from 5 to 30

Major Achievements

Identification of OWAs other than commercially available OWAs

- The E-values of identified OWAs was the highest for di-sulphonated OWA (505) followed by hexa-sulphonated OWA (483).
- It was observed that on adding 0.5 kg /t of hexa-sulphonated OWA in surface sizing along with 4 kg/t of disulphonated OWA at wet-end gives comparable optical properties to that of adding 6 kg/t of di-sulphonated OWA at wet-end.

Validation of results at CPPRI

- All sets of experiments carried out at CPPRI showed better results compared to ACIRD.
- It was recommended that the plant trial with the use of selected OWA with suitable filler may be carried out at TNPL/ BILT.

Major Achievements

Demonstration of results in the plant scale

- Plant scale trial was conducted for 1 day in wood based paper mill at BILT SGU-Yamunanagar resulting in improvement of brightness and whiteness by 0.9 and 1.4 units, respectively along with reduction in cost of Rs 45/t of paper.
- Plant scale trial was also conducted for 1 day in agro based paper mill at Satia Industries Ltd.-Muktsar during which the dose of OWA was reduced gradually (i.e. from 4 to 3.1 kg/t) at wet end and the comparable optical properties were observed.

Major Achievements

Publication

- Deepak Kumar, Shubhang Bhardwaj, Ashish Sharma, Vipul S. Chauhan, Nishi K. Bhardwaj and R. Varadhan, (2016). Effect of optical whitening agents in wet end and surface sizing on recycled fibre based paper with different fillers. IPPTA J. 28 (3), 78-88.