Study on Use of Cast Copper Alloy Components for Rotorvanes & Rollers

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TEA MANUFACTURE

WITHERING	MOISTURE REDUCTION FOR NEXT OPERATION
ROLLING	BREAKING INTO SMALL SIZE PARTICLES
ROLL BREAKING	EXTRACTION OF BROKEN PARTICLES
AERATION	OBTAINING TEA LIQUOR CHARACTER
DRYING	MOISTURE REDUCTION FOR STORAGE
GRADING	SEPARATION INTO DIFFERENT SIZE TEAS AND CLEANING

ROLLING MACHINERY-Orthodox Roller

Orthodox Roller

Battens

Cone

ROLLING MACHINERY- Rotorvane

Vanes
fixed on the centre shaft

Resistors
fixed on inner surface of the barrel

PROBLEM IDENTIFIED

High wear & tear of cast copper alloy components

Frequent failure of cast copper alloy components.

- Poor performance of machinery
- Interruption to Rolling process

POSSIBLE CAUSES .

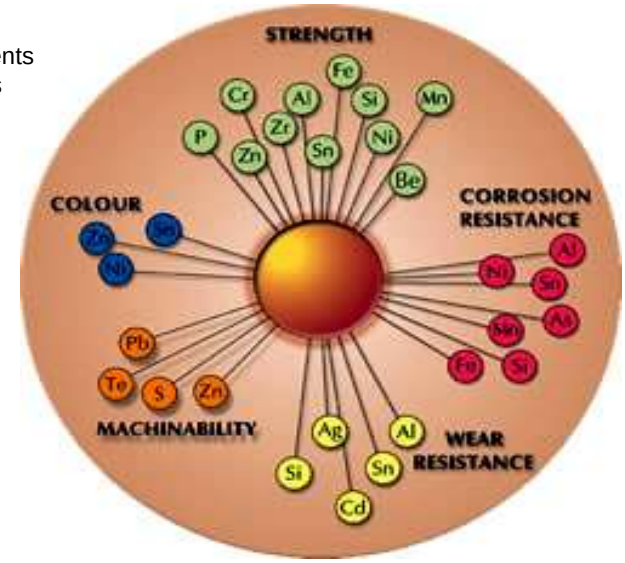
1. Changes in operational practices mainly to increase small grades.

   Increased speed of rotorvane shaft
   Reduced opening of end plates
   No of reverse pitch vanes increased
   More and more passes in rotorvane to minimize the quantity of big bulk.

2. Poor Operational and Maintenance Practices.
3. Poor Leaf standard.
4. Poor quality components/ Casting/ Material.

ELEMENTS IN COPPER ALLOY

Alloying Elements
- Properties



CAST ALLOYS

Unified Numbering system: C81300 - C99999

Cast alloys		
Coppers	C80100-C81100	>99%Cu
High-copper alloys	C81300-C82800	>96%Cu
Red and leaded red brasses	C83300-C85800	Cu-Zn-Sn-Pb(75-89%Cu)
Yellow and leaded yellow brasses	C85200-C85800	Cu-Zn-Sn-Pb(57-74%Cu)
Manganese bronzes and leaded manganese bronzes	C86100-C86800	Cu-Zn-Mn-Fe-Pb
Silicon bronzes, silicon brasses	C87300-C87900	Cu-Zn-Si
Tin bronzes and leaded tin bronzes (Gun metal comes under tin bronze family)	**C90200-C94500**	**Cu-Sn-Zn-Pb**
Nickel-tin bronzes	C94700-C94900	Cu-Ni-Sn-Zn-Pb
Aluminum bronzes	C95200-C95810	Cu-Al-Fe-Ni
Copper-nickels	C96200-C96800	Cu-Ni-Fe
Nickel silvers	C97300-C97800	Cu-Ni-Zn-Pb-Sn
Leaded coppers	C98200-C98800	Cu-Pb
Miscellaneous alloys	C99300-C99750	

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GUN METAL- C90500

Element	Composition (% by mass)	Allowable range (% by mass)
Cu	88	86-89
Sn	10	9-11
Zn	2	1-3
Pb		0-0.3
Fe		0-0.2
P		0-0.05
Ni		0-1
Al		0-0.005
S		0-0.05
Sb		0-0.2
Si		0-0.005

Common uses are
- piston
- Bearings
- Bushes
- Gear wheels
- Valve guide

high wear and tear resistance

rolling - similar requirement

Favorite alloy for sand casting

SAND CASTING

Raw material
- Charged into furnace to melt

Molten alloy
- poured into mould
(casting temperature)

Cooling rate
- controlled

Microstructure

Finishing – Machining

OBJECTIVES

Primary objective:

To study causes for high wear & tear and failure of cast copper alloy components used in Rotorvanes and Rollers.

Specific objectives:

1. To study chemical composition, microstructure and hardness of cast copper alloy components.
2. To identify causes and recommend possible solutions.

MATERIALS AND METHOD

1. Collecting samples of cast copper alloy components from different suppliers and factories.
2. Conducting Chemical composition Analysis on the samples
   - Industrial Technology Institute.
3. Testing the samples for Microstructure and hardness
   - University of Moratuwa.
4. Analyzing the results

RESULTS & DISCUSSION

BATTENS:

Chemical Analysis, Hardness of Battens and closest alloy/alloy group

Element	% by mass		
	Batten 1	Batten 2	Batten 3
Cu (86-89%)	87	81	86
Zn (1-3%)	0.31	12.6	3.91
Sn (9-11%)	9	1.61	5.19
Pb	0.86	1.54	3.12
Fe	0.46	0.33	0.48
Al	-	0.57	-
Hardness (HV)	130±13	66±5	88±8
Alloy/ Alloy Group	C-90500	leaded red brass	C-92200

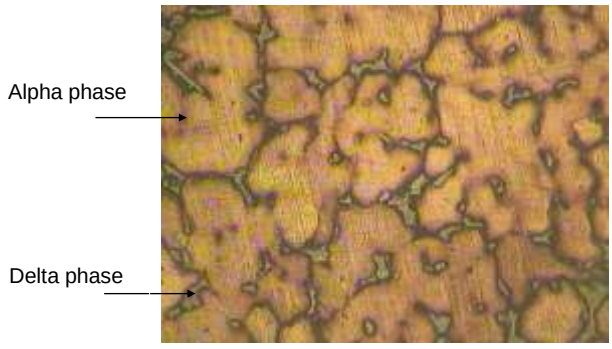
Batten

Batten 1
– closer to Gunmetal

Batten 2 & 3
– deviated from Gunmetal

RESULTS & DISCUSSION contd.

Element	% by mass
	Batten 1
Cu (86-89%)	87
Zn (1-3%)	0.31
Sn (9-11%)	9
Pb	0.86
Fe	0.46
Al	-
Hardness (HV)	130±13
Alloy/ Alloy Group	C-90500



Microstructure of Batten 1

Grains - alpha (light colour) and delta phase (dark colour) as appear in gunmetal.

- Well distributed delta phase and higher hardness contribute to wear & tear resistance property.

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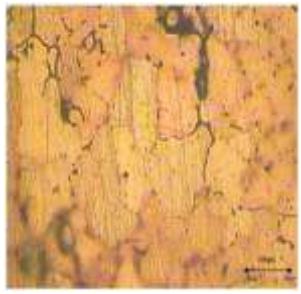
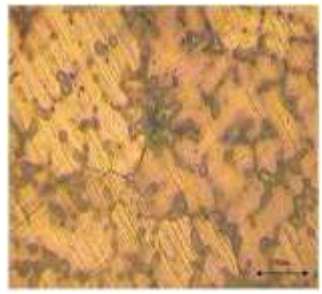
RESULTS & DISCUSSION contd.

Element	% by mass	
	Batten 2	Batten 3
Cu (86-89%)	81	86
Zn (1-3%)	12.6	3.91
Sn (9-11%)	1.61	5.19
Pb	1.54	3.12
Fe	0.33	0.48
Al	0.57	-
Hardness (HV)	66±5	88±8



Microstructure of Batten 2



Microstructure of Batten 3

Batten 2 - Low hardness due to low tin content .
Al (as impurity) → porosity & breakage
Larger grain size

Batten 3 - Moderate hardness due to 5.19% Sn
No Al as impurity.

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RESULTS & DISCUSSION contd.

CONES:

Chemical Analysis, Hardness of Cones and closest alloy/alloy group

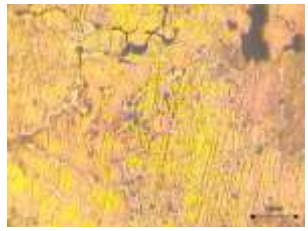
Element	% by mass		
	Cone 1	Cone 2	Cone 3
Cu (86-89%)	76	74	89.1
Zn (1-3%)	9.52	17.1	6.24
Sn (9-11%)	11.13	3.06	3.33
Pb	1.44	2.57	1.2
Fe	0.62	0.27	0.1
Al	-	0.19	-
Hardness (HV)	127 ± 13	76 ± 3	145 ± 6
Alloy/ Alloy Group	leaded yellow brass	C-84800	leaded red brass

Cones

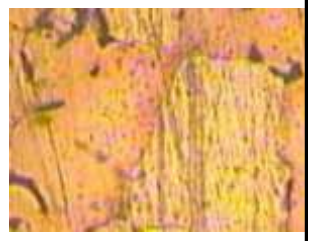
- Deviated from Gunmetal

RESULTS & DISCUSSION contd.

Element	% by mass	
	Cone 1	Cone 2
Cu (86-89%)	76	74
Zn (1-3%)	9.52	17.1
Sn (9-11%)	11.13	3.06
Pb	1.44	2.57
Fe	0.62	0.27
Al	-	0.19
Hardness (HV)	127 ± 13	76 ± 3



Microstructure of Cone 1



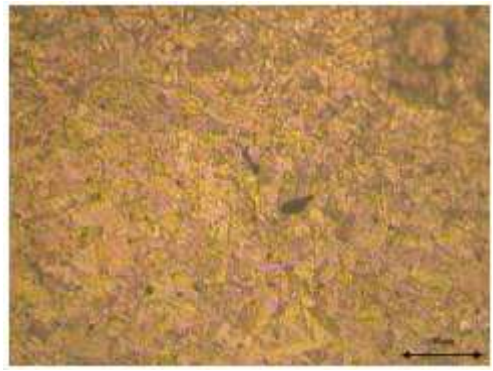
Microstructure of Cone 2

Cone 1 - High hardness due to 11.13% Sn, No Al impurity

Cone 2 - Lower hardness due to low Sn Content.
Al (as impurity) could lead to porosity and breakage.

RESULTS & DISCUSSION contd.

Element	% by mass
	Cone 3
Cu (86-89%)	89.1
Zn (1-3%)	6.24
Sn (9-11%)	3.33
Pb	1.2
Fe	0.1
Al	-
Hardness (HV)	145 ± 6
Alloy/ Alloy Group	leaded red brass



Microstructure of Cone 3

Higher hardness - due to fine grain size, No Al impurity.

RESULTS & DISCUSSION contd.

VANES:

Chemical Analysis, Hardness of Vanes and closest alloy/alloy group

Element	Vane No / % by mass									
	1	2	3	4	5	6	7	8	9	10
Cu (86-89%)	71	68	79	67	63	68	90	75	82.3	82.4
Zn (1-3%)	20.8	26	10.3	25.9	29.8	24.7	0.71	18.8	10.2	10.2
Sn (9-11%)	2.43	0.68	5	1.45	1.54	1.89	4.14	2.3	3.17	1.2
Pb	2.27	2.61	2.53	2.32	2.34	2.6	4.83	3.04	1.52	2.08
Fe	0.45	1.21	0.27	0.52	0.46	0.46	0.02	0.5	0.88	1.2
Al	0.18	0.39	0.21	0.34	0.34	0.25	-	-	-	-
Hardness (HV)	75 ± 7	103 ± 5	97 ± 10	79 ± 4	96 ± 3	83 ± 9	106 ± 5	74 ± 12	87 ± 4	---
Alloy/ Alloy Group	C-85200	C-85400	C-84400	C-85400	C-85400	C-85400	leaded tin bronze	C-85200	C-84400	C-84400

No vane samples meet chemical composition of gunmetal.

RESULTS & DISCUSSION contd.

Element	Vane No / % by mass					
	1	2	4	5	6	8
Cu (86-89%)	71	68	67	63	68	75
Zn (1-3%)	20.8	26	25.9	29.8	24.7	18.8
Sn (9-11%)	2.43	0.68	1.45	1.54	1.89	2.3
Pb	2.27	2.61	2.32	2.34	2.6	3.04
Fe	0.45	1.21	0.52	0.46	0.46	0.5
Al	0.18	0.39	0.34	0.34	0.25	-
Hardness (HV)	75 ± 7	103 ± 5	79 ± 4	96 ± 3	83 ± 9	74 ± 12
Alloy/ Alloy Group	C-85200	C-85400	C-85400	C-85400	C-85400	C-85200

Vane 1 &8
– Group C-85200
Low hardness

Vanes 2,4,5 & 6
– Group C-85400
Low hardness.

due to low Sn% and Al impurity

RESULTS & DISCUSSION contd.

Element	Vane No / % by mass		
	3	7	9
Cu (86-89%)	79	90	82.3
Zn (1-3%)	10.3	0.71	10.2
Sn (9-11%)	5	4.14	3.17
Pb	2.53	4.83	1.52
Fe	0.27	0.02	0.88
Al	0.21	-	-
Hardness (HV)	97 ± 10	106 ± 5	87 ± 4
Alloy/ Alloy Group	C-84400	leaded tin bronze	C-84400

Vane 3 & 9
- Group C-84400
  Moderate hardness
  Some tin content

Vane 7
- Leaded tin bronze
  high hardness
  Some tin content
  No Al impurity .

RESULTS & DISCUSSION contd.

Element	Composition (% by mass)			
	Gunmetal	Tested Samples	Leaded yellow brass	
			C-85200	C-85400
Cu	86-89	63-90	72	67
Sn	9-11	0.68-11	1	1
Zn	1-3	0.3-29.8	24	29
Pb	-	0.86-4.83	3	3

CAUSES:

source of raw material – scraps with widely varying chemical composition from gunmetal.

Scraps of

Brass ornaments, house hold items, automobile spares, architectural trims and plumbing fixtures.

RESULTS & DISCUSSION contd.

Uncontrolled melting and casting Temperature

Melting point
Sn - 232 °C
Zn - 419.6 °C &
Cu - 1084 °C

- Sn < 10%.
- Sn % reduced every time scrap is recycled.

Tin bronze/ Leaded tin bronze	Recommended Casting Temperatures (°C)		
	Thickness of component		
Cu–Sn–Zn–Pb	***<15mm***	***15–40mm***	***>40mm***
83/3/9/5	1180	1140	1100
85/5/5/5	1200	1150	1120
86/7/5/2	1200	1160	1120
88/10/2	1200	1170	1130
90/10	1120	1100	1130

Foseco Non-Ferrous Foundryman's Handbook: Eleventh edition, Revised and edited by John R.Brown

Solution - Adding adequate amount of virgin Sn by checking chemical composition of scraps used.

CONCLUSIONS

- One cast copper alloy sample component was found to have chemical composition that of gunmetal.
  Chemical composition of other samples deviated from that of gunmetal.
- Low hardness found in samples was due to low Sn content and large size grains. Low hardness could lead to high wear & tear. Presence of Al could lead to failure.
- Fine grains in microstructure was found to contribute hardness. This shows importance of good foundry practices.
- The results show possibilities of use of scrap material with varying chemical composition from gunmetal.

RECOMMENDATIONS

For Foundries/ Engineering Firms:

- Using scraps having chemical composition closer to gunmetal.
- Adding required amount of virgin raw material by checking chemical composition of scrap to have desired chemical composition.
- Checking casting temperature and casting without delay are good casting practices to be adopted.

For Stake Holders:

- Purchasing components directly from foundries and returning the wasted components to the same foundry.
- Working together with Foundries / Engineering Firms. - Data Base on Foundries.

DATA BASE ON FOUNDRIES

Data base on Proprietary Foundries/ Engineering Firm which cast tea machinery components.

DATA BASE ON FOUNDRIES CAST TEA MACHINERY COMPONENTS	
Name of the Foundry	
Name of the Engineering Firm	
Components Casted	
Address	
Telephone No	
Fax No	

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Thank You