COPPER TO COPPER WELDING OF 3-PHASE TRACTION MOTOR IN CLW

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INTRODUCTION

Copper plays a very important and major role in electrical engineering work, because of its excellent electrical properties like electrical conductivity (which is second only to silver but much more cheaper than silver), thermal conductivity, resistance to corrosion, formability and strength.

Chittaranjan Locomotive Works (CLW) is one of the major consumers of copper for manufacture of electric locomotive. CLW is manufacturing various types of electric locomotives for Indian Railways using conventional DC series as well as 3-Phase Induction Motor technology and hence CLW is manufacturing Traction Motor for all Single Phase and 3-Phase needs in House. At present, CLW is manufacturing DC (Hitachi) Traction Motor, Type: HS 15250 (630 KW output power) for WAG-7 & WAP-4 locomotives and 3-Phase AC Traction Motor, Type: 6FRA-6068 (850 KW output power) for WAG-9 freight locomotive and Type: 6FXA-7059 (1150 KW output power) for WAP-5 (Passenger) locomotives.

CLW requires different type and size of copper for manufacturing different types of Traction Motors, Smoothing Reactor and Inductive Shunt depending upon functional requirement.

MIG WELDING IN 3-PHASE TRACTION MOTORS

In the manufacturing of the 3-Phase AC Traction Motors, which is a Squirrel, Cage Induction motor, the rotor bars need to be MIG welded to the resistance ring or the Short circuiting ring. The quality of this MIG welding has a serious bearing on the ultimate performance of the traction motor. A poor MIG welding results in large number of blowholes and porosity and leads to rotor overheating and even crack in the rotor bars ultimately leading to a failure of the Traction motor.

MATERIAL COMPOSITION OF COPPER USED FOR MIG WELDING

The material composition/properties of the copper used in original design and subsequent changes made are indicated as below:

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Comparison of Various Parameters of Specification of Rotor Bar & Resistance Ring for 3-ph Traction Motor

(A) Rotor Bar

Requirements	4TMS.096.060	4TMS.096.060 Alt 1	4TMS.096.060 Alt 2	4TMS.096.060 Alt 3
Chemical Composition and Properties	As per DIN 1787 SE-CUW No. 2.0070	As per DIN 1787 SE-CUW No. 2.0070	As per DIN 1787 SE-CUW No. 2.0070	As per ASTM 187M'97 (UNS No. C10100)
	DIN 40500 Part 3	DIN 40500 Part 3	DIN 40500 Part 3	
% of Cu	99.90	99.90	99.90	99.99%
Phosphorus/ Oxygen content	0.003 (approx) (P)	0.003 (approx) (P)	0.003 (approx) (P)	5ppm (O_2)
Density	8.9KG/dm^3	8. 9 KG/dm^3	8.9 KG/dm^3	
Tensile strength	200 to 250 Nlmm^2	300 to 360N/mm^2	300 to 360N/mm^2	260 to 345N/mm^2
Elongation (A5)	Min 30%	Min 10%	Min 10%	Min 10%
Hardness (HB)	80 to 105	80 to 105	80 to 105	Min 80 (Rockwell)
Delivery Condition	Soft annealed & Drawn	Hard & Drawn	Hard & Drawn	Hard & Drawn
Test condition	DIN 40500 Part 3	DIN 40500 Part 3	DIN 40500 Part 3	As per ASTM 187M'97
Conductivity	57 MS/m	56 MS/m	56 MS/m	—
Resistivity at 20°C	0.01786 ohm mm^2/m (Max)	0.01786 ohm mm^2/m (Max)	0.01786 ohm mm^2/m (Max)	0.15585 ohm g/m^2
Source of raw material	—	Source of raw material not indicated.	Source of raw material included, indicating M/s HCL as raw material supplier	Source of raw material M/s Outokumpu/ Malaysia or any reputed source

(B) Resistance Ring

Requirements	4TMS.096.064	4TMS.096.064 Alt 1
Chemical Composition Mechanical / phys. ch.	As per DIN 1787 SE-CUW No. 2.0070	As per ASTM 187M'97 (UNS No. C10100)
% of Cu	99.90 (min.)	99.95 min.
Phosphorus/Oxygen	0.003 (approx)	0.001-0.005
Conductivity	56 Ms/m	
Tensile strength	Approx 220 N/mm^2	240–310 N/mm^2
Elongation (A5)	—	15%
Hardness (HB)	70 min.	75 min. (RH)
Test condition	DIN 40500 Part 3	As per ASTM 187 M'97
Source of raw material	—	Source of raw material M/s Outokumpu/ Malaysia or any reputed source.

As can be seen from the table that the Oxygen content in the rotor bars has been progressively reduced to avoid hydrogen embrittlement, while for the resistance ring phosphorus has been added purposely to drive out the oxygen, phosphorus being a pentavalent element.

(C) Processes of MIG Welding Adopted in CLW

(1) A V-Groove is cut in the resistance ring. The V-Groove of the resistance ring is preheated as below:

Temp	Duration	Rotor Speed	Distance of Torch from Resistance Ring	Method of heating
350°C	Until temperature is achieved	4 r.p.m.	8-15 mm	Oxyacetylene gas heating

(2) The rotor cage is earthed with copper braided wire, after pre-heating.

(3) MIG Welding is carried out following the following parameters:

Current	Volt	Rotor speed	No.of runs	Welding wire
370-380A	30.4 Volt	1/4 rpm	2-3	Cu-Sn

Dia of Wire	Duration	Gases used	Wire feed
1.6 mm	9-10 min	Mixture of Helium + Argon (70 : 30)	7.5 m/min.

(4) After welding the rotor is put in pre-heated oven of temperature 300°C. For thermal stress relieving.

(5) Then the rotor is allowed to cool down to ambient temperature in the oven.

(6) We then carry out Proof turning of the rotor.

(7) After proof turning the ultrasonic testing of every joint, *i.e.*, (88 Bars) is done.

(8) Finally we Braze all the Rotor Bar with Resistance Ring at DE & NDE side with Ruptam brazing rod grade IS: 2927 BA-Cu-Ag-16A and Flux.

CONCLUSION

The aim of presenting this paper is that even after changing of material specification of Resistance Ring and Rotor Bar, CLW has not been able to achieve the required result. The main problems faced are

(1) Porosity at junction between parent material and weld material.

(2) Blow holes in welding portion.

Suggestions are invited to overcome these problems. The experts in "Copper to Copper Welding" field as well as ICDC are requested to study the problems and suggest any changes in welding process/copper material, etc.

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