MANUFACTURING PROPERTIES OF ALUMINUM TO COPPER STRAIGHT AND PARALLEL JOINT CONNECTORS

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ABSTRACT

The overhead wire systems for transmission of electrical power with high voltage of 132 up to 400kV use straight and parallel groove connectors to join aluminum and copper wires in a transmission network.

In this work, straight and parallel grooves connectors of aluminum and copper cables have been manufactured to transmit high tension power of 132KV. A joint compound material has been painted at the interface between Al and Cu metals within the connectors. The joint compound is prepared in a laboratory with high resistance of corrosion.

The manufacturing connectors are tested to study their mechanical and electrical properties. The results shown that the resistance between the terminals of Al and Cu with the anticorrosion material between them is 0.1Ω. While the Tensile Test Report for the specimen of straight connectors confirmes the value of maximum tensile force of 5.75 tone. The failure section occurred at 2cm inside the Cu cable and not inside the manufacturing straight connectors.These manufacturing connectors are examined successfully for 6 months within the transmission network under the authority of the General Company for Generation and Transportation of Electrical Power in Basra. A certificate has been issued by this company confirming the good quality for the application of these connectors.

Key words*: Mechanical and Electrical Properties of Metals.*

INTRODUCTION:

Modern technology has at its disposal a wide range of constructional materials – metal and alloys, plastics, rubber, ceramics, wood, etc. and the selection of an appropriate material for a given application is the important responsibility of the design engineer. No general rules govern the choice of a particular material for a specific purpose, and a logical decision involves a consideration of the relevant properties, ease of fabrication, availability, relative costs, etc. of a variety of materials.

Metal or alloy may be selected on the basis of its mechanical, physical and chemical properties, where the fact that there are the effects of the interaction of a metal with the environment on those properties of the metal which has been defined as a “corrosion”.

Aluminium and it’s alloys lend themselves to many engineering applications because of their combination of lightness with strength, high corrosion resistance, thermal and electrical conductivity, light reflectivity and non-toxic qualities. Copper and it’s alloys are amongst metals have been used from prehistoric times, and their present-day importance is greater than ever before (1).

The binding medium or binder between Copper and aluminum consists essentially of organic material with the basic physical and chemical properties of the paint, but these will be modified by the nature of circumstances to formulate a paint. A consideration of the most important causes of paint failure must include effects of climatic conditions on paint films. High temperature and wet weather reduce the life of any paint film as well as being detrimental to its appearance (2).

The priming paint or coating provides the bond between the metal and the coatings later applied, and gives electrochemical control of corrosion. Adhesion depends largely on the nature of the organic binder and the metal on the surface (3).

In this work, a joint compound material (coating material) is prepared laboratory with high resistance of corrosion. It has been painted at the interface between aluminum and copper metals within the connectors. The connectors were manufactured locally with straight and parallel grooves and then applied as apart of electrical power transportation and distribution network inside Basra for a period of six months with high tension of 132KV. The manufacturing properties have been investigated to study the electrical and mechanical properties of these connectors.

THEORY:

A stress is called a *hydrostatic pressure* and can be expressed in force units per unit of area. The term *strain* refers to the relative change in dimensions or shape of a body which is subjected to stress. A *tensile strain* in the bar is defined as the ratio of the increase in length to the original length (4).

$$\text{Tensile strain} = \frac{l - l_o}{l_o} = \frac{\Delta l}{l_o} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where: (l_o) is the original length of the bar, (Δl) increase in length, while the tensile stress can be expressed by this formula:

$$\text{Tensile strength} = \frac{\text{Ultimate tension force}}{\text{Area}} = \frac{F}{A} \qquad \ldots\ldots (2)$$

$$\text{Breaking Load of Connectors (Kg)} = \text{Min. Slipping Strength (\%)} \times \text{Ultimate strength of Conductor (Kg)} \quad \ldots (3)$$

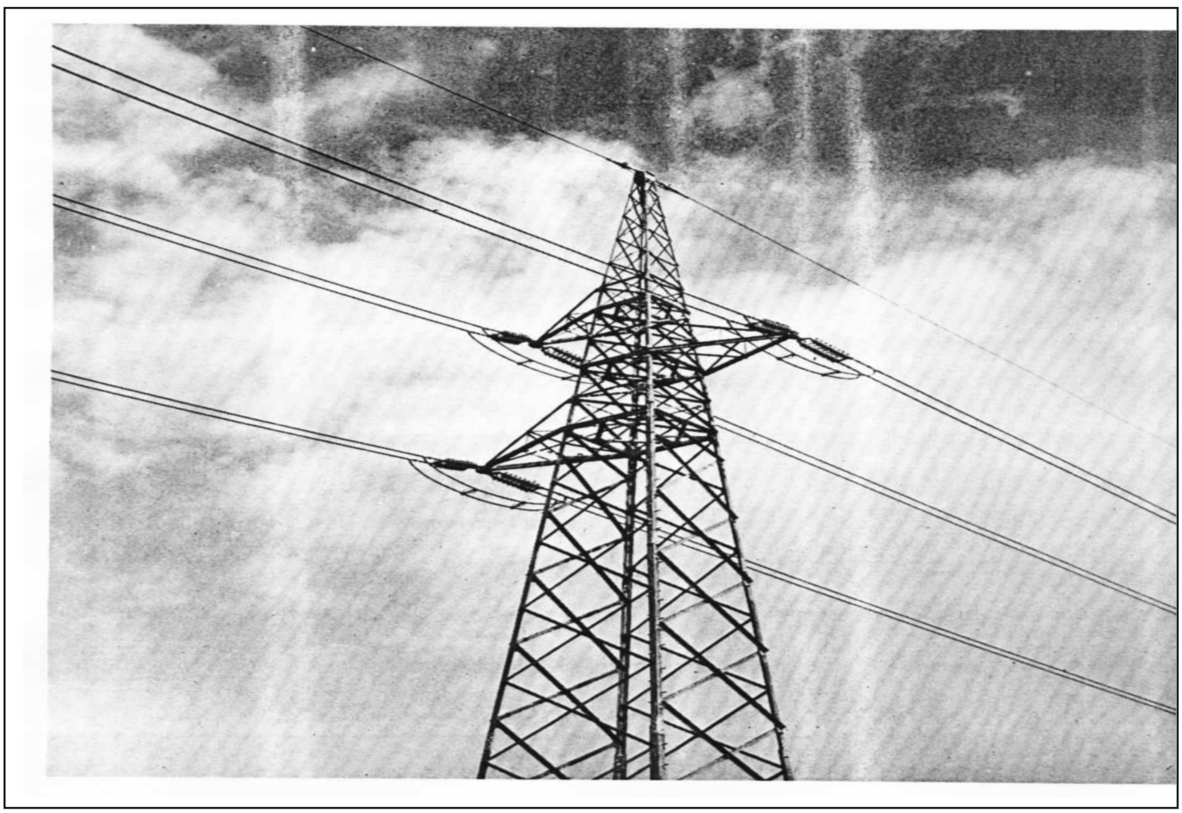


Fig.(1): Power Transmission Tower

A designed connector should be dependable on the following requirements: Mechanical *strength*; is a subject to the loads imposed on the conductors by ice, wind and the expansion and contraction of strains possible under extreme conditions of load cycling and ambient temperature changes. Actually, the greatest mechanical stress that a connector is subjected to occurs during installation, and if the connector is properly designed to which the connector would normally be subjected during the life of the joint. *Corrosion resistance*; connectors are very often built in which the atmosphere is highly corrosive. This is true wherever aluminum is being joined to copper (5). Figure (2) shows the joining of Al and Cu conductors.

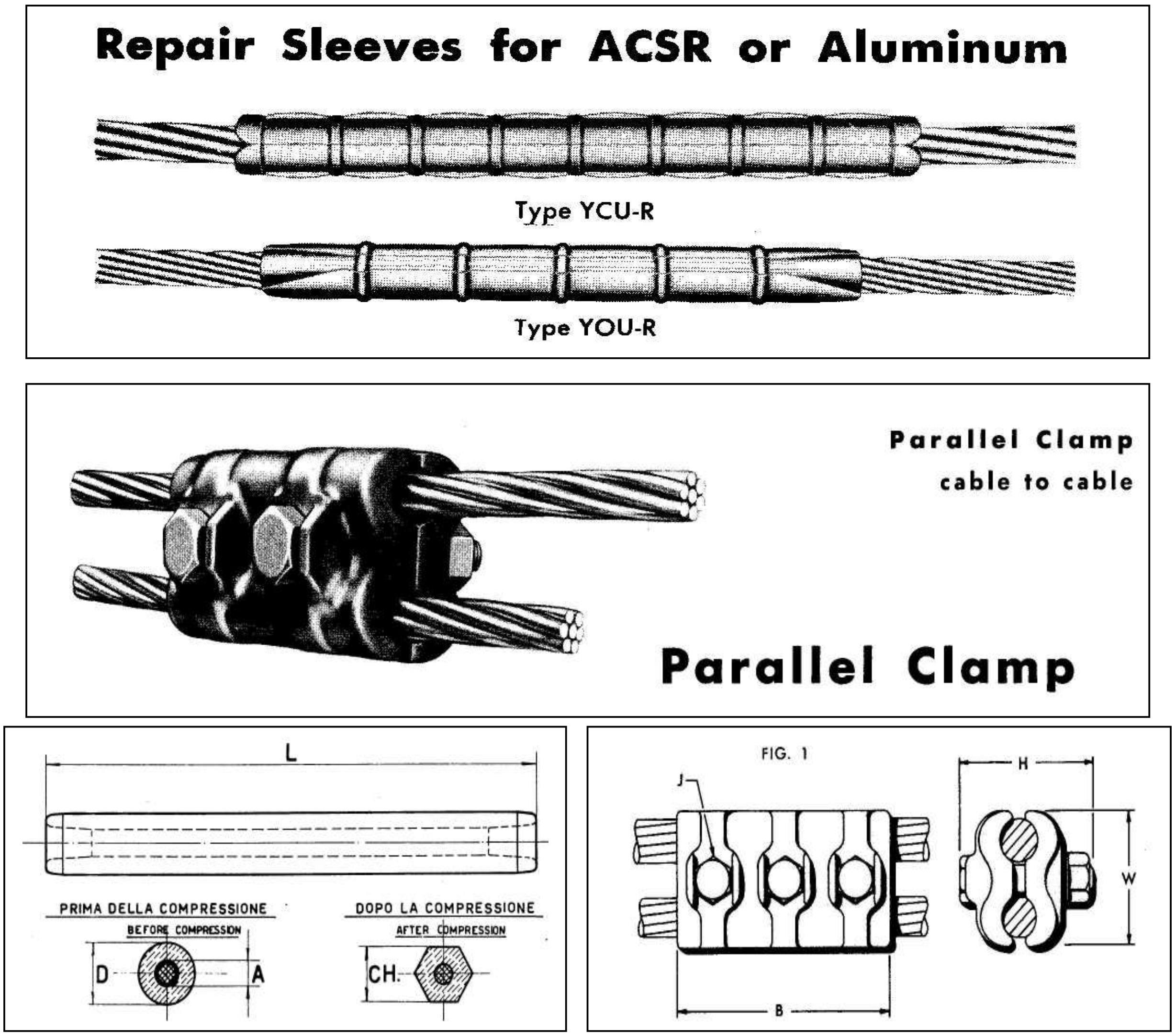


Fig. (2): Longitudinal and Cross – Sections of Straight and Parallel Clamps

EXPERIMENTAL:

In order to enable a simple use of clamps to join one type conductor either Al or Cu to join both conductors. Connectors with both of these conductors were manufactured for the use of overhead transmission lines with high voltage of 132 up to 400kV. The sectioning details of straight joint is showing in Fig. (3):

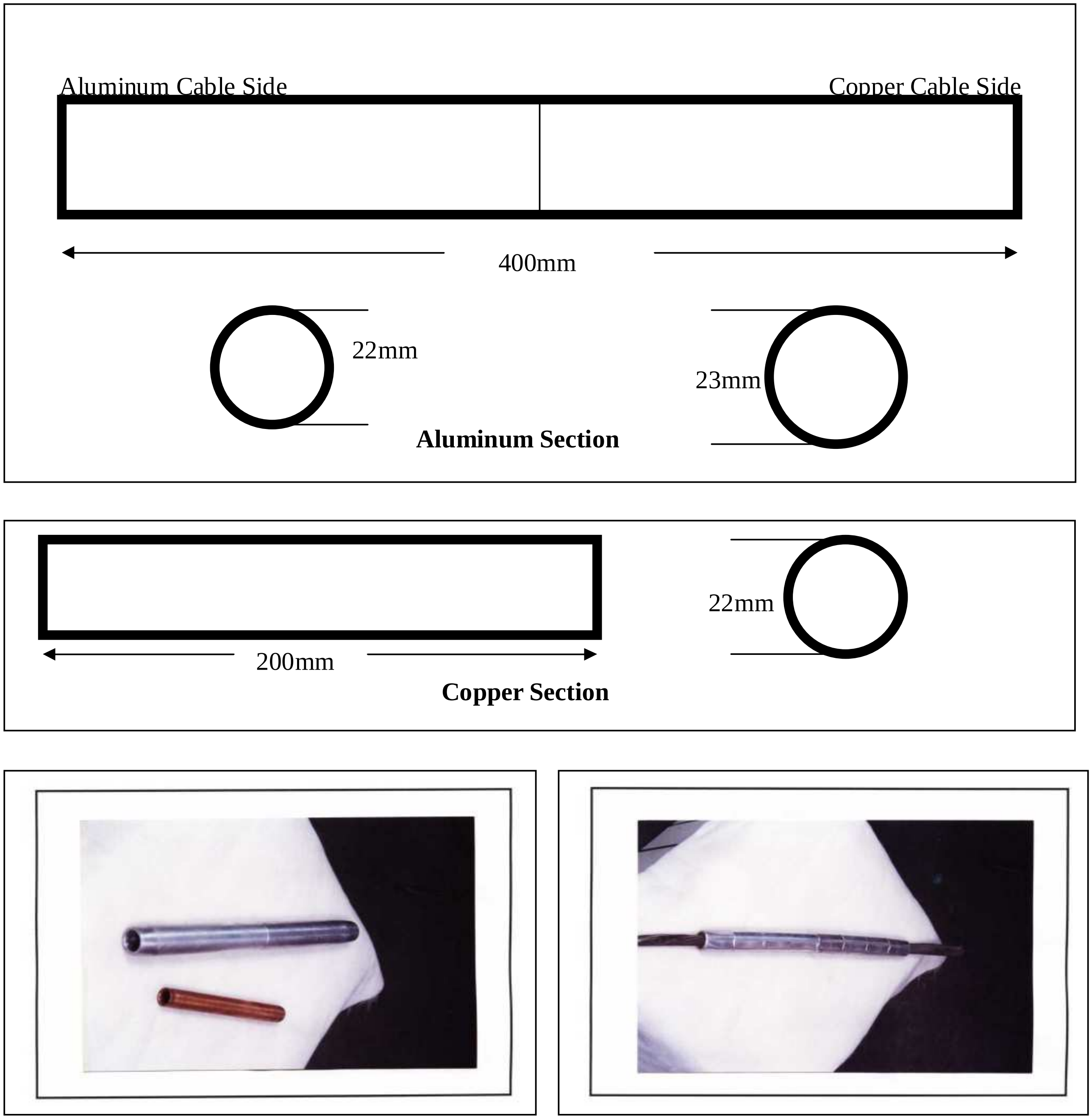


Fig. (3): (Upper) Sectioning of Al and Cu straight connectors, (Lower) The manufacture connectors before and after compression.

The parallel clamps for joining aluminum and copper conductors wires were manufactured and show in the figure (4):

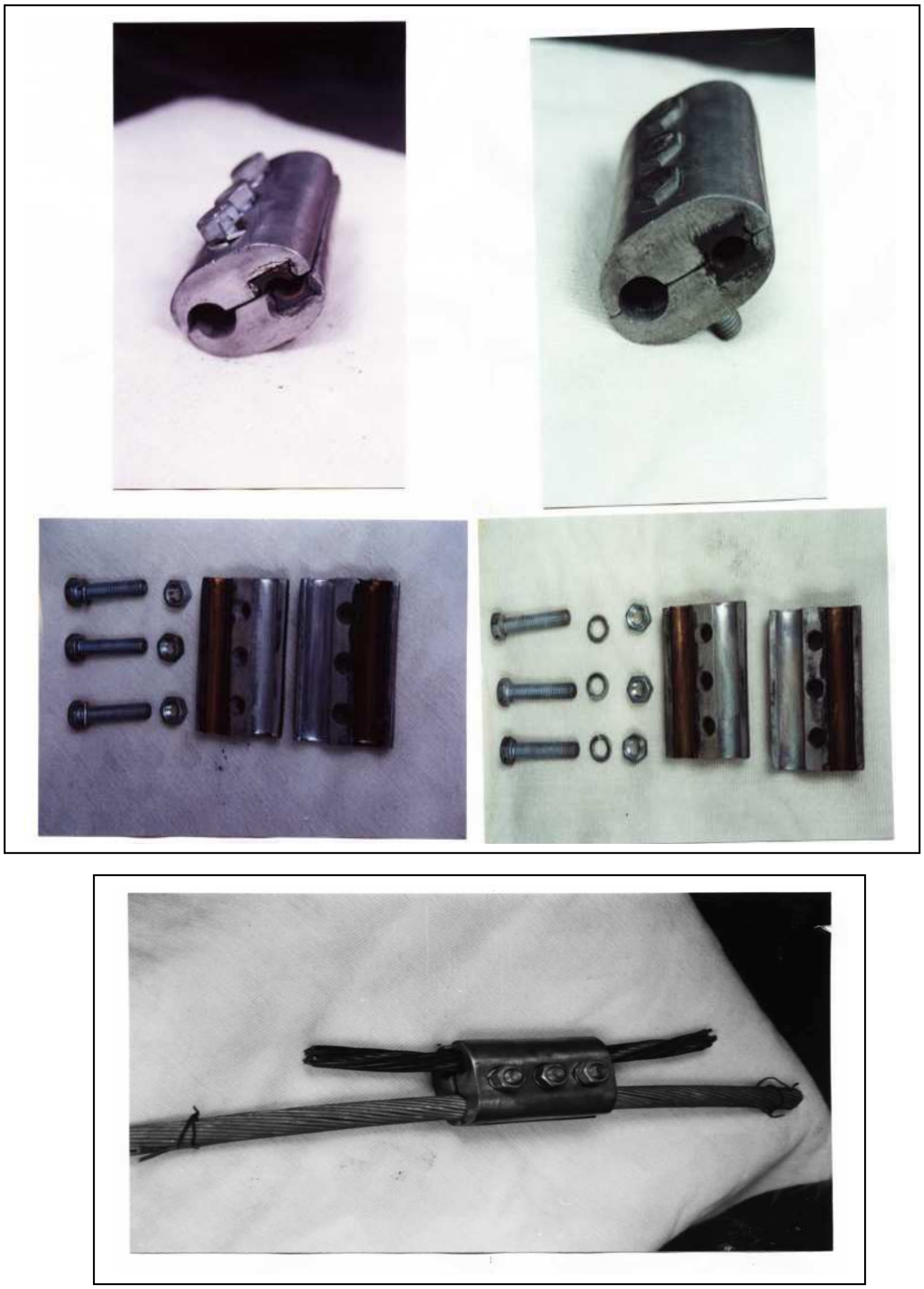


Fig (4): (Upper) Parallel clamp connector to joint Al and Cu conductors before (left) and after (right) examined for 6 months within network of power transmission, (Lower) Al andCu conductors with manufacture parallel clamp system

This research development on preparation locally the joint compound between Al and Cu conductors, and testing the manufacturing straight and parallel clamps. Every property of aluminum which differs substantially from that of copper was considered.

The material employed by ENSTO, an electrical production equipments company, has been used as an anticorrosion material to join aluminum with copper conductors[6]. Another joint compound is prepared laboratory with high resistance of corrosion.. The composition of this material and their physical properties has been published in Ref. (7).

The joint compound material has been painted at the interface between aluminum and copper metals inside the connectors. The resistance between the terminals of Al and Cu with the anticorrosion material between them is 0.1Ω.

For the straight joint connector, the copper metal with cylinder shape has painted outside surface with joint compound and slided inside the aluminum. The conductors Al and Cu wires are inserted inside the connector in both sides and then compressed with machine to avoid any current losses.

For the parallel joint connector, the copper metals with bar shapes have been painted also with joint material at one side and then slided inside aluminum sections. This connector contains two parts; both are tightened with the aluminum and copper wires using galvanized bolts.

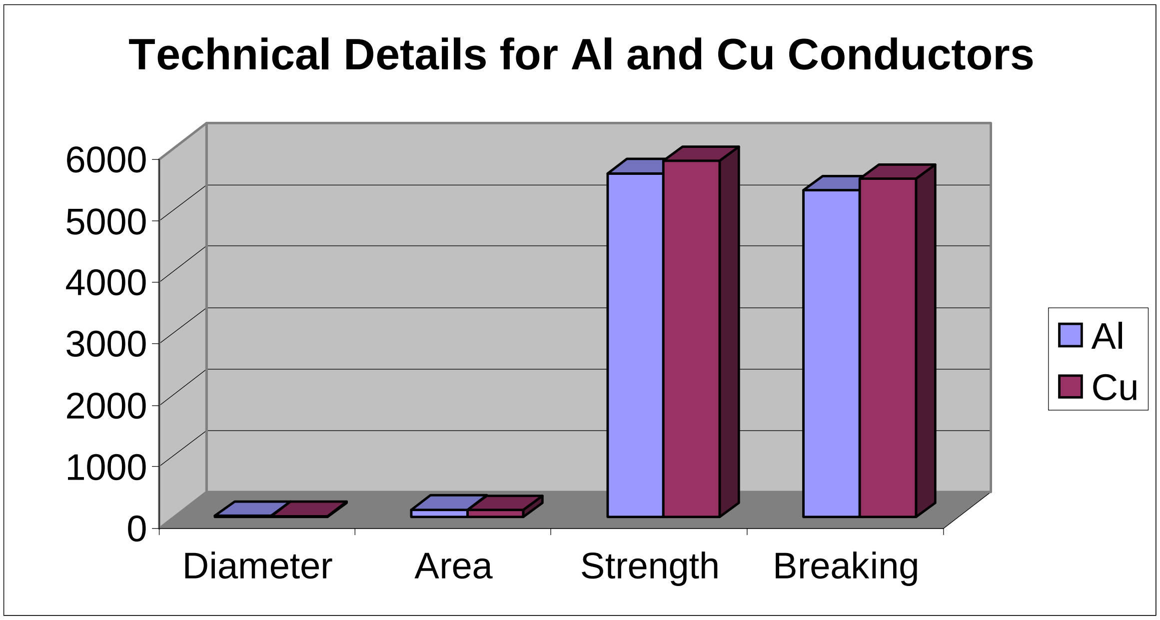
The description of these straight and parallel connectors with the joint material is shown in figures (3,4). It is also mention the ease of installations of these connectors. It not only has the economic advantage of reducing installation time, but also results in greater assurance that the both types of manufacturing connectors will be installed properly.

I would like to confirm at this stage, the General Company for Generation and Transportation of Electrical Power in Basra used this manufacturing types with the first time and has been successfully tested for 6 months within the network.

RESULTS:

The technical details for aluminum and copper overhead transmission conductors lines have been calculated and arranged in the following table. The minimum slipping strength for conductors is 95% from Ref.6.

Conductors	**Aluminum**	**Copper**
Overall diameter (mm)	20	16
Sectional Area $(mm)^2$	123	117
Ultimate Strength (Kg)	5600	5800
Breaking Load (Kg) of Connectors	5320	5510

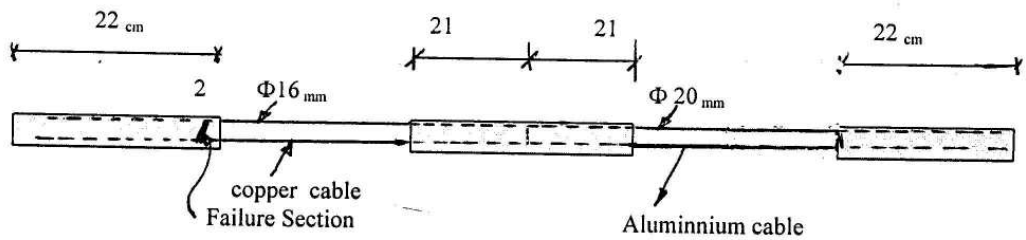


Tensile test on cable specimen for straight connectors has been confirmed the value of maximum tensile force of 5.75 tone. The failure section occurred at 2cm inside the Cu cable and not inside the manufacturing straight connectors. This means that the connector sections are heavy enough to carry loads, and to withstand the forces applied during installation as well as those developed under extreme service conditions of expansion and contraction. The test is carried out by College of Engineering in the University of Basra and the report is demonstrated below:

كلية الهندسة	جامعة البصرة

Test Report

Type : Tensile test on cable specimen shown below



Results :

Maximum tensile force = 5.75 ton. Failure section Occured at 2 cm in side the copper cable joint as shown above

<u>خلاصة النتائج</u>

١. القوة التي انقطع بها الكيبل =٧٥ر٥ طن

٢. حدث القطع ، على عمق ٢سم من نقطة ارتباط كيبل النحاس مع المفصل الايسر النحاسي.

تم اجراء الاختبار من قبل المهندس عماد حسن ٢٠٠١/١١/١٤

تم اعداد التقرير من قبل المهندس جمال عبدالصمد ١/١١/١٤

DISCUSSION:

Straight and parallel grooves connectors of aluminum and copper conductors cables have been manufactured to transport high tension power of 132 up to 400kV. A joint compound material has been painted at the interface between Al and Cu metals within the connectors. The joint compound is prepared in laboratory with high resistance of corrosion.

It can be mentioned here that these types of manufactured connectors to join both Al and Cu cables are applied first by General Company for Generation and Transportation of Electrical Power in Basra and has been successfully tested for 6 months within the power transmission network

The tensile test on cable specimen for straight connectors has been confirmed the value of maximum tensile force of 5.75 tone. The failure section occurred at 2cm inside the Cu cable and not inside the manufacturing straight connectors. Also, it has been shown that the resistance between the terminals of Al and Cu with the anticorrosion material between them is 0.1Ω.

It can be concluded that these manufactured connectors sections are heavy enough to carry electrical loads, and to withstand the forces applied during installation as well as those developed under extreme service conditions of short circuit, expansion and contraction, and the pressure applied from bolts as well as from compression machine does not weaken these connectors in strain application.

These manufactured connectors with the prepared joint compound are designed to avoids crevices in which moisture might accumulate, or through which corrosive atmospheres might penetrate.

Finally, the straight and parallel connectors can be used on a range of aluminum and copper cables. Body is cast of high conductivity, high strength aluminum alloy, and a joint compound contact surfaces insure full conductivity.

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[illegible]

للأسلاك الألمنيوم والنحاس المستخدمة للفولتيات العالية " كانت ناجحة وقد اثبتت هذه المفردات كفاءتها بالعمل .

للتفضل بالاطلاع ... مع التقدير

[illegible]

شبكات البصرة -كتابكم ٢٧٥ في ٢٠٠٢/٦/٢٣

٢٠٠٢/٧/١٦

الخواص التصنيعية لروابط الالمنيوم والنحاس المستقيمة والمتوازية

سعد متي بطرس

قسم الفيزياء – كلية العلوم – جامعة البصرة

الخلاصة

تستخدم الروابط المستقيمة والمتوازية ضمن شبكات نقل الطاقة الكهربائية ذات الفولتيات العالية 132 الى 400kV لربط اسلاك الالمنيوم والنحاس .في هذا البحث تم تصنيع روابط مستقيمة ومتوازية من الالمنيوم والنحاس لربط اسلاك نقل الطاقة الكهربائية في شبكات النقل حيث تم اضافة مادة الربط في هذه الروابط بين مادتي الالمنيوم والنحاس لمنع التاكل بينهما بفعل الاختلاف في تركيب المادتين اضافة الى تاثير العوامل الجوية . بينت نتائج البحث ان المقاومة الكهربائية بين مادتي الالمنيوم والنحاس وبوجود مادة الربط بينهما في الروابط المصنعة هي 0.1Ω وان قوة الشد لهذه الرواط بلغت 5.75 tone بموجب شهادة الفحص الخاصة بدراسة الخواص الميكانيكية للروابط المصنعة. ربطت الروابط المصنعة ضمن شبكات النقل للطاقة الكهربائية ولمدة 6 اشهر متواصلة حيث اثبتت كفائتها ونجاحها بموجب كتاب تاييد من الشركة العامة لانتاج الطاقة الكهربائية للمنطقة الجنوبية والمبينة في متن البحث.