2D Simulation of Crimping ProcessFor Electric Vehicle Battery Charge Cable

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Abstract

Turkey Electric and Hybrid Vehicle Platform (TEHAD), according to 2017 data in our country, the first 9 months 2763 Total electric and hybrid vehicles were sold. Worldwide this figure has been 2 million. While the total number of charging stations in our country (open and not yet used) was 1000 in 2016, it reached 1500by the end of 2017.Additionally, it will start the first domestic electric vehicles and Tesla's sales in 2021 also considering entry into the market when Turkey, its development and growth potential of our country in the field of electric vehicle technology can be clearly seen. There is no dependence on imports due to the fact that there is no domestic company producing charge cable in return for the volume of electric vehicle market in our country. In the case of imported charging cables, due to the overheating and burning problems observed due to the crimp area and plug-socket connection designs, there is a need for domestic technology production on this area due to the flexibility problems in the cable parts. In this study, the design of the domestic Electric Vehicle Charging Cable will be implemented in accordance with IEC 62196-2 standards and different from similar products, in which high performance values can be guaranteed in terms of electrical and physical characteristics.

Of utmost importance in appliance design and manufacture are the features for protection from fire and for personal safety. Appliance engineers are continually in pursuit of better, longer-life appliances that will provide both lower cost to the consumer and lower energy consumption. Therefore, a 2D simulation of crimping process has been proposed using COMSOL software. Convective and conducting heat analysis results may help engineers decide the optimal crimping shape and process.

Introduction

The aim of this study is to first design a product in our country which meets IEC 62196-2 standards and eliminates heating problems at the cable crimp region and female / male plug and socket region connection points, which are different from similar products abroad, so that the connector connectors that fill the life are easily replaceable. The development of 7 Pinned Type-2 domestic Electric Vehicle Charging Cable designs with extended locking system according to IP44 / 55 is one of the basic goals of this work. In this study, pin design for conductor and plug parts, design of material and coating method, optimization of heat transfer and temperature distribution, design of cable and design are designed with finite element method [1-4].

Crimping is considered one of the most reliable metal joining technologies in the connector industry. Although it is among the oldest methods of establishing a permanent wire to terminal connection, the underlying mechanical principles of this process still become a source of heated debates within the industry's engineering community. Even a quick literature search is guaranteed to yield a list of publications that disagree with each other and state quite opposite points of view on 'what makes a good crimp' [4-7].

The Turkish household appliances sector started production as an assembly industry in the 1950s and it has achieved tremendous growth since then. Now, the household appliances industry is one of the well-established and dynamic sectors in Turkey. The industry is mainly composed of two subsectors; namely, the white goods (durables) which dominate the sector and the small household appliances. This trade sector brings new ideas for power cables and their connector industry. Crimping process is very important in terms of power cables and connectors and undesirable problems may often occur due to its wrong usage/processes [7,8].
Another computer simulation study for conductor segments will be carried out to improve the crimp region design. At this point, firstly heat transfer and temperature distribution measurements on existing models, temperature and resistance increase measurements and crimp breaking strength simulations were done with crimp region cross section estimation. In order to obtain the design with the best crimp form in the data obtained from these simulations, the crimp process simulations were made using Finite Element Analysis and decided the most suitable crimp structure. In the cable design and design development process, the primary purpose is to avoid physical and electrical deformation such as breakage of the copper cable in the case of sudden forcing and bending due to the low bending value [8-10].
Heat is the main problem in crimping process and should be analyzed carefully. Therefore, this paper addresses and focuses convective and conducting heat transfer study of a selected crimping process using finite element method.
The most important added value of the project is to remove the import dependency in this area by bringing domestic technology product crimp designs to white goods sector. In addition, reducing the waste and production costs of crimps product groups will directly contribute to the profitability and productivity increase in the white goods sector. In addition to this, this paper will enable new research work to be undertaken in order to examine in-depth the effects on the electrical and mechanical properties of the products' improvements in crimp designs [11-13].

Material and Methods

A general 2D view of the proposed crimping structure is seen in Fig. 1.

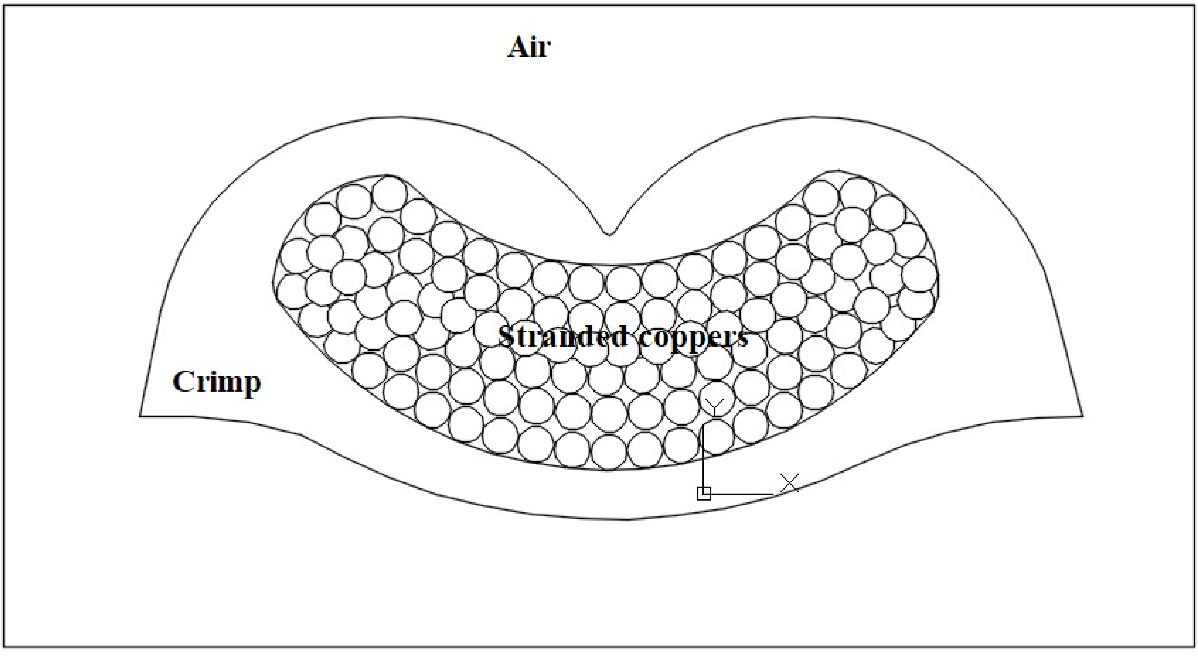

Figure 1. The proposed crimp structure

242-stranded copper wire with a diameter of 0.2mm is used in crimp process. Crimp material is chosen as silver and surrounded by air in the COMSOL model. Nominal electric current of 63A is defined as rated current representing battery charge cable for electric vehicle. The model uses both electric current and convective heat transfer modules. Heat source is the total power dissipation density from electric current physics. The simulation time is set to 60min as defined in standards. Then performance curves of temperature and power dissipation are obtained. According to the simulation results highest temperature is 71^{o}C and total power dissipation is 2.04mV/mm^{3}.
The model has the following modeling strategies.
a) Electric current physics and
b) Heat transfer in solids.
Heat source is the ***total power dissipation density*** from electric current physics. Stranded copper wires are defined as '***terminal***' as a source current while the outer boundaries are defined as ***ground***. Heat transfer in solids physics consists of convective heat flux and surface to ambient radiation sub-features. Time dependent solution is chosen as Study Step with a relative error of 0.01. The time interval is defined as ***range(0,1,60)*** with time unit of min. Fig. 2 shows the meshed view of proposed crimp model.
Materials are defined as follows:
a) Air for the crimp environment,
b) Copper for the stranded conductors, and
c) Silver for the crimp.

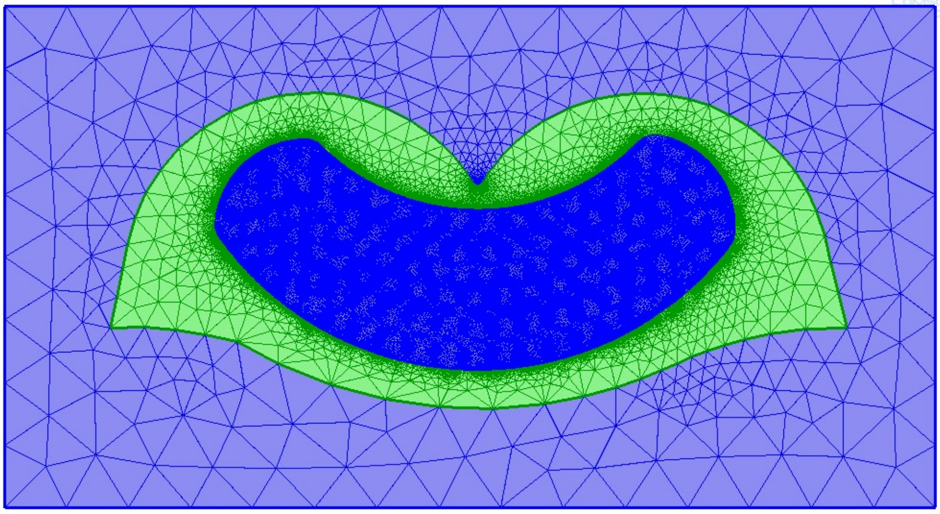
Figure 2. Meshed view of proposed crimp model

Electric potential distribution is given in Fig. 3.

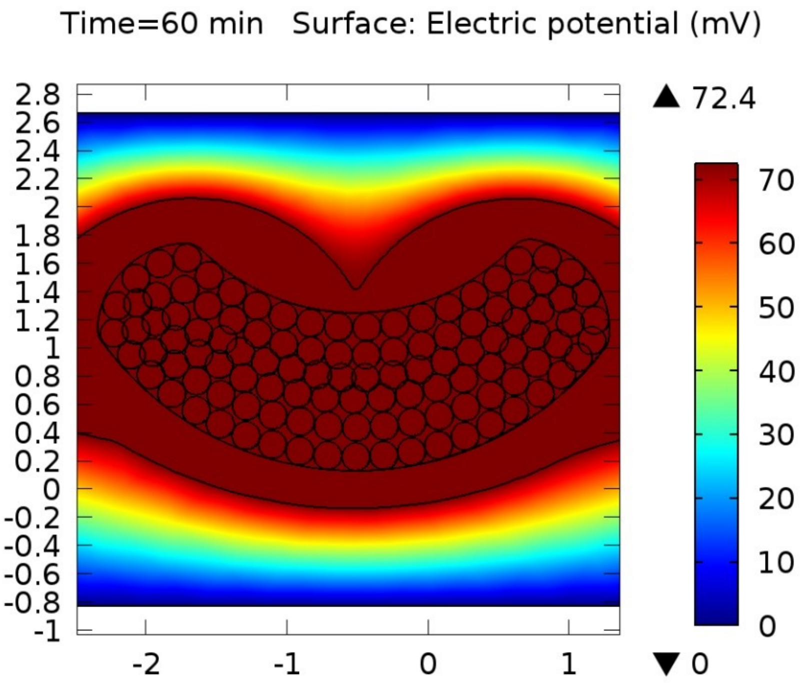

Figure 3. Electric potential distribution of the proposed crimp model

Temperature distribution is given in Fig. 4.

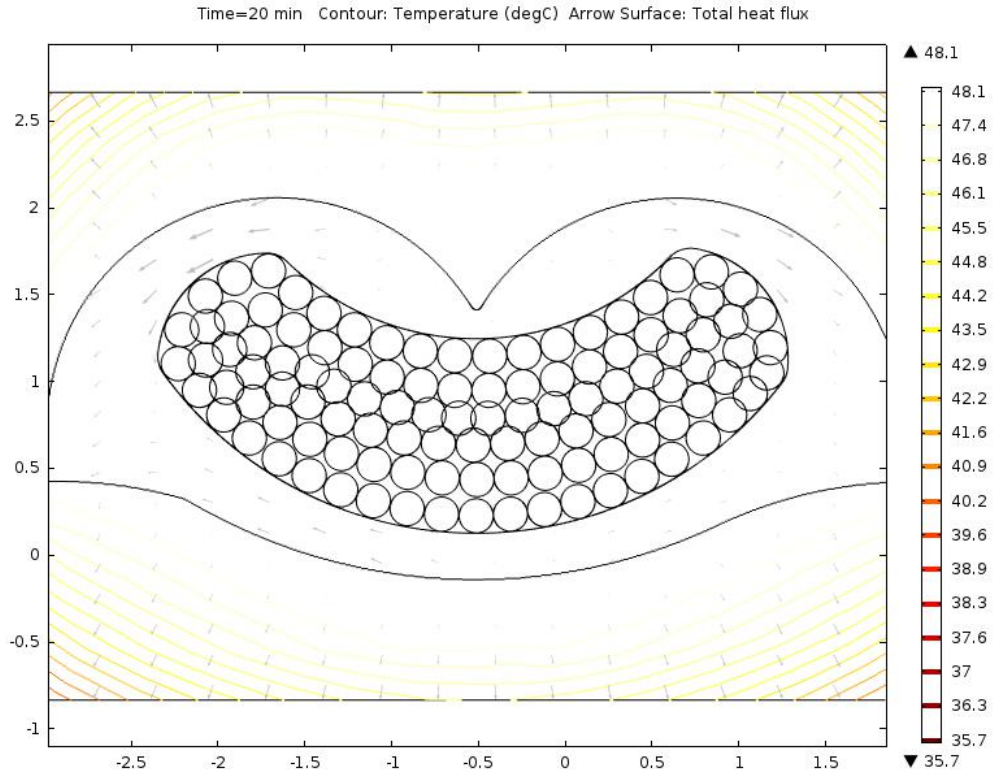

Figure 4. Temperature distribution of the proposed crimp model

Total power dissipation is given in Fig. 5.

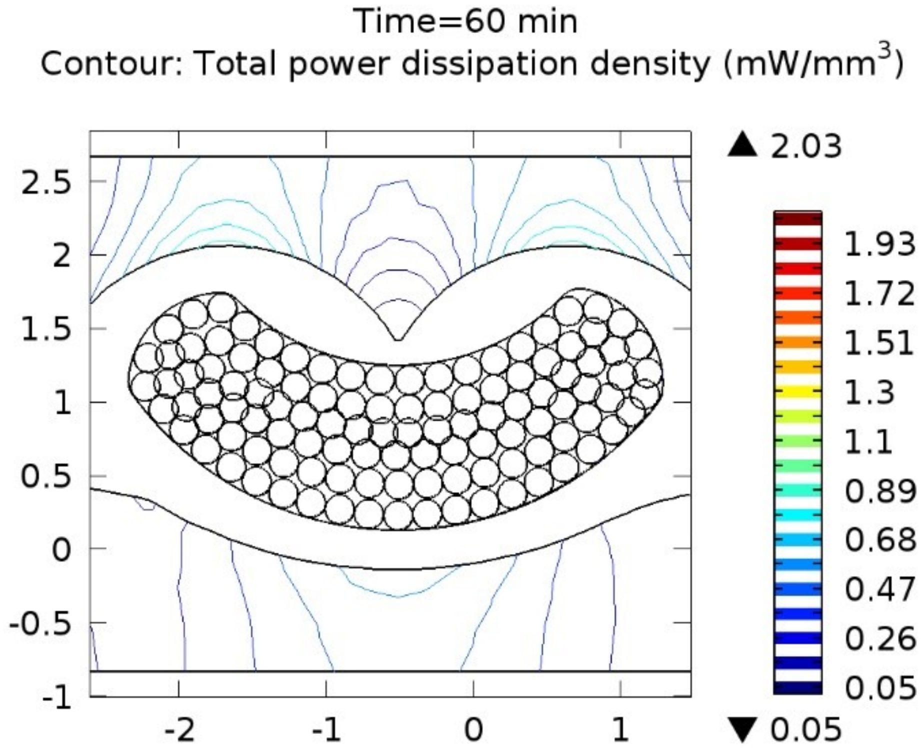

Figure 5. Total power distribution of the proposed crimp model

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Conclusions

The connection between the vehicle and the charging station for the charging of electric vehicles around the world is achieved by using special plug-in cables developed for this purpose, and the performance values of the pre-charged cables are provided by the IEC 62196-2 standard. In IEC 62196-2 three different charging systems have been standardized for the connection of electric vehicles. These types of charging systems are not compatible with each other. With the three standard systems defined and standardized, all of the consumers' high security requirements are met. As mentioned above, electric vehicle charging cables around the world are divided into 3 classes as Type-1, Type-2 and Type-3.The Type-1 charging system in Japan is designed for single-phase operation only and offers limited options for a three-phase European network system. For this reason, the use of Type-1 in Europe is very limited and short-lived. On the European market, Type-2 and Type-3 charging systems, which are completely different in design, are used.Type-2 has a single plug geometry for all charging capacities from single phase to three phase. In Type-3, there are three different geometries depending on the charging capacity and the number of phases.Type-2 does not have an additional protection mechanism, while Type-3 has a locking system as additional protection. Most European countries have chosen Type-2 because of their numerous benefits. Most European countries have chosen Type-2 because of their numerous benefits. Even though some countries have not prepared any infrastructure for electric mobility, they have also announced that they will use Type-2 charging systems in the future. According to the "Eurelectric Location Report" published March 2012, Type-2 appears to be the "de facto standard" for Europe. Today, most European automobiles, including Tesla, as well as BMW, Audi, Porsche, Volvo, Porsche and Mercedes, use a Type-2 charging cable in

most car connections. The vast majority of public charging points have also implemented charging points that provide service through Type-2 connectivity. All cars except Tesla brand cars can be charged with the same Type-2 plug. Tesla vehicles can be charged with specially designed "Type-2 Mennekes" plugs that allow 80% battery charge in 30 minutes and no other vehicle can be charged with this cable.
One of the most important concept for charging cables is the design of crimping structure. For this reason, this paper investigates the possible crimping structure in comply with the IEC 62196-2 standard. The proposed crimping design is found suitable in terms of related standard.

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