

Crimp Analysis Simulation Technology

Naoki Kakuta
Yazaki Parts Co.,Ltd.

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ABSTRACT

Crimping is a fundamental technology that is widely used as a method to permanently connect a terminal and wire in the automotive wiring harness industry. The crimping process involves large deformations (that exhibit strong non-linear behavior) to create multiple contact points between the terminal and wire strands. This paper discusses analysis done with a finite element simulation technology specially developed for crimping, the usefulness of the analysis simulation, and future issues and prospects of this technology.

INTRODUCTION

Crimping is a connection method that is widely used in automotive wiring harnesses (Figure 1). Connector systems (Figure 2) in the wiring harness consist of two (2) electrical connections. The first is a permanent crimp connection between the terminal and wire. The second is a detachable connection between the male and female terminal pair. These two connections have a large influence on the performance of the connector system. Due to growing needs to reduce the product development lead-time, the design and development of a crimp must also be completed in a shorter period of time. Analysis simulation technology enables us to examine and visualize complex mechanical events to verify crimp performance without performing actual testing. This simulation technology is intended to be an alternative to physical evaluation.

The purpose of this crimp analysis technology is to simulate performance using computer models for the crimp die shape, terminal shape, and applicable wire size. This analysis can be used to perform engineering studies and make design decisions before fabricating any physical samples. This can help reduce the number of unnecessary trials and reduce the quantity of samples used for testing. As a result, it is possible to reduce development lead-time and cost.

Crimping involves large, complex deformations (that behave in a non-linear fashion) to create multiple

contacts between a terminal and wire (as shown in Figure 3 and Figure 4.) In this paper, examples of a Finite Element Method analysis simulation technology specially designed for crimping is explained, as well as its usefulness, future tasks, and prospects.

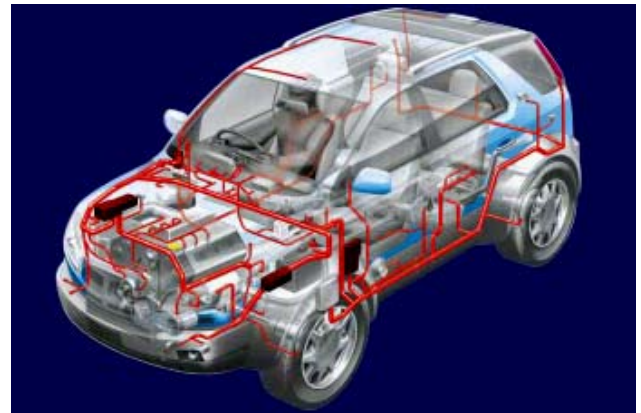


Figure 1: Automotive wiring harness

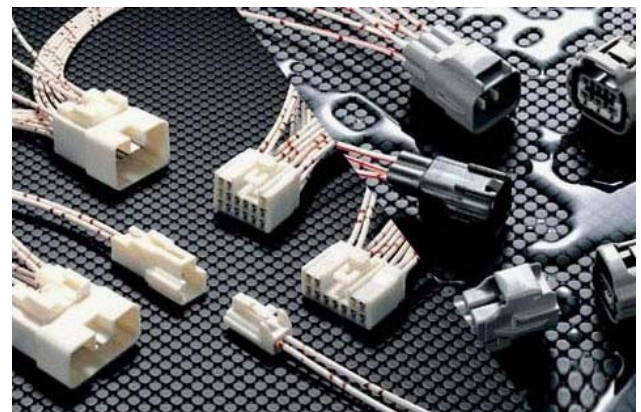


Figure 2: Connector

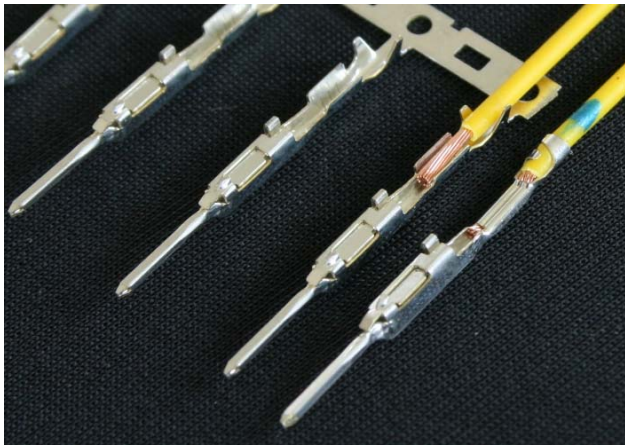


Figure 3: Appearance of crimp

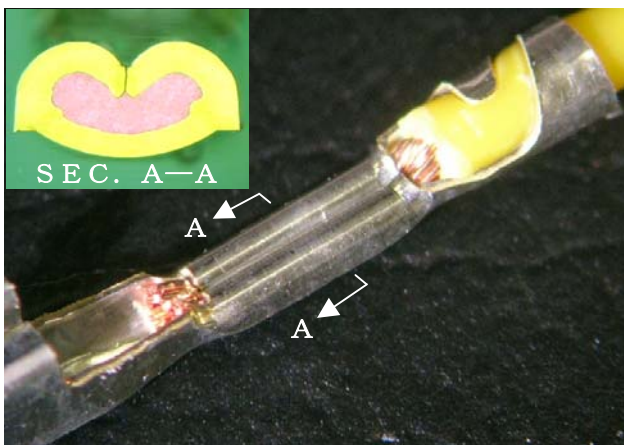


Figure 4: Detail and cross-section of crimp

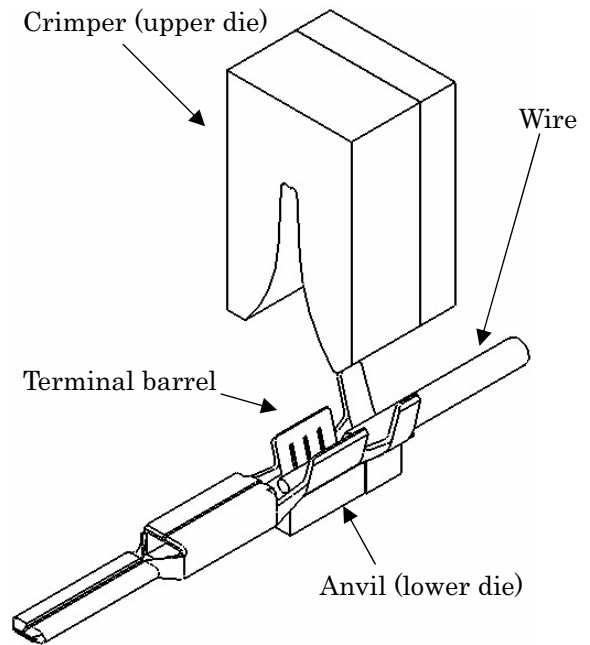


Figure 5: Crimping

CRIMPING PROCESS

A typical crimp process (as shown in Figure 5) involves placing a terminal on a lower die ("anvil"), then placing a stripped portion of wire onto the so-called "barrel" portion of the terminal. The upper die ("crimper") moves down to apply mechanical pressure to the terminal and wire. Due to the applied pressure, the terminal and wire undergo plastic deformation creating a permanent connection between them.

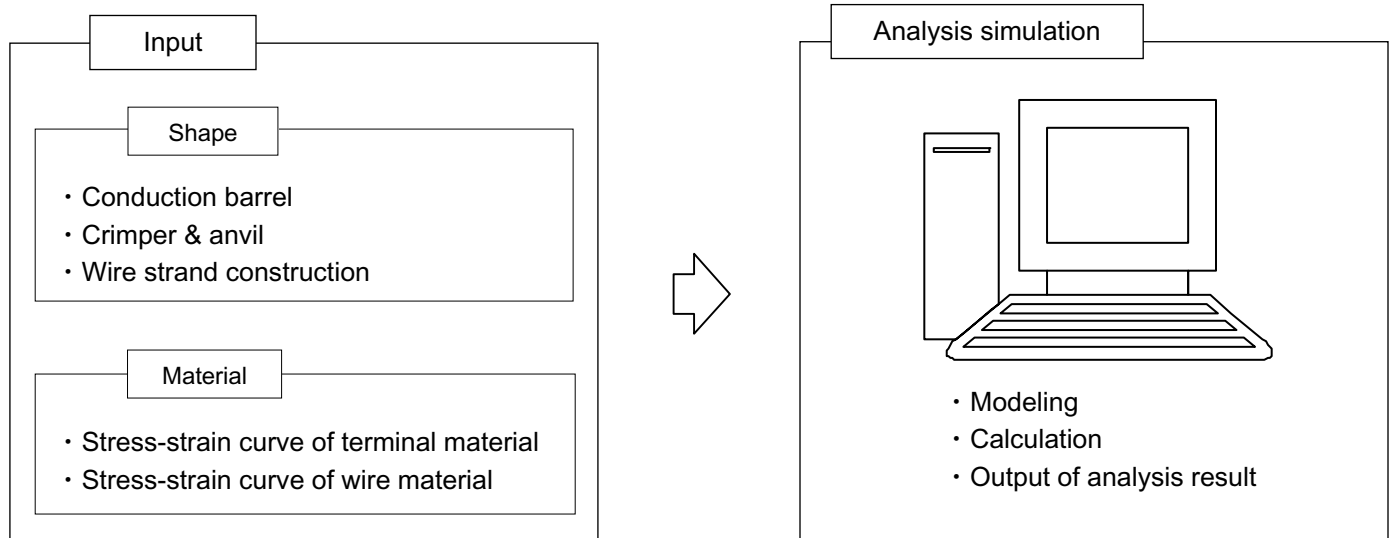


Figure 6: Crimp analysis simulation method

CRIMP ANALYSIS SIMULATION METHOD

Figure 6 shows the overview of the crimp analysis simulation method. Two types of inputs are required for the analysis: (1) part shape information and (2) material property information. The “part shape information” includes the shape of terminal conductor barrel, construction of the wire strands, and the shape of the crimping dies (anvil and crimper). The “material property information” is the stress-strain curve of the terminal and wire material. Based on this information, the specialized Finite Element Method analysis software can be used to analyze the crimp. The results are processed using standard Pre/Post software.

The crimp analysis simulation technology discussed on this paper uses a two-dimensional model that begins at the start of crimping process, to the point where the crimper reaches a predetermined bottom dead point. It is assumed that pressure is continuously applied by the crimping dies to the part. “Spring back” (discussed in chapter “ISSUES AND FUTURE PROSPECTS”) is not included in this simulation analysis.

CASE EXAMPLE OF APPLICATION OF CRIMP ANALYSIS SIMULATION TECHNOLOGY

The following is an actual case where crimp performance was improved by merely changing the shape of the crimping dies (crimper & anvil with no change in barrel design and wire). This modification was made based on the engineer's experience and idea. We used for this case the crimp analysis simulation to consider what the potential problem was in the part before the modification and how the modification contributed to that improvement.

SAMPLE – Figure 7 shows the terminal, wire and crimping dies used in the actual testing and the analysis simulation. The terminal is made of brass and the material thickness at the conductor barrel is 0.2mm. The wire core is composed of 11 strands, which are made of annealed copper wire. They are twisted together and compressed to have a circular shape, so each strand has complex polygonal profile. As stated previously, construction (and shape) of the strands is one of the inputs necessary to implement this analysis. However, this analysis simulation method cannot process a polygonal wire strand shape before crimping. Therefore, we simplified the strand shape by using a round strand as shown in Figure 7 (11 strands - each with a 0.32mm diameter). Figure 8 shows the detailed shape of two conductor crimpers, where the die crimp width is 1.30 and 1.50, respectively (hereinafter “crimp width” is referred to as “C.W.”). These crimpers differ in not only the width but also in shape. Moreover, the anvil also has differences. Hereinafter, the sample produced with the crimper that has a C.W. of 1.30 will be called the “1.30 die part”. The sample from the crimper that has a C.W. of 1.50 will be referenced as the “1.50 die part” as well.

CRIMP CHARACTERISTICS – A proper electrical and mechanical connection between a terminal and a wire is required for a good crimp (Figure 9). Therefore, when determining the optimum crimp height (hereinafter referred to as “C/H”) range, we need to consider not only the electrical resistance, but also the wire pull-out force (i.e. wire retention force) of the crimp. In Figure 10, the results of wire pull-out force test and electrical resistance in the crimp connection after a high temperature exposure test (120°C for 120 hours) for the 1.30 and 1.50 die parts are shown.

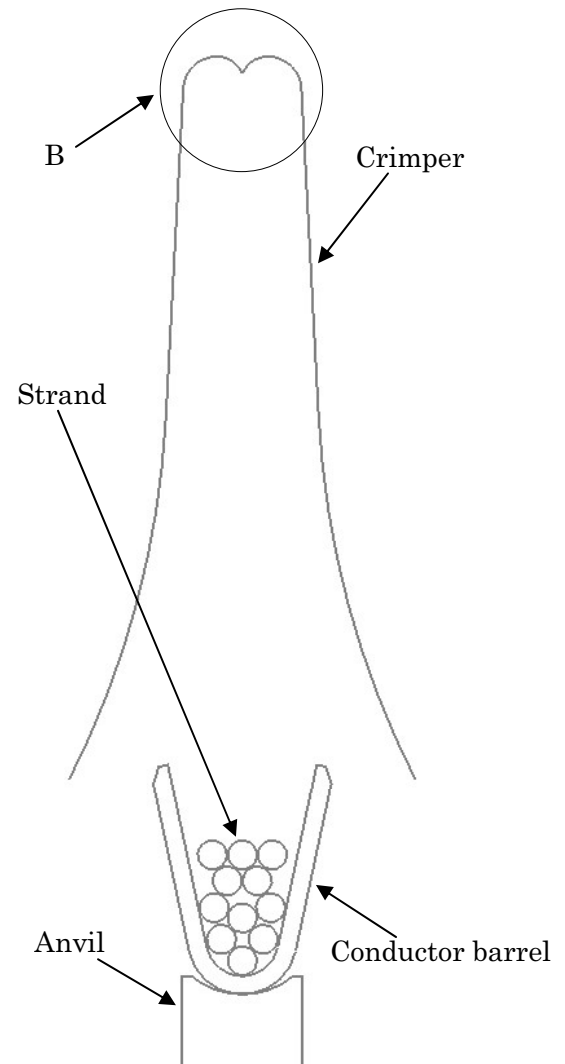


Figure 7: Parts before crimping

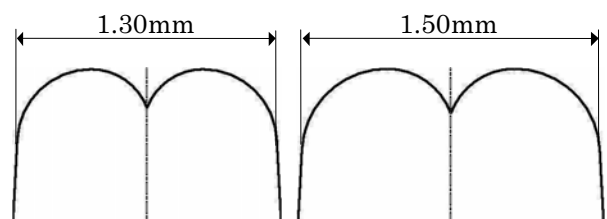


Figure 8: Detail of B