Crimp Force Monitoring – The Recipe for Success

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In my line of work, I have the privilege of visiting many wiring harness shops that produce wiring harnesses for many different industries. One of the common issues I've noticed when visiting shops that use crimp force monitors (CFMs) is that the CFMs are usually turned off, regardless of the brand, because engineers and operators are not using them properly. While I hope this does not apply to your specific situation, it may be worth paying an unexpected visit to your crimping work areas to look for indications of whether the CFMs are being used regularly. Chances are they are not. Unless of course it's audit time, then you can be sure all the CFMs will be on!

Why, with all of their benefits, are CFMs not being used regularly by employees? One of the biggest problems is the lack of understanding of the variables affecting the CFM's ability to detect variations. Crimp quality detection is similar to baking a cake. There are a lot of ingredients and if one ingredient is missing or of bad quality, you likely are not going to achieve your desired result. This article will go back through the basics of a crimp quality detection system and discuss what ingredients or variables you need to consider before switching off that CFM.

What can CFMs actually detect?

One very basic and important concept that needs to be understood in order to achieve successful crimp force monitoring is "what a CFM can actually detect." There is a general assumption within the industry that crimp force monitoring will provide reliable detection of all general crimping errors during processing, including:

- Wrong strip length
- Missing strands
- Wrong wire cross section
- Wrong terminal
- Inconsistent terminal material
- Insulation in wire crimp
- Wrong insertion depth
- Wrong crimp height

Is this assumption correct? It depends! While this is not a very scientific answer, it is the correct one. What many people fail to realize is that simply plugging in a CFM will not solve all their crimp quality issues. The main function of a CFM is to be a process monitor and to detect variations along the crimp force signature curve that are outside of the programmed tolerances. The CFM considers any variation outside of the programmed tolerance a "bad" crimp.

An operator must teach the CFM what to identify as a good or bad crimp through the "teach-in" process. This consists of running several crimps and manually verifying that the data associated with that crimp (crimp force, crimp height, etc.) is correct. The CFM then compares all future crimps to this data. Therefore, in CFM terms, "bad" really means: the actual crimp curve is outside of the tolerance range that was defined from the known good crimps during the "teach-in" process. But, since this does not fit in the CFM's display screen, it is simply called a "bad" crimp. Different applications require different CFM parameters and operators need to learn to interpret the feedback from the CFM to determine where the variation occurred and if that variation really constitutes a "bad" crimp.

What Causes Variation

Once an operator truly understands what is meant when a CFM detects a "bad" crimp, the variables that affect the crimp curve can be taken into account. There are many factors that can affect an application and how much each variable affects the CFM's ability to detect crimping problems varies.

Application feasibility is the most critical factor in the crimping process. Application feasibility is determined by the "headroom." Headroom is the difference in the peak force required to crimp a terminal with wire versus the peak force required to crimp a terminal without wire. The headroom determines how "hard" the terminal is in comparison with the wire. Usually, companies determine the best headroom to be from 30% to 40% (See figure 1). When these conditions are met, problems such as missing strands, strands over insulation, positioning problems, etc. can be easily detected.

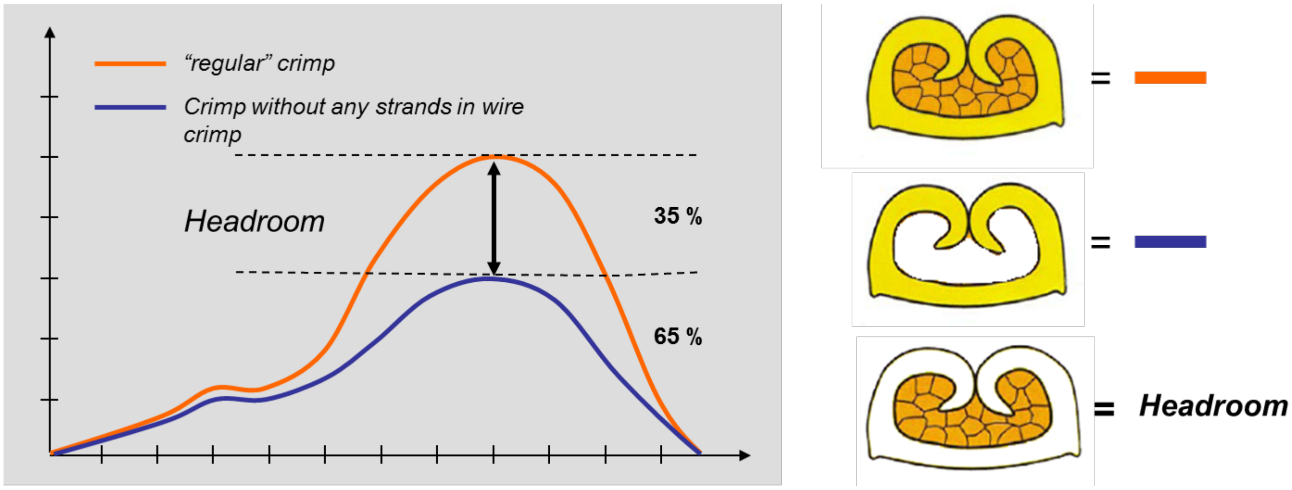


Figure 1

Material type and hardness of the terminal is another big factor in determining the application headroom. The harder the terminal, the smaller the headroom and the more difficult it will be to detect other crimping problems. The finish of the material also plays an important role since some materials "slide better" on the crimping tooling than others. Some materials, such as gold, tend to build up on the tooling if not lubricated properly thus having an impact on the crimp curve. The tolerance of the stock thickness of the terminal is very important as well because the CFM will detect a difference in thickness if it varies from the teach-in samples.

The proper combination of wire, terminal and seal is also critical to the crimping process. If the wire is too small or too large for the terminal and seal being used, the CFM will have a difficult time detecting a good versus bad crimp.

Type and quality of the wire also need to be taken into account. It is very important that the wire has a good quality and consistency in its mass. Wire quality is one of the critical conditions since 30 to 40% of the crimping force is required to form the strands into a gastight honeycomb geometry. If the copper mass varies too much throughout the wire, this will have a significant impact on the crimping force detection. Also, strand count is very significant because monitors are typically only able to detect around 10% or more missing strands. Therefore, if the wire has 7 strands, the CFM can detect 1 missing strand, whereas in a 19 strand wire, 2 or more strands would need to be missing in order for the CFM to detect an error. Insulation also plays a role in crimping force, although to a lesser degree. A cleanly stripped insulation allows for better force detection.

The **applicator** is also a critical factor in the crimping process. It is important that a well lubricated and reliable applicator is used. A reliable applicator is a quality made applicator with a good feeding mechanism and quality made tooling.

A **press** with good consistency that is statistically capable (i.e. Cmk > 2.33) and well maintained means repeatable force will be applied to the wire/terminal combination. Presses also have to be designed so that they can consistently flex enough for frame sensors to be able to detect the deflection and therefore the force applied. For ram or base installed sensors, this is also important although to a lesser degree. Cmk is the key here.

Wire preparation also plays a part in the crimping process. A well prepared wire is required with consistent cut and strip dimensions and without damaged strands. Manually stripped wires have a greater chance for inconsistency and damage to the wire and therefore will have a bigger impact on variability. To achieve the best results it is recommended that a quality automatic cut and strip machine is used to cut and strip wire.

Presentation is another variable to consider. For manually fed crimping presses, the operator must present a properly stripped and straightened wire consistently to the wire stop position before initiating a crimp cycle.

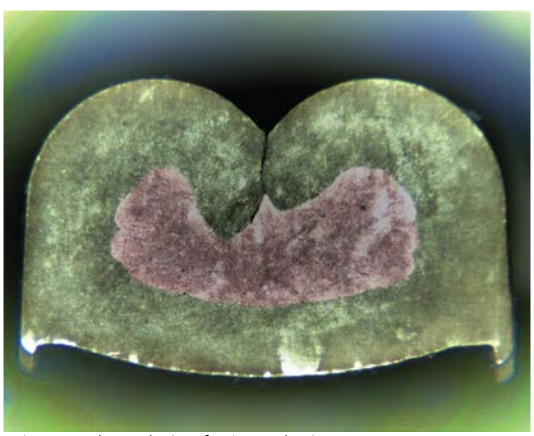
One factor that often goes unnoticed is **temperature.** Extreme temperatures or variations in the factory temperature throughout the day can have an effect on the CFM's ability to detect variation.

The **CFM** itself will also have an effect on the data. It is important that the user know about the type of CFM and force sensor that is being used and is familiar with the positioning of the sensor.

Crimp force monitors are very effective tools when the conditions previously mentioned are fully understood, considered carefully, their optimum conditions met and the influence of the different variables taken into account. Paying close attention to these factors is the only way to achieve meaningful detection of crimping problems.

Properly Interpreting the Data
Most importantly to the process, operators need to learn to read the data they are given by CFMs and understand what it means. As mentioned earlier in the article, an operator must teach the CFM what to identify as a good or bad crimp. In order to do this properly, first time crimping studies must be performed to determine the detection feasibility, taking into account all of the factors discussed above. Because the teams in manufacturing usually have little say in determining what combination of wire and terminal to use, one of the best ways to effectively determine the capability of the application is through a thorough analysis done before releasing the tools and materials to the production floor. The most important output from these analyses includes:

- Conductor Crimp Height CPK
- Pull Out Force CPK
- Micrograph Analysis



Micrograph analysis of crimped wire

Performing these analyses before beginning production will provide valuable information about the proper combination of wire, terminal and crimp specs.

Once the quality of the equipment, materials, and headroom is determined, the crimp zones need to be established. The easiest way to do this is by looking at the curve graph through a computer or the software in the equipment. Some applications introduce unwanted equipment and terminal noise at the beginning and the end of the crimping process, known as feeding noise (See figure 2). This is not critical to the crimping process and needs to be filtered out from the equation. The crimp zones should focus only on the actual crimp curve and need to be set on the CFM.

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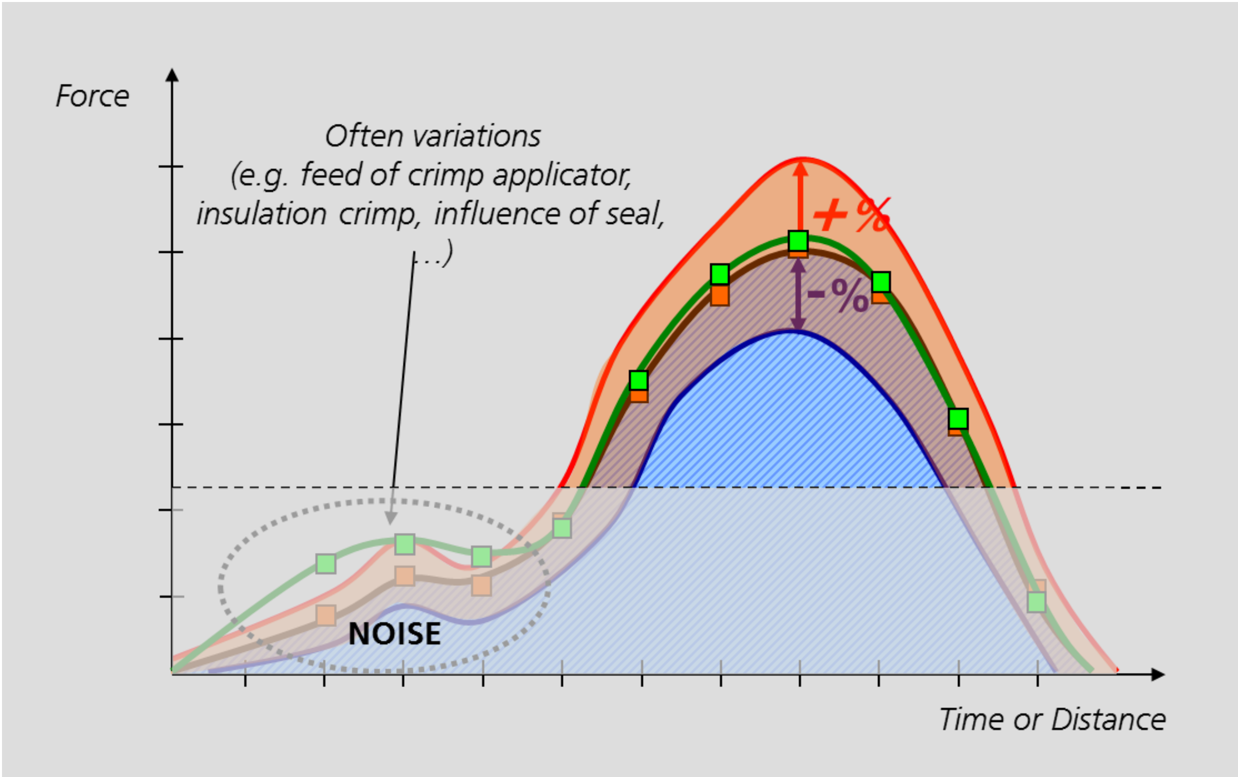

Figure 2

Once unwanted noise is filtered out, then the averages of correctly crimped wires can be taken to determine the signature curve. Accomplishing this requires trial and error to determine how many missing wire strands a certain range will be able to determine as bad. Strands can be taken out of the crimp one at a time to determine the effect of the missing strands to the deviation from the signature curve. Once completed, this will determine the CFM's ability to detect the percentage of missing strands. After gathering all this data, the percentage tolerance from the mean curve of the known good crimps is determined.

Documenting Results

Finally, documentation is very important to determine process values for the correct terminal/wire/tool/CFM combination. Having these process values readily available and posted next to the crimping press or downloaded automatically into the machine's software will ensure proper adherence to the process charts at all times and give valuable reference data for troubleshooting purposes.

Conclusion

There are several variables that need to be evaluated and understood for successful use of a CFM. Of course, all CFMs come with base parameters that will work for many applications. However, in order to do a professional job and create products with the highest quality and reliability, we, like chefs in the kitchen, need to ensure each ingredient in the process is properly prepared before sending out to the production floor. That is the recipe for success!