DESIGN AND DEVELOPMENT OF CLAMPING UNIT IN SCREW-LESS ELECTRICAL TERMINAL BLOCKS

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Abstract— A terminal for detachably connecting an electrical lead connector pin to an electrical circuit is disclosed. The terminal includes an end contact and a movable clamp for movement between first and second positions relative to the end contact. The clamp has a pocket at one end which a relative motion to and fro due to force applied by the tilting action of the screw driver. The pocket receives an electrical lead into the pocket when a force is applied using screw driver, as the screw driver is removed, the clamp moves to its original position which locks the electrical lead to a end contact. As a huge amount of force is required to give a relative motion to the clamp by the screwdriver, the design is bought under modifications.

Index Terms—, Cage Clamp, Clamping force, Screw-less terminal blocks, S-Clamp, Conductor.

I. INTRODUCTION

In today's market, most companies redesign to create new products. Redesign improves product quality and reduces cycle time. However, most techniques limit innovation. They modify a single reference product, which closely matches user needs, and only introduce new products when major conflicts exist between user needs and existing products. This study introduces a new redesign for product innovation approach. The approach combines two or more distinct reference designs into a single new product. The process creates design conflicts. The induced conflicts stimulate innovation. which improves solution quality and reduces cycle time.

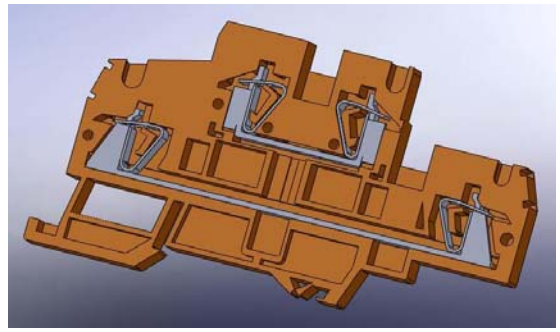
After products are on the market for some time, they often need to be redesigned. There are many reasons for redesigning products. First, design faults may be found, or customers may change requirements. Products may also be redesigned to improve quality, reduce costs, extend product life, or reduce environmental impacts. As a result, redesign is an important part of the product development process. In fact, in today's market, most new products are also developed using redesign techniques. New products are generally derived from similar products Therefore; new product design is generally a derivative work, which consists of changing prior designs to make them suitable for new applications.

In fact, more than 75% of all engineering design activity involves reusing prior design knowledge to solve new design problems there are many advantages through using a redesign approach to develop new products. Redesign generally improves the quality and efficiency of the product. Design process Redesign solutions are generally more feasible and reliable, since they have already been used successfully in prior products Reusing prior design information also reduces product costs, required design resources and cycle time.

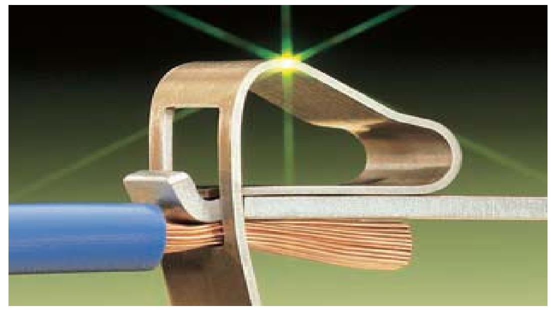
Therefore, redesign is an important key to business success However; current redesign techniques can also limit product innovation. Redesign generally focuses on resolving conflicts between current product needs and prior design capabilities. Most techniques start by choosing a reference design that reduces conflicts between user needs and product functions, as much as possible. Remaining conflicts, depending upon their degree, are resolved by changing component attributes, replacing components, or changing the structure of the original design.

Fig (1). Shows *Screw-less terminal Blocks* which are constructed employing good engineering practices. As the name suggests this type of terminals blocks does not require a screw for termination of a conductor within the clamping unit. In case of screw clamp connections, it is necessary to ensure proper tightening of screw with a torque screwdriver. In screw-less terminal blocks cage clamp is opened by insertion of a screwdriver. Conductor is inserted into this “opened” clamp and connection is secured as soon as the screwdriver is withdrawn.

The clamping force in cage clamp connection adjusts automatically according to cross-section of the conductor inserted as shown in Fig(2). Larger the conductor, more the force exerted on it. There are no external factors which can change this force.

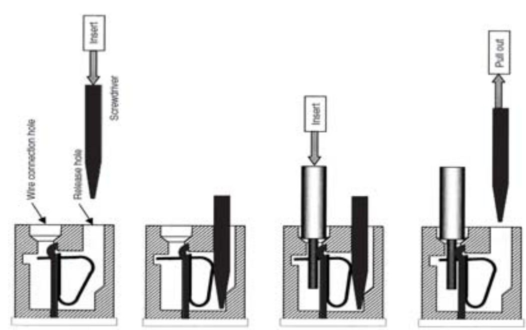


“Fig (1). Screw-less terminal blocks”



“Fig (2). The cage clamp, end contact & conductor”

This newly developed *cage clamp* system functions in a similar way to the proven clamping yoke. Separation between the mechanical and electrical functions has also been maintained with the tension clamp version. The tension clamp made of high-quality, non-rusting and acid resistant steel draws the conductor towards the electroplated copper current bar. Minimal contact resistance and high corrosion resistance is achieved by the tin-lead surface and permanently maintained by the compensating action of the tension spring. The following Fig (3) show steps to insert the electrical conductor in to the cage clamp.

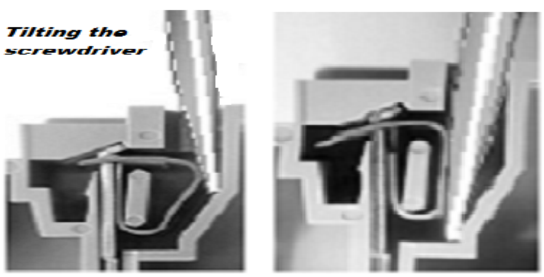


“Fig (3). Steps to insert conductor into cage clamp”

II. PROBLEM DEFINITION

In *Screw-less terminal blocks* cage clamp is opened by insertion and slight tilting action of a screw driver. Conductor is inserted into this "opened" clamp and connection is secured as soon as the screw driver is withdrawn. As the clamp does not open due to the insertion of screw driver, a slight tilting action requires a huge force.

Fig (4). Describes the method to insert the conductor which depends on the tilting action of screwdriver. If lubricating liquid, such as oil, is present on the tip of screwdriver, the screwdriver may fall out resulting in injury to the operator. Insert the screwdriver into the bottom of the hole. It may not be possible to connect cables properly if the screwdriver is inserted incorrectly. Sometimes due to improper insertion, the plastic body, rail supports, supporting walls may get damaged or the clamp insert may come outside from the body as the huge force is applied by the screw driver.



"Fig (4). Tilting action of screwdriver"

III. SCOPE OF PROJECT

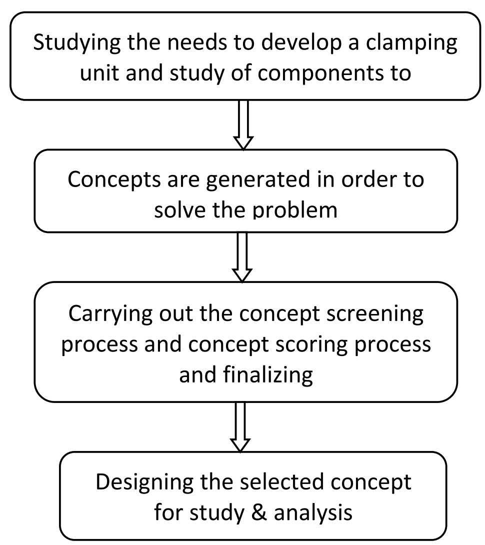
The primary objective of the work is to design a new clamp for holding the wire with necessary contact pressure with reduced clamping force. Reducing the cycle time and forces on the operator is also an objective of the project.

The following points briefly discuses the scope of the project.

- ✓ Studies of geometry of the component in order to generate the design concepts to achieve the primary objective.
- ✓ Number of concepts has been generated by considering different reference surfaces in order to design of clamping unit.
- ✓ Modeling of the different concepts using solid works software and selecting the best concept using concept selection process.
- ✓ Detail designing of every component in the part. And finally assembled to check the clearances, mechanical properties.
- ✓ The load required to clamp should be minimum; therefore the analysis of the clamp is required.

III. METHODOLOGY

Methodology is the systematic step-by-step planning approach in designing an clamping unit in screw-less terminal block. It includes the activity of finding solutions to technical problems by applying insights from natural and engineering sciences, at the same time taking into account the conditions and constraints of a given task. It includes the following steps in general which is shown in fig (5).



"Fig (5) Flow chart of methodology"

A. Identifying the Requirements to Design

The process of identifying needs and collecting the data is an integral part of the design and product development process and is most closely related to concept generation and concept selection. Needs are largely independent of any particular product we might develop; they are not specific to the concept we eventually choose to pursue. Raw data is collected and interpreted in terms of customer needs. Then the needs are organized into a hierarchy of primary, secondary, and if necessary into tertiary needs. Relative importance of needs is established. The results and the identification process are reviewed.

The need in this project was to find a solution that would effectively hold the conductor firmly with necessary clamping force. In order to achieve these many design concepts are generated. Based on the collected data and needs different types of concepts are generated. Finally the developed concept should be such that it makes use of the selected reference and effectively holds the conductor.

The needs recognized for this project are as listed below:

- ✓ The current bar should come into the open slot provided in the clamping unit towards one end when at rest. When pushed by screw driver the slot should open and conductor will be inserted.
- ✓ A clamping unit has to be conceptualized in order to effectively arrest the conductor firmly. Such that when a weight is attached at the other end of the wire, the contact should not fail.
- ✓ The clamp material should be hard enough to withstand the force applied by the screwdriver without deforming and to transmit that force to move front and back.
- ✓ The clamp material used should be corrosion resistant, good current carrying capacity, fatigue resistance etc.

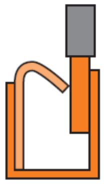
B. Concept Generation

The concept generation process begins with a set of customer needs and target specification and results in a set of product concepts from which a final selection has to be made. The most common concept generation method is known as brainstorming. The term brainstorming is frequently applied to any idea generation technique

In this study approximate concepts are generated that give a description of the technology, working principles and form of the mechanism that has to be built in order to improve the clamping force.

The concepts are expressed as sketches. Each concept is important for the designer to interpret the needs and clarify the problem. In order to clarify the problem the designer can decompose the problem for easier and better understanding and is followed by a brief textual description. In order to generate concepts the designer has to have a very brief knowledge of what and why he has to design and so it becomes very easy.

a. Push-In Connection

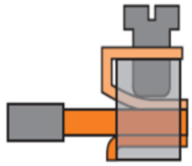


"Fig (6) PUSH-IN connection technology"

Fig (6) shows PUSH-IN connection concept, a stainless steel spring which is fitted in a separate housing, with the top end being folded towards inside slot. The pin being a stainless steel has a high elastic property it always tends to regain its original shape, taking this as a advantage the conductor can be locked firmly in slot to some extent.

In this PUSH IN connection concept only the stripped solid conductor is simply inserted into the clamping point as far as it will go. And that completes the connection. No tools are required. But the flexible conductors with crimped wire end ferrules or ultrasonic-welded conductors is difficult to insert into the slot because of small stripped wires.

b. Leaf Spring Connection



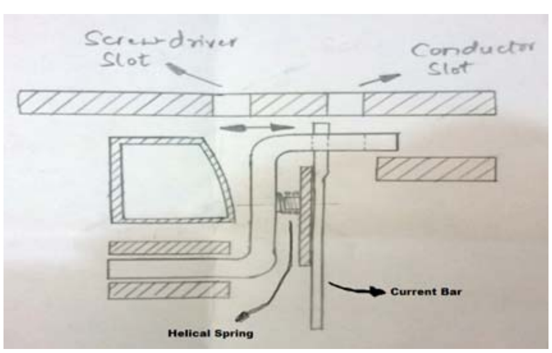
"Fig (7) Leaf spring connection technology"

Fig (7) shows the most commonly used leaf spring is the semi-elliptical leaf spring. The semi-elliptical spring may be considered as two cantilevers and elliptical spring as four cantilevers. The stress induced in a semi-elliptical leaf spring is same as that of full elliptical leaf spring. But the deflection in a semi-elliptical leaf spring is equal to one half of full elliptical leaf spring. The unloaded spring is cambered, the magnitude of the camber being such that the spring is approximately straight under the full static load. Using a screw on the top of the spring, as the screw tightens the straightness under full static load is utilized to hold the conductor firmly.

But in this leaf clamp connection system only large conductor cross-sections can be held firmly, for smallest wire cross-sections the force is insufficient.

c. S-Clip Technique

Conceptualization was carried out for clamping unit and conductor installing mechanism. For this process the input was gained after identification of needs for clamping unit and conductor mounting mechanisms.



"Fig (7) The concept made by hand sketch"

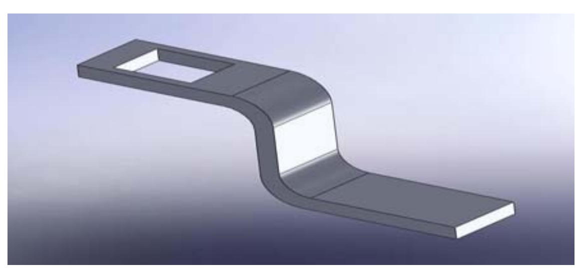
Keeping all the constraints in mind such as less clamp pushing force, good conductor holding force, vibration resistant, gas-tight connection etc. the concept was developed by considering the different holding mechanisms which is discussed in the design concepts and shown in fig (7), and this design is modeled and analyzed in the later stages.

IV. MODELLING

CAD modeling is used by many designers to create elaborate computerized models of objects before they are physically produced. CAD stands for computer-aided design. Engineers, architects, and even artists utilize computers to assist in their design projects. Computers allow them to visualize their designs and confront problems before they have expended any of the resources necessary to put them into physical form. Many different professions make use of computer-aided design.

It is an important industrial art involved in automotive, aerospace and artistic designs. The use of CAD modeling is massively widespread; anything from chairs to rockets can be designed with the aid of computer programs.

At one time, this step would have involved several drafters making dozens of sketches and diagrams until a perfected model could be devised. Now, a single CAD file can be made, edited, and continually tweaked until the object is ready for production. In this section the concept which is developed with the help of design concepts, literatures, mechanisms etc has been modeled into a two- dimensional, three-dimensional drawings for better interpretation, understanding and to analyze.



"Fig (8) The S-Clip"

Fig (8) shows the conceptual S-clamp design which has been modeled using a CAD software, Now the wire holding *cage clamp* has to be replaced with the *S-clamp*. Due to unavailability of a old model using a technique called reverse engineering, the model has been developed for the full scale with the help of measuring instruments. Fig (9) shows the electrical terminal block which consists of a plastic body, copper conductor and a cage clamp.

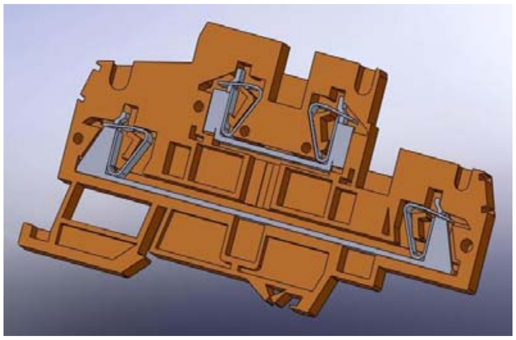


Fig (9) The Assembly view

Now to make feasible for the new design (S-clip) the current terminal block with cage clamp has been modeled. The current assembly has been modified in some specific areas to suit for the new conceptual design (S-clip), a new helical spring has been used to get necessary contact force. Fig (10) & (11)shows the details of the changes made to the current design.

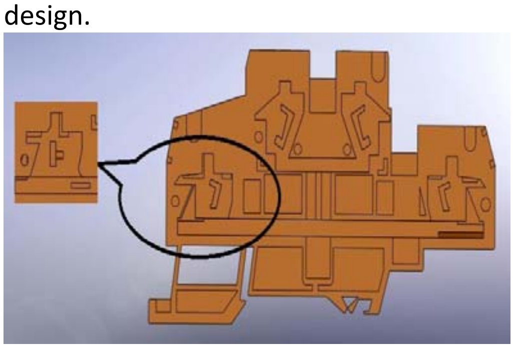


Fig (10) The Modified Area in the body

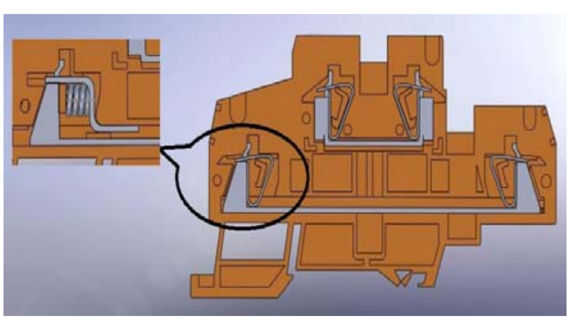


Fig (11) The Modified Clamping Unit in the Terminal Block

The following points explain the modifications made for the screw-less electrical terminal block.

- ✓ Firstly, instead of cage clamp the S-clip has been designed. The body and other parts have been subjected to design change on this basis.
- ✓ The screwdriver entry and conductor entry remains unchanged.
- ✓ The rib inside the cage clamp has been removed. And replaced with a wall towards end contact.
- ✓ This wall has a pin extended which is necessary to hold the spring.
- ✓ The inclined support for the screw driver after insertion has been increased for two degrees.
- ✓ The sharp edges are provided with a fillet to reduce stress concentration factors.
- ✓ Remaining part has been left unchanged.
- ✓ The end contact connecting two ends remains unchanged.

V. ANALYSIS

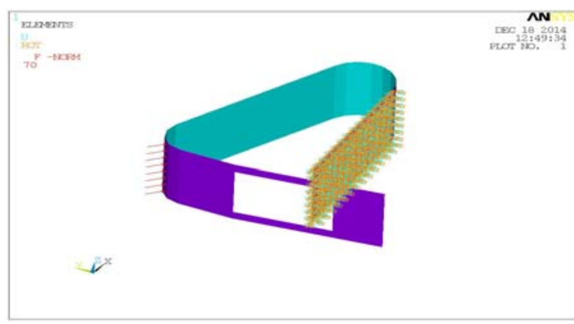


Fig (12) Cage clamp with BC's & force applied

Fig (12) shows the cage clamp, the boundary conditions are fixed at straight wall which is visible in fig by yellow lines, the material properties of stainless steel has been assigned and the force is applied on the spot where actually the screw driver pushes the clamp in the pre-processing stage. Next the problem has been solved in the solution stage.

Fig (13) & (14) shows the results obtained for the solution in the post-processing stage, where the displacement being 3.68689 mm and the von-misses stress being 6491.13MPa for the *cage clamp*.

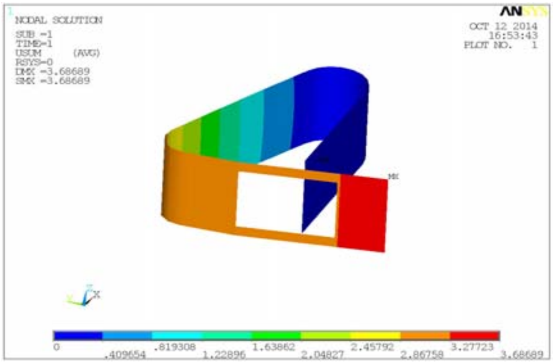


Fig (13) Displacement obtained for the applied load

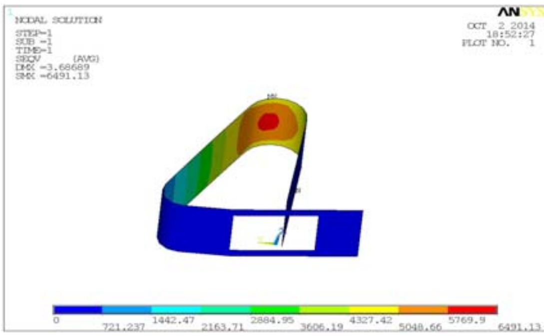


Fig (14) Von-Misses stresses in MPa

The obtained results are now compared with the new design, when the new design has been subjected to a same force of 70MPa with the same material properties, changed boundary conditions. Following fig (15) & (16) shows the results we have got.

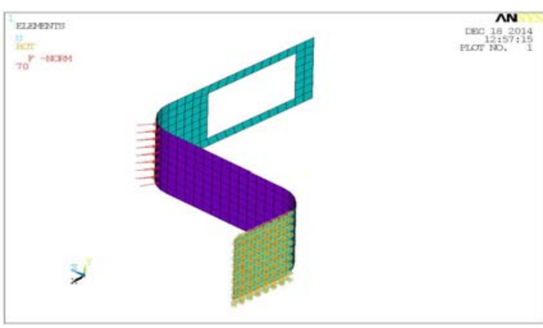


Fig (15) S-clip with BC's & force applied

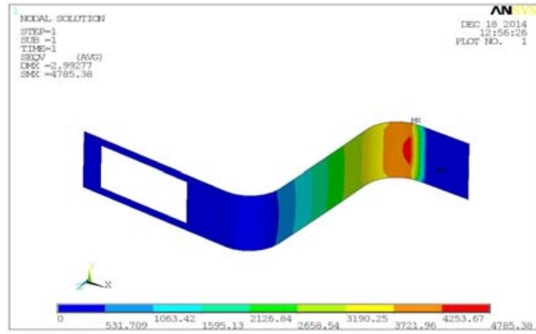


Fig (16) Von-Misses stresses in MPa

VI. Conclusion

The following points are the conclusion obtained by modeling, analyzing and testing this clamping unit.

- ✓ The information related to this work has been collected through various journals, existing techniques, problems etc.
- ✓ Based on the above information concept generation technique has been implemented to obtain different concepts.
- ✓ Reverse engineering technique has been used to obtain the dimensions of *cage clamp,* end contact, body. And has been successfully designed according to the requirement.
- ✓ Modeling, assembly, detailing of the *cage clamp* is carried out using solidworks.
- ✓ Different concepts have been designed to check the feasibility of those mechanisms. Based on the clamping force, drawbacks of this design. A new design technique called *S-clip* technique has been developed.
- ✓ Necessary changes have been made in the body, end contact to accommodate this *S-clip* technique.
- ✓ Analysis has been made to compare the displacements, stresses in the material of the techniques.
- ✓ For the same amount of forces the stresses are minimal in *s-clip* technique compared to *cage-clamp* technique.

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