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DEFINITION AND VALIDATION OF A KNOWLEDGE BASE AND THE ARCHITECTURE OF A COMPUTER TOOL TO ASSIST THE DESIGN AND MANUFACTURING OF WELDED PRODUCTS

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ABSTRACT
This paper presents the first results of a research work, which purposes were to develop the knowledge base and the architecture of computer tool to assist the design of welded products. The most important contributions of this research work were the definition of knowledge structure and its components, formal and heuristic knowledge components construction, and the development of a design process model for manufacturing and assembly and the validations of contributions on projects of local metal-mechanical industry.
The knowledge base includes principles and rules to design, information about costs and welding times, selection factors for welding processes, welding standards, definition of welding construction types, pre-welding and post-welding processes and welding geometry among others aspects..
Keywords: Design for manufacturing and assembly, concurrent engineering, welded products and welding processes, knowledge-based systems

1. INTRODUCTION
Now day conception in the design processes and product development for the companies makes clear the necessity to structure and to implement design methodologies of technological and engineering character for guiding and help the manufacturer, in some or all the phases of the life cycle in order to structure, solve and optimize the many tasks or problems related. [1, 2, 3].
A philosophy that has accomplished to integrate all the actors of the process simultaneously in the design and product development stages is the denominated concurrent engineering, based on this philosophy was developed the DFMA methodology for welded products. The information and knowledge base for welded products formulated in this paper were developed from specialized bibliographical references, the authors experience and experts at the area.

2. DFMA ARCHITECTURE AND KNOWLEDGE BASE FOR WELDED PRODUCTS.
The architecture and knowledge base of DFMA methodology for welded products are made up from principles and heuristic rules for the manufacture design and assembly of welded products, also the cost information and welding time, usual weld processes and factors that affect their selection, normalization required in welded constructions, welding symbols, considerations of strain and stresses in welded joints, base and filler materials; all these factors interact in the DFMA for welded products and are used as a conceptual and operative support. The architecture feeds other areas of the company and also provides its feedback, being consequent with the philosophy expressed at the concurrent

engineering. All these elements are shown in figure 1. The DFMA for welded products proposal can be extrapolated to other DFMA scenes (with other processes) because the nature of the components can be the same one, only that it should be distinguished for those other processes or products.

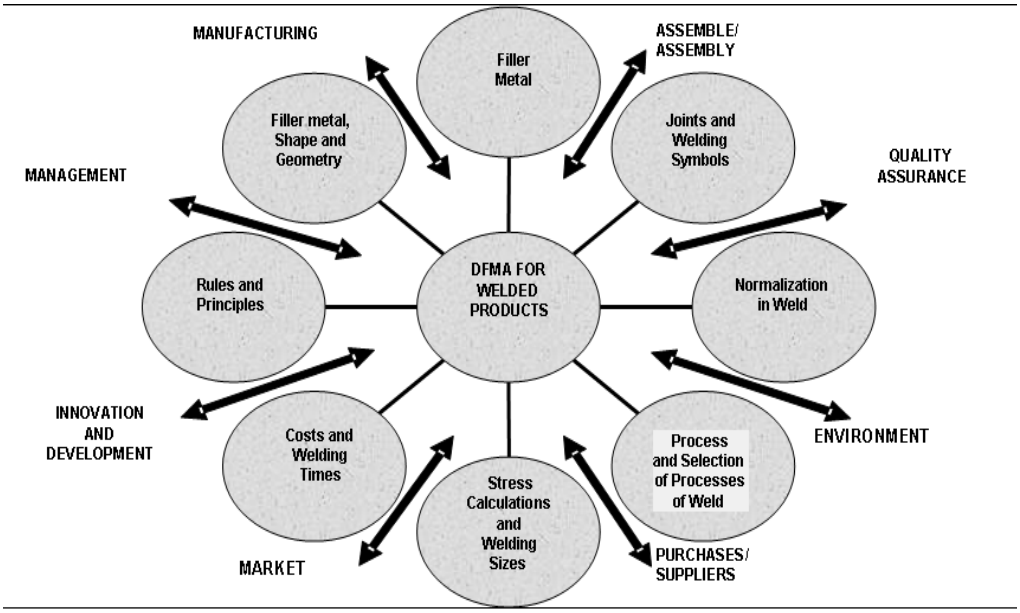

Figure 1. Schematic structure of the components in which is supported the effective application of DFMA of welded products.

3. DESIGN FOR THE MANUFACTURING AND ASSEMBLY FOR WELDED PRODUCTS

All design methods and strategies orientated to integrate in the process design of welded products, the implications of the decisions about the manufacture and assembly of the products, obviously are under the approach of concurrent engineering [4], as the proposed in this research work.

3.1. Influential factors in DFMA for welded products

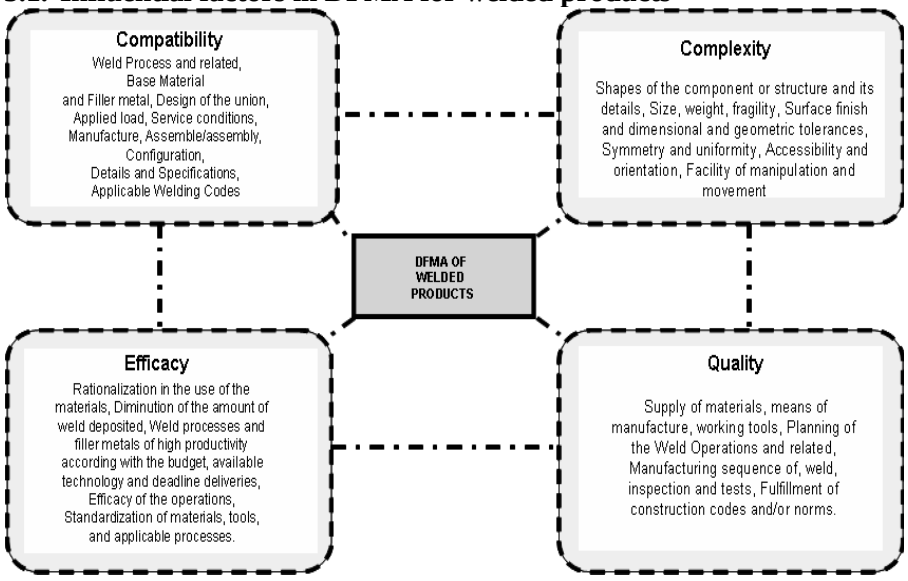

Figure 2. Factors that affect the DFMA of welded products.

The process of design for the manufacturing and assembly of welded products requires the identification and analysis of the factors that affect it, see figure 2, therefore it is necessary to consider them for their analysis and later development [5].

Compatibility. This analysis is made to assure that the design specifications are going to be respected, avoiding expensive design, modifications in advanced phases.

The compatibility takes in count specifications that are for the design and for the production. The compatibility in welded products talks about: Welding Process/Material, Welding Process/Joint type, Material base/Filler metal, Welding joint design/loads and service, Configuration/manufacturing and assembly, Detailed design/codes and standards.

Complexity. Employing a design with less complexity the manufacturing and assembly time and costs are reduced. The factors that determine the complexity are: Component or structure geometry, Weight or sizes of components, component fragility, superficial finished, geometrical and dimensional tolerances, symmetry and uniformity, accessibility and orientation, among others.
Quality. The quality of a welded product depends on its design and the management, the organization and the correct application and use of the processes and equipment available, to reach the shapes, tolerances and requirements specified by the clients, codes and standards applicable to the product. The factors that improve the quality of the welded products are among others [6]:

- Availability of materials, means of manufacture and adequate working tools (cutting, shaping, welding, heat treatments, inspection and tests equipments)
- Planning of the welding Operations
- Welding sequence, inspection and tests
- Standards and welding codes

Effectiveness. In the design for manufacturing and assembly of welded products must be focused to: a rational use of materials, use the discontinue weld except with dynamic loads, use the materials and processes appropriates with the budget and delivery times, standardize materials, joint designs, tools and processes.
DFMA scope in welded products. The DFMA approach implies to improve the performance, the manufacturing, the assembly, do easier the maintenance, reduce the costs and manufacturing and assembly times, among others aspects.

4. DFMA DESIGN PROCESS MODEL FOR WELDED PRODUCTS AND PRODUCTION RULES

A previous stage in process design of the structural joint is the selection of the mechanical type joint. For this purpose, it is necessary the evaluation of available type joining methods considering a multiple criterions as disassemble-ability, sealing requirements, cost, among others.
The figure 3 shows the required steps to design of welded products from a DFMA approach, which should be applied from the initial specification stage with special focalized on configuration and detailed design stages.
This model is highly effective if it is used with the heuristic knowledge as thumb rules, design principles and standard and codes dispositions applicable to level of design, manufacturing or assembly.
Standards. Must be applied in the design, construction of welded products to obtain an adequate level of safe, quality or reliability depending of the specific product (ASME, AWS, API)
Rules and Principles. A set of simple rules or principles can be employed from the design of welded products to improve their performance, manufacturing, assembly, safe, cost, among others aspects [7, 8]. Some rules aim to reduce stress raisers, distortions or the difficult of selected welding processes.
Another knowledge components are required such as: material base, standard type joints, standard welding line geometry, standard electrode properties, stresses formulas, standard welding processes, standard welding symbols, cost and welding time estimations, complexity index evaluation, test and non destructive tests, among others.

5. ADVANTAGES OF DFMA OF WELDED PRODUCTS

Traditionally the manufacturing engineers do not participate in the product design before of the design launch, these iterative and sequential practices bring to the development process retarding and non-competitive process [7].
The DFMA in welded product has the following advantages:

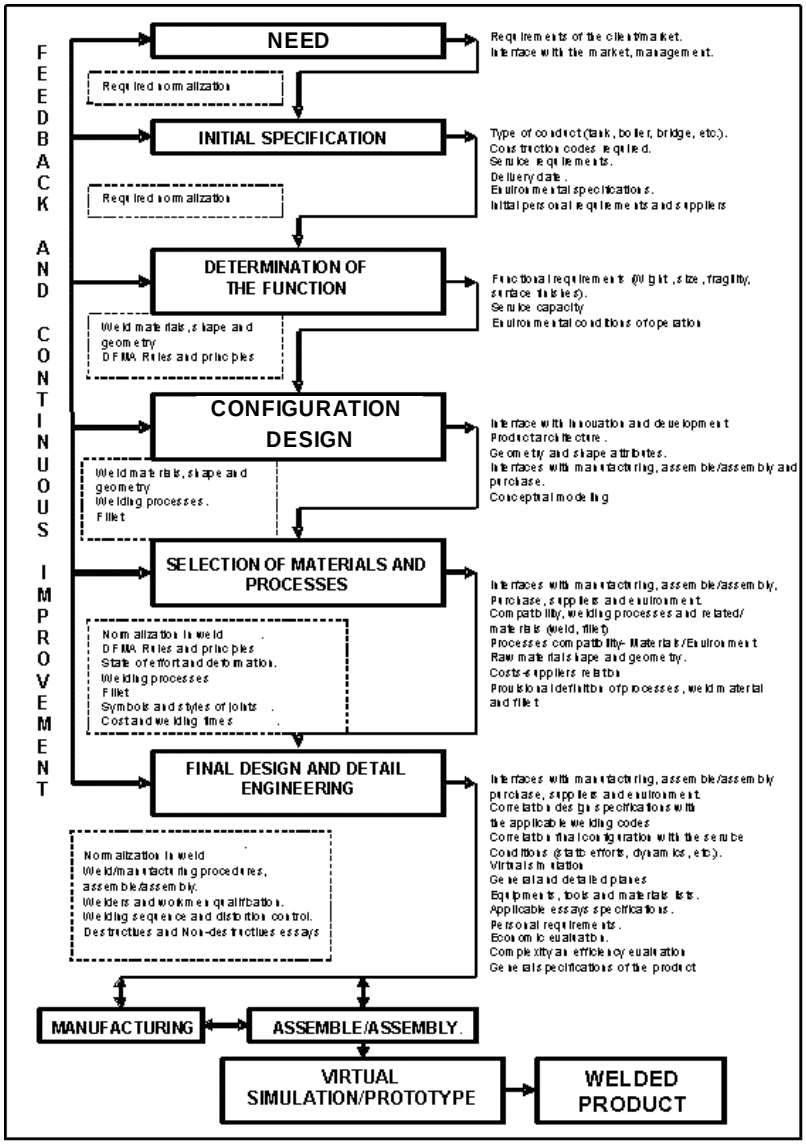

Figure 3. Design process model for manufacturing and assembly of welded products

- From the same design can be reduced the costs and manufacturing times
- Do easier the design for novel engineers
- Particularly, provides specialized knowledge about joint preparation, preheat treatment, post-welded treatments, etc.
- Promote the integration of the design, manufacturing and assembly departments
- To improve the quality in product development
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6. CONCLUSIONS

The mean contribution of the research work was the definition the knowledge components and the computing architecture for an assistance tool to design of welded products considering their manufacturing and assembly. These knowledge components and nature were defined, for example: a process design model, production rules, designs principles, material, standard electrodes and formulas bases, among others. The contributions of this work were validated on two pilot projects of design-welded products: a machine frame and fuel atmospheric container.

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