

## HIGH BEARING MECHANICAL STRUCTURES MADE OF THIN WALL STEEL PROFILE USING INNOVATIVE SOLUTIONS IN THE FIELD OF HYDRAULICS AND RESISTANCE CALCULATION METHODOLOGY

Ph.D.Eng. Gabriela MATACHE<sup>1</sup> Dipl.Eng. Ionel NITA<sup>1</sup>

Ph.D.Stud.Eng. Alexandra VISAN<sup>1</sup> Dipl.Eng. Adrian Georgian PANTIRU<sup>1</sup>

<sup>1</sup>Hydraulic and Pneumatic Research Institute, fluidas@fluidas.ro

**Abstract:** *This article presents technical solutions to achieve the underlying strength of metal structures for construction (halls, houses) of thin-walled steel profiles with improved performance, as an alternative to current solutions used, in which by combining hydraulics and techniques calculation to obtain a device capable of operating in terms to meet these requirements. As a specialized institute in the field of hydraulics, INOE 2000-IHP Bucharest participate in the realization of the design solutions of multitasking equipment and part of the process that underlies the technology to achieve new types of structures with wall profiles thin.*

**Keywords:** *steel profile, multitasking equipment*

### 1. Introduction

The new thin-walled sections which are subject in achieving enhanced structures-bearing called composite profile realized by axial assembly of standard metallic profiles from thin metal sheet in accordance with mechanical resistance requirements in the field in which are used and checked and certified during the manufacture process of the complex section profile. In this purpose is made a new technology that combine the modern technical analyze software in manufacturing process of the thin complex section profiles with electronic display console on which is visualize the technological working parameters.

The products made on this equipment are used, in general, like resistance pillow or buoyant beams in civil engineering especially at halls with metal structures, home building and in others applications.

The equipment used to manufacture these products, that involves using data from a logistics center equipped with IT hardware and software design and verification constructive steel structures, these in formations are sent to the equipment (also to the similar equipments that used the same technology, if is necessary). The product manufacture and the technical working data display on a fixed to the equipment, from whom it possible to control all the manufacture process.

Market attractiveness of such equipment is based on the following:

1 - The proposed technology that will be used for equipment, guarantees a correct choice of metal structure by builders, giving them a complete analyze which for thin profile is different from the classical structures;

2 - the pillar and beam buoyant made form assembled profiles lids to cut down the montage cost on site, different from technological the classical solutions used before;

3 - the montage of new structures on site, not require changing existing technologies work;

## 2. State of art

### 2.1. Global and national situation in this field of *laminated thin profiles*

Cold laminated worldwide market is constantly developing, regardless of category which we refer: cold rolled, cold bent or cold pressed.

resistance allied with a comparable price per meter. In this way it was removed the restriction to use thin profiles as bearing elements.

Thin profiles that we can find on the international market have many sections, but we can find only 10 of them in portable systems applications, including those with section composed not in Europe, but in America and Asia.

In the last decade, thin-walled profiles industry had the highest rate of growth due to the real-estate boom with 15% each year, in which were used to create thermal isolation systems. This step was largely related to technological improvements made in this field of activity, of which the most in buoyant was the replacement of corrosion protection procedures with other forms of protection. Most effective replacement proved was thin galvanized sheet profiles, with sheet

Currently there is only one company in Romania that produce thin profiles structures, and this company is "GIROMETAL" from Galati. The few existing international brands in Romania, like LINDAB, that have the means to manufacture the buoying systems are not yet interested in any business to start with this field.

### 2.2. Global and national situation in this field of *manufacture technologies and equipment performances*

The most productive systems are using roll lamination in order to obtain simple profiles, this process is particularly recommended for large production series or when is done a profit over 3 m in length. In small series, most profitable are obtained in bending or molding processes.

In all of these cases are dozens of companies in Europe to produce equipments or devices for thin sections, but only a few multitasking equipments, like: SCHRODER-Germany, RICO -Portugal; JORNS AG - Switzerland.

In Romania from the processing equipment industry profiles are made by several companies, as for example "SC EUROTECHNICS SRL", but none of them make composed section profiles. From this point of view, SC FAST ECO offer to be the first to propose a device for composite profiles

### 2.3. Research activities in the field of *thin profiles in Romania*

In Romania the research in profiles with thin walls were made by several research centers, such as: Timisoara "Politehnica" University - who published several books in this area, "Tehnica" University from Cluj-Napoca - Department of Resistance that has made some experimental activities on this types of products; and also by Research Centers like: INCERC – Bucharest, and URBAN PROJECT, in bearing structures expertise activities and approval release.

## 3. Solutions description

### 3.1. Technical and/or Scientific Content

Scientific and technical aspect, the use of thin buoyant profiles made of cold-formed high-strength alloy steel involves **solving outstanding design issues that are not encountered in the design of structures made of ordinary steel profiles**, obtained by hot rolling or by welding plates.

The effect of cold forming by cold-straining, affects physicochemical properties of base material (steel plates) by raising the flow value and the resistance over the profile, resulting in reduction of material ductility.

Also cold forming by rolling, bending or pressing, induce a residual stresses by flexion, which higher at the corners, but with opposite sign comparing with yield factor.

Cross-sectional shapes for cold-formed profiles are of great variety and usually more complex than those of hot-rolled or welded.

The most used are the types are: U, L, Z, C, T, G, and  $\Sigma$ . As you can see, cold-formed sections are usually conjugate and even unsymmetrical, having additional thickening at the ends or on soles, and even intermediate thickening on the middle arias and wide soles.

Cross sections due walls slenderness are class 4 or, at most, downgrading to class 3.

Therefore, the calculation of structures made of these profiles will be always in the elastic domain when the sections view the walls are class 4 but in the same time it is necessary to take in to consideration the buoyant phenomenon and to operate on reducing the geometric features, namely to the transversal effective section.

Forms of local instability and distortion can be considered as global instabilities that are submitted to simple or compound stress (bending, twisting or bending, twisting), giving rise to buckling phenomena that is influenced by geometric imperfections or by type loading, that is dramatically reducing the ability buoyant structural elements.

Therefore, the sizing of simple or complex structures made by thin profiles is necessary to make the stability test of sections made from these profiles.

To achieve thin-walled structures from steel profiles is generally used a specific assemblage technology, calculation and checking procedures are largely different from conventional metal joints used in construction.

Consequently, **the choice of profiles technology implementation, their dimensioning analyses and design are essential operation in order to obtain a safe and effective structure from technical and economical point of view.** Overall conception of the thin walled structures made of cold formed steel sections, the composition of structural elements with simple or complex section, the methodology and details of assemblage, their design procedure is different from conventional metal structures.

From these reasons, for this type of structures is essential to elaborate specific dimensioning and design normative. On national level this normative is STAS 10108/2-1983 – „Constructii civile, industriale si agricole. Calculul elementelor din profile cu pereți subțiri formate la rece”, completed by NP012/1997 – „Normativ pentru calculul elementelor din profile de otel formate la rece” published in Buletinul Construcțiilor no.15/1998. NP012/1997 is the adapted Rumanian technical standards system of for construction steel Romanian, the European standard EUROCODE 3 – Part 1.3 (ENV 1993-1.3/1996). At this normative are referring to thin profiles, in this project it is achieving an dimensioning algorithm that can establish a the geometric shape and dimensions, the maximal loads, the bending and twisting moment verified thro mathematical analyze and simulations, and experimental validation in laboratory. In the end will be integrated in a specific technologic system.

### **3.2. The originality of the project is based on the following:**

#### **a) Regarding the proposed technology.**

Approach the issue of achieving high load buoyant structures (pillars and beams) of thin complex profiles in industrial field and not in the construction, like any metal construction it is required that the chef of the executing team to have a high AQ level, taking in to consideration the risks and the responsibilities, and also the European normative regarding the safety in civil engineering field. This project has an original view, by using in a unique way the virtual analysis techniques, dedicated software and special methodologies The control unit uses the analytic techniques for dimensioning the simple and complex profiles, developed form 1997. These algorithms will be implemented in a specific methodology together with dedicated software, in order to respect the European normative for thin profiles, which is referring to the exploitation safety of this product, EUROCODE 3 – Part 1.3 - ENV 1993-1.3/1996

#### **b) Regarding proposed equipment**

In this project we want to make **three versions for this equipment** that will be able to **manufacture, assembly and verify** the complex profile which will derive from the model proposed in this project, in this way will be possible to be configured this system in accordance with the beneficiary needs in order to manufacture an complex product with high performances;

It follows thus achieving a high precision control methods for those that manufacture this type of large buoyant structures, taking into account the European recommendations regarding construction safety;

Unlike traditional technologies that need more equipment in order to realize the complex profile, our equipment has a multitasking unit, with a unique power unit that is mentioned as Force group.

### 3.3. The innovative aspects

The innovative elements of this project will produce patents proposals that will be relate to:

Developing two new profiles with complex section, similar in concept to proposed **patent registered to OSIM no. A/01009 from 07.10.2011 by SC FASTECO SA;**

Using of the new hydraulic control units in order to adjust the working parameters of this equipment (forces, moments, working speeds). It has applied to the extrapolation of the proposed **invention registered to OSIM no. A/00183-23.02.2011 by IHP Bucharest**, regarding the selection procedure of operating modes at compression units using proportional hydraulic with digital interface;

Developing a new working technologies of this equipment that combine the profile dimensioning program with resistance testing method directly on the machine.

### 3.4. Representative types of the proposed composite profiles to achieve and equivalent their classical solutions.

In Figure 1 are presented as examples four profiles composite model sizes representative: the equivalent section I, square, rectangular and cylindrical whose main features are:

- Form factor (dimensional)  $K_{ab}$  is reduced to 1.5 ... 2 times the  $F = ct.$ ;
- Bearing coefficient (resistance)  $K_{forta}$  increases of 1.5 ... 2 times  $a, b = ct.$

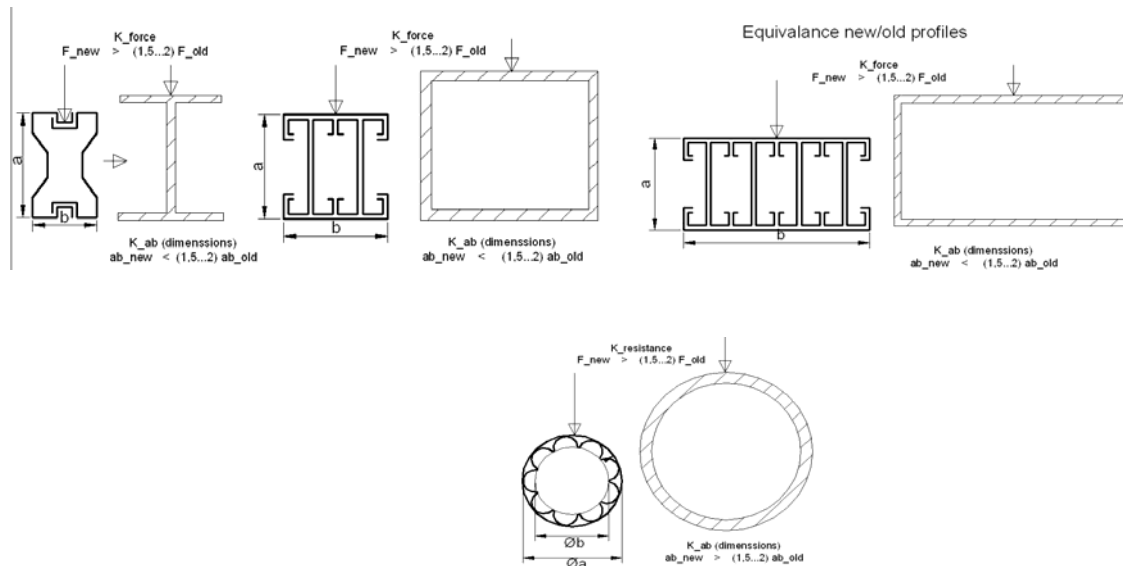


Figure 1

Technological achievement module of these profiles makes the subject of a patent application filed with OSIM of IHP Bucharest and SC FAST ECO SA Bucharest

The principle scheme that underlies the proposed technologies is shown in figure 2

New technology features consists of:

-compound profiling on a single equipment

-equipment ensure the profile test made at performance to required by application.

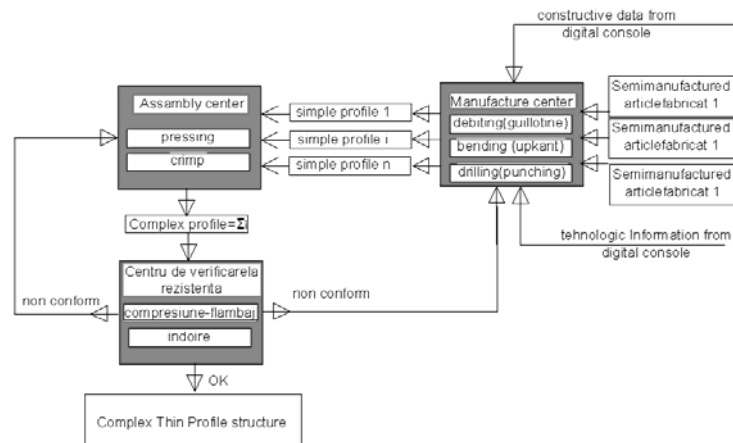


Figure 2

### 3.5. Description of of multitasking equipment to achieve composite profiles

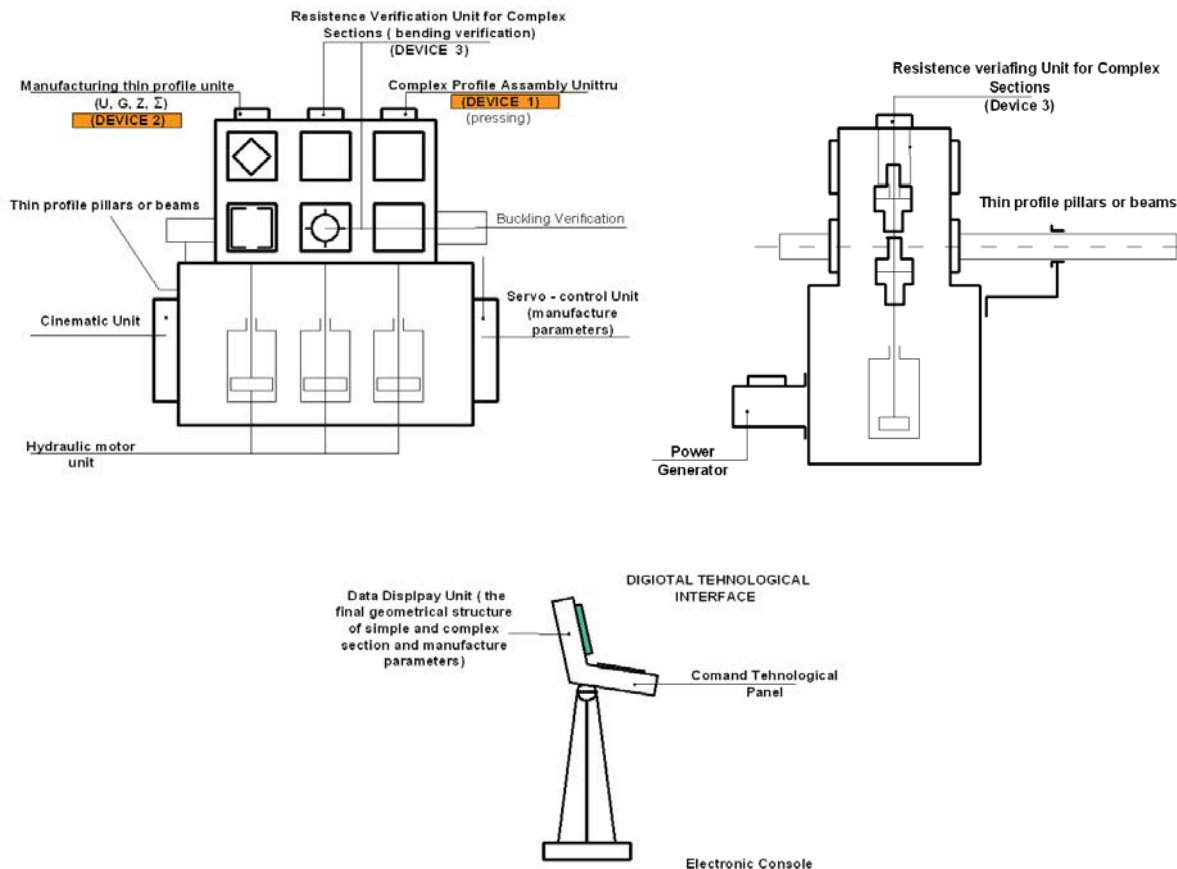


Figure 3

The structure of this equipment is presented in Fig.3 and contains:

Manufacture and assembly complex profile equipment:

Minimum 5 working place with 3 working devices (manufacturing process, assembling and resistance checking);

A power group of 5.5kW, that train a group of hydraulic linear or rotary motors in accordance with technical operation realized by devices that are connected to a mechanical kinematic system;

A control unit with electro-hydraulic classical command meant to select the technological operations;

A control unit with proportional electro-hydraulic in order to establish the working parameters in accordance with technical operations.

- Digital technologic interface;
- Mechanic-electronic consol;
- Data display;
- Data acquisition system;
- Electronic interface with manufacture equipment.
- The dedicated software package:
- Software for optimal constructive section of thin profile;
- Software to establish the working parameters of this equipment (process system).

#### 4. Conclusions

Comparing products that our project intends to develop to those existing on the worldwide market, it can be stated that:

- Thin-walled profiles made are competitive with those existing on the worldwide market;
- The proposed technology will certify from experimental point of view, the right choice of a composed profile.

Products are distinguished from other project of the same kind that already is on the national and international market by the following characteristics:

Have a thin compose section different from those existing that will be manufacture by an multitasking equipment;

The proposed technology will be able to make an easy interface with the operator by means of a digital display, communicating the geometrical configuration of product directly to machinery and the technological parameters. In this way is eliminated the subjective factor in buoyant structure chosen and in this way is increased the exploitation safety factor.

This technology will be able to realize, besides conventional processing and profiles assembly operations and checking.

#### References

- [1] D. Dubina, V. Ungureanu, " Calculul si proiectarea constructiilor metalice cu pereti subtiri formate la rece ", Vol.I. Lindab 2004, Vol.II. Lindab 2007
- [2] Otescu, Popescu, " Cercetari operationale in domeniul materialelor si echipamentelor din constructii ", Editura Tehnica, 1993, Bucuresti
- [3] M. Avram, " Echipamente hidraulice si pneumatice cu mecatronica incorporate ", Editura Tehnica, 2005, Bucuresti
- [4] Euretechnics - Romania - Catalog de masini de indoit profile subtiri
- [5] Holzman – Catalog masini de prelucrat profile