Stage IV. *Experimentations. Comparative study achievement. Functionality demonstration; activities whose description and presentation is done further on were performed.*

Activity IV.1

Drawing up the experimentation plan. Equipment purchase

In January 2008, all the consortium partners had a meeting at ISIM Timisoara headquarters, were the following were analyzed:

- carrying out the activities and reaching the indicators according to the plan for project achievement, until the stage IV;

- setting the measures for finalizing the project and reaching the planned indicators;

- drawing up the experimentation plan.

Experimentation plan

- Achievement of models for special steel welded joints by ISIM Timisoara and ICMET Craiova;

- Thermal stress relief at ISIM Timisoara;

-Stress relief by mechanical controlled vibration at University - Cluj, ICMET Craiova , ICPE CA Bucharest;

- Structural analysis before and after stress relief at ISIM Timisoara;

- Measurement of remanent stresses by photo-elasticity method, at Politehnica University - Bucharest;

- Measurement of internal stresses before and after stress relief, at ICMET Craiova, by drilling method. The partners: Politehnica University Bucharest, University – Craiova , ICPE-CA Bucuresti and VIG SRL participated, too.

Within the project, ICMET purchased by own funds a *"System for measuring the remanent stresses by drilling method"* whose description, operation and used methods are presented in Annex1.

Activity IV.2

- Achievement of welded joints from non-alloyed steels and welded alloys, chosen for experiments

- dimensional measurements and internal stress measurements

Six experimental models (annex 2) of metallic joints got by jump welding, for achieving as high as possible level of internal stresses, were achieved at ICMET Craiova. Internal stress measurement was done at ICMET Craiova by means of RESTAN system, and the results are presented at Annex 3.

Activity IV.3

Estimation of thermal stress-relief cycle influence on structural and mechanical analyzed characteristics

Steels used in achieving the experimental models 16Mo3 and OLC 10 belong to the group of weldable steels used in the construction of metallic parts, with mechanical resistance assured until 400^0C. The experimental program contained distinct phases, regarding the achievement of welded joints by the two steels and also the application of post-welding treatments (thermal stress relief) with a view to assessing the comparative characteristics on welded joints. The assessment of structural hardening was based on the determination of DHVI estimator, whose values below 50% attest the lack of the required local hardening.

By assessing the internal stress levels, correlations related to the positive influence of stress relief cycles (thermal and mechanical) on the operation behaviour of the welded joints could be achieved; the results are presented in Annex 4.

Activity IV.4

Estimation of the influence of mechanical vibration stress relief parameters (frequency, amplitude) on the structural and mechanical analyzed characteristics

Within this activity, specialists from the University in Craiova achieved a mathematic model of the procedure of stress relieving by controlled mechanical vibrations; they determined the mathematic relations between the amplitude and frequency of vibrations transmitted in the parts subjected to treatment and the elastic characteristics of the rubber buffer.

The part which should be stress relieved is placed on rubber buffers, especially manufactured for this. The rubber buffers were assimilated to some connections type Kelvin-Voight. The vibration of the amplitude of the part subjected to stress relief depends on:

- pulsation of the external force, i.e. vibrator speed;
- weights of eccentrics and distances from them to the vibrator rotation axis;
- angle between the two eccentrics;
- elastic and damping characteristics of the buffers;
- weight of the part subjected to stress relief.

At the same time, the phase difference between the forced vibration and the excitation force depends on the excitation pulsation, part weight and characteristics of the buffers where the part is placed.

Vibrator mounting is done so as it should not be parallel or perpendicular to the geometrical boundaries of the part.

Depending on the vibrator slope, the mathematical relations, amplitudes and phase differences of the vibrations on the two axes were determined. A program was developed in Visual Basic, by means of which numerical simulations were done, in tabular or graphic form: disturbing force depending on n and α (phase

difference), amplitude on Ox, Oy depending on part weight, vibrator position to the geometrical boundaries of the part and α, eccentric phase difference.

The full paper is presented in Annex 5

Activity IV.5

Experimentation of methods for internal destructive and non-destructive stress relief, after the stress relief treatments

The system for measuring the remanent stresses - RESTAN – is able to calculate the internal stresses by many programs:

- calculation of internal stresses by Kockelman method. This method may be considered as an approximation of integral method, and is useful because it provides information for a height larger than the diameter of the hole;

- calculation of residual stresses by the power series method. This is based on some simplifying hypotheses and may be considered as an approximation of the integral method;

- calculation of residual stresses by the integral method. This method is able to provide the width distribution of residual voltages;

- calculation of residual voltages by the method from ASTM E D37 – 01.

The program calculates the sums and differences of the measured deformations, ε1 + ε3 and ε1 - ε3, respectively. Each data set is expressed as fraction of their values when the hole height is four times the average diameter of the marks; they are graphically represented depending on the ratio h / d (h –hole height and d – hole diameter). At Politehnica University – Bucharest, measurements of internal stresses by photo-elasticity method were performed. The parts chosen for determining the residual stress level before and after performing the stress relieving were tubes with thick walls manufactured by longitudinal seam welding made of steel 15MO3.

Experimental determinations were focused on setting in parallel the level of residual stresses from specimens taken from thick wall tubes, welded, before and after stress relieving; an important percentage decrease of the internal stresses was found. The full paper is presented in Annex 6.

Activity IV.6

Presentation of functionality and usefulness of the functional models of the welded steel stress relief equipment

The functional model for *"Equipment for stress relieving by mechanical controlled vibrations with a.c. motor, flexible shaft and microprocessor",* achieved within this project, was selected by ANCS for being presented in the Romanian Research and Innovation Exhibition, International Fair – Hanover 2008 and European Research and Innovation Exhibition – Paris 2008.

By the participation in International Fair – Hanover 2008 and European Research and Innovation Exhibition (SERI) – Paris 2008, companies whose activity field is technological transfer, consulting and advising for participating in European programmes FP7 and EUREKA were contacted; ICMET activity, very well exposed

by the Marketing team of ICMET on a CD ROM, was presented to these companies. Having in view one of the present research desiderata, that one of converting the research costs into revenues, 5 pieces of such installations for foreign customers: Promex Braila, Fimaro Cluj, 24 Ianuarie Ploiesti, Meetal Steel Galati, Simrom Sibiu are now in course of development.

The product sheet and the poster presented at Hanover and Paris are presented in Annex 7.

Activity IV.7

Drawing up a comparative study with a view to improving the ecological stress relief procedures and setting the methodology for non-destructive determination of internal stresses

For determining the internal stresses, the photo-elasticity technique and the drilling method (which could be considered a non-destructive method, taking into account the hole size) were used.

Internal stresses were measured before and after the thermal and vibratory stress relief. Experimental results confirmed the soundness of the theoretical hypotheses set within the stage I, namely the decrease of the internal stresses after vibratory stress relief by 50 – 70 %, and by more than 80 % in case of thermal stress relief.

As a result of performing experiments (vibratory stress relief and measurement of internal stresses by drilling method with RESTAN system) at customers, the degree of confidence in this procedure and in concluding contract for this product by foreign customers increased.