ENGINEERING REQUIRES CONTINUING EDUCATION ON FRACTURE

L. Faria [1]

Many ruins due to fracture, fatigue and creep are largely influenced by bad design, bad manufacture and quality control, bad maintenance and misuse. These ruins result in many cases from a lack of knowledge of the basic principles of fracture mechanics.

On the other hand, the advanced research in this area is not immediately transferred to engineers and technicians responsible for design, manufacture and operation of machines, structures and other equipment.

A proposal on continuing education in this area is presented.

1. INTRODUCTION

Although the phenomenon of fatigue has been put in evidence by Wöhler by the end of the XIX century, the scientific base of fracture and of the correlated aspects (fatigue, creep, etc.) begun only to be established in 50's of our XX century.

Since this time this new branch of science developed and improved our knowledge on the behaviour of materials, increasing the reliability of equipments and structures.

The action developed by different organisms, contributed firmly for this knowledge, supported by the research activity of many centers of Universities and State and Industrial Laboratories all over the world. In this aspect the European Group on Fracture has played an important role.

Unhappily the teaching of these matters not always followed the development of this knowledge. This gap

[1] Instituto Superior Técnico, Universidade Técnica de Lisboa, CEMUL (INIC)

or delay is due to many reasons, as for instance:

- the rapid evolution of this new science branch;
- the different interpretation of fracture phenomena;
- the traditional teaching.

So, in many cases, the equipments and structures do not include the more recent developments, do not assure the required reliability, present high manufacturing costs or colapse due to fracture or to other ruin causes.

2. NEED OF TRAINING AND EDUCATION TEACHING

The knowledge of the behaviour of materials requires a non-stop research activity, due to the existance of new materials, to new applications to new working conditions, to the need of a better correlation between the materials structure and their resistance.

So it is important to assure a permanent teaching action for updating the knowledge of people working in industry, for supporting the transfer of knowledge from the research activity to the practical applications. And this is not a easy task for which the participation and collaboration of researchers, professors, engineers, will be required.

To improve the behaviour of equipments and systems, to assure their reliability for the working conditions during the period of their forecast life, the principles of quality assurance should be applied.

As a matter of fact the requirements to prevent the ruin of structures, due to britle fracture, to fatigue, to corrosion-fatigue, to creep or to any other cause of fracture concern many aspects besides the specific behaviour of the material itself, mainly:

- the knowledge of the applied loads, load cycles;
- the forms of the parts adopted in the project and their criticallity;
- the joints adopted in the design;
- the influence of the manufacturing process, originating defects of various shapes, densities, directions;
- the quality control system used and its

effectiveness; the influence of the final inspection;
- the influence of the assembly adopted and the defects created during the transport and erection, if any;
- the maintenance adopted.

In consequence the prevention of fracture should be established in the early phase of designing the system, requiring the establishment of a programme of quality assurance that should forecast the risk envolved, consider the calculation method adopted (deterministic or probabilistic) and all other aspects above mentioned.

To assure the equipments and systems are reliable, corresponding to the quality level predefined, it is required that people envolved in designing, in manufacturing, in quality control, in maintenance be aware of all the problems and adopt and follow the more recent principles and rules.

For this purpose an adequate education system should be adopted, considering the quick evolution of the knowledge and the people to whom this education will be addressed: engineers and technicians recently formed or with industrial experience.

Some suggestions will be presented below, in order to fulfill the needs of training and education above mentioned.

3. INTENSIVE COURSES

In many engineering courses (undergraduate level) the fracture is taught, but usually it is not given a global view of the problems the students will face during their engineer's career on the point of view of safety and reliability of machines and equipments and of safety of workers.

So, an intensive course (saying 1 week, 35 hours) during which the review of the fracture mechanics principles, the teaching of probabilistic and deterministic design of machines and structures and corresponding reliability, the learning of risk analysis and of the principles of quality assurance applied to design, manufacturing and maintenance, will give to the students in their last year this required global view.

Similar courses, but intended to engineers with industrial experience, should also be taught for updating their knowledge. These courses will give the more recent developments on the behaviour of materials and structures, allowing an effective transfer of knowledge from research to industry. These courses can be organized in a modular way having in attention to whom they are addressed: designers, manufacturers, quality controlers, maintenance engineers; and also considering the type of equipments and the materials used in their manufacturing for instance, handling equipment, vehicles, airplanes, turbines, industrial equipment for mechanical industries, steels, polymers, composites, etc..

4. POSTGRADUATE COURSES

For training and educating people required for research and for teaching, postgraduate courses - level Master of Science, or equivalent - are more adequate, and could lead to a doctorate degree for those interested in attained this degree.

This postgraduate course will introduce in the engineering curricula at the Universities the knowledge concerning the new developments on the behaviour of materials and their influence on design, manufacturing, quality control and maintenance leading to assure or improve the reliability of machines and structures. The course could teach topics, such as:

- new developments on fracture mechanics;
- statistics applied to quality assurance;
- mechanical and metallurgical behaviour of conventional and new materials (allied steels, ceramics, polymers, composites, etc.);
- quality assurance principles applied to design, manufacturing, assembly, maintenance and control;
- influence of manufacturing processes in quality;
- new principles and procedures of quality control;

The students will present at the end of the course a thesis on a research or applied topic.

The course will take in principle one semester, the second semester being dedicated to the thesis. The mobility of students should be foreseen, allowing the

students to start the 1st semester in an University and to conclude the course - 2nd semester for the thesis - in another University.

5. SUPPORT OF THE PROPOSED EDUCATION

To support the education action above described the author suggests:

- the patronage of EGF, with the collaboration of the different committees and tasks and working groups;
- the finantial support of ERASMUS programme, as the proposed action foresee the mobility of students and teachers from the Universities that be willing to adhere to this education action;
- the support of the University of Europe (headquarters in Paris) as soon as the postgraduate course is recognized as an European Master Course;
- the support of the Joint Research Centers (ISPRA and PETTEN), from EEC, mainly for the intensive courses and for the thesis of the postgraduate course on the financial and organizational point of view;
- last but not the least, the support of the Universities and research centers of the European countries and of their professors and researchers.