Increasing Role of Material's Engineer and Technologist in the Automotive Industry.

U. L. Businaro

Fiat Research Centre S.p.A. - Torino, Italy

1. – Introduction.

The ability to use materials at their optimal conditions has always been the key to a successful development of durable low-cost products, flexible for a variety of user missions, such as cars and commercial vehicles.

This notwithstanding, the frontiers of materials science have been pushed forward more by the application problems for other products such as aircraft, nuclear reactors, chemical plants. The automotive industry sector has taken advantage of the development in materials science in other fields by transferring available know-how with a lot of « prudence » based on the engineering judgement of long experience on vehicle testing.

This situation is partially due to the lack of incentive to depart from « good enough » solutions, but it is also dependent on the fact that the optimal design of a road vehicle is a very complex problem, less suitable for a detailed analytical approach than, for instance, the design of an aircraft.

For comparison's sake, let us take the use mission: for aircraft it is well defined in terms of number of take-offs and landings, and of cruiser speed. In a road vehicle the variability of user's needs, road surfaces, sudden brakings, accidental terrains, etc. is such that each manufacturer considers as a highly proprietary information the testing procedures to which new models have to be submitted, cumulating hundreds of thousands of kilometres before deliberating them for commercialization.

There are now evidences that in the next future the automotive industry will contribute much more directly in advancing the state of materials science and engineering. In fact, « good enough » solutions are no longer compatible with the objective to drastically reduce the fuel consumption in vehicles, while maintaining high flexibility of use and high performance (as measured in accelerating capability, comfort, safety).

In the next ten years fuel consumption will be halved with respect to today average cars, by reducing the aerodynamic and rolling resistances, the loss for nonrecuperable kinetic energy in braking and by improving the efficiency of the vehicle's power plant.

Optimal material's use is mandatory to meet this objective, because of the need to reduce vehicle weight, to increase temperature for better thermodynamic efficiency in engines, to reduce friction and wear.

In fig. 1 and indication is given of the effects of weight reduction on the fuel economy in a typical car, according to the different use missions.

To better focus the increasing role of the material's engineer and technologist to meet the ambitious innovation targets of the vehicle industry in

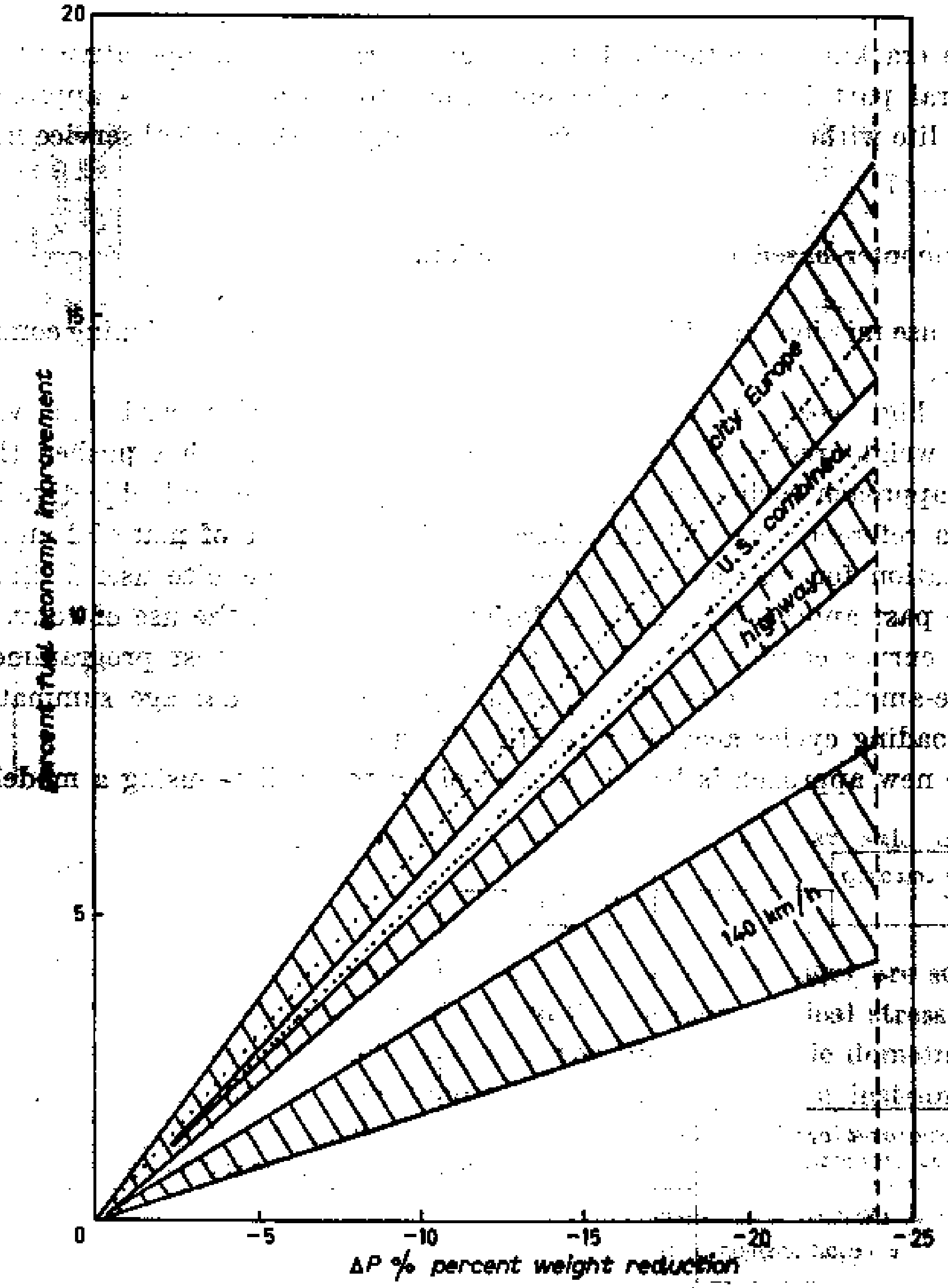

Fig. 1. – Effect on fuel economy of car weight.

the next decade, three cases of increasing complexity will be presented here:

computer-based fatigue life prediction for optimal materials use in vehicle mechanical components and body structure,

optimal choice of light alloys and process technologies in engine of increased thermal and mechanical performances,

new ceramic materials development and the related probabilistic design approach with high-confidence-level quality assurance.

Common to all the cases is a basic change in design philosophy: from a « safe-life » approach (*i.e.* design with a built-in safety factor so as to ensure that no cracking initiation will take place during all the operative life of the structural part in every service condition) to a « useful life » approach (*i.e.* a given life without failure is assured depending on the typical service mission).

2. – Computer-based fatigue life prediction.

The use mission variability is of particular relevance in designing commercial vehicles.

The high cost of vehicle experimentation, together with the value of vehicle weight reduction in terms of increased pay-load, has pushed the analytical approach earlier than the fuel economy improvement objective in cars.

As a reference we will, therefore, consider the case of material and design optimization for rear axle housings of trucks with definite useful life.

The past approach for fatigue design was based on the use of conventional fatigue curves combined with experimental data from test programmes with variable-amplitude stress blocks, applying the linear damage summation for single loading cycles according to Miner's rule.

The new approach is based on the ability to predict—using a model which

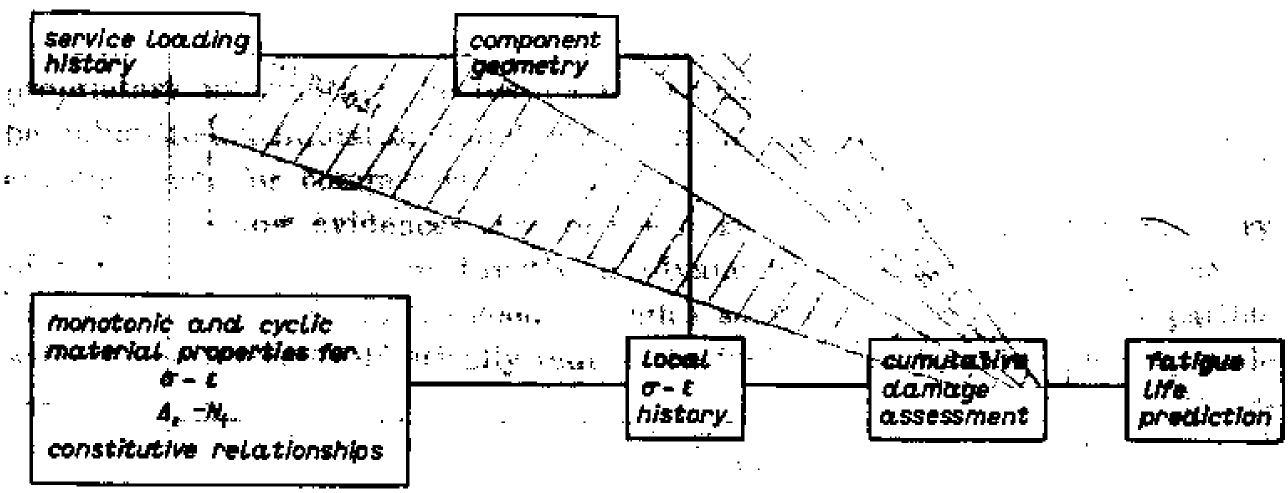

Fig. 2. – Flow chart illustrating the procedure for fatigue life prediction.

— omissis —