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STRESS-FREEZING PHOTOELASTICITY AS A DESIGN TOOL - STATE OF THE ART AND OUTLOOK FOR FUTURE

Photoelasticity is one of the oldest engineering methods of experimental stress analysis. Its first engineering application could be dated back to 1913 when photoelasticity was used to analyze stress in a new design of the bridge across river Seine in France. The major breakthrough is connected with names Opel, Monch and Kuske who in 1936 discovered the stress-freezing phenomenon.

Stress-freezing photoelasticity has been unique among the experimental methods because the information related to the stress in every point of the model is stored permanently in the stress-frozen model. The way how this information is decoded, depends entirely on the scope of the study and can be completed at the discretion of the analyst. Stress-frozen fringe pattern does not relax or change with time. This permits developing more detail information or changing the decoding strategy if this is deemed to be necessary during the course of the study. The method permits an analysis of the stress distribution even in areas not accessible for an installation of conventional sensors.

Despite its uniqueness the use of stress-freezing photoelasticity declined in late sixties and early seventies. The reason was simple - its cost. The traditional approach, machining the model from the block of precured photoelastic material was time consuming and therefore expensive, not taking into consideration the fact that some configurations of the components could not be machined at all. The development of the fast curing strain-gage cements together with greatly reduced prices of strain-gages took off all incentives of using photoelasticity. Why machine a three-dimensional photoelastic model if a metallic prototype could be machined in the same time-frame and for the same or even lower price?

If any method of stress analysis is to be efficient in the industrial environment, it must be capable of providing a feed-back for a designer during an early stage of the design process. The results of the analysis have to be available long before the prototype is built because redesigning the component within the restricted envelop is extremely costly and difficult.

This presentation outlines the results of a long effort to transform photoelasticity into the responsive and cost-effective design tool.

The new methodology of three-dimensional photoelasticity, which transformed it into the method competing very successfully with finite elements method is presented in detail. The chemical composition, processing, and properties of two new fast curing photoelastic materials which do not exhibit "rind effect" are described. The new method of preparation of special molds for casting photoelastic models, a chemical composition and properties of the mold making materials are also described in detail. The methods of slicing, measurement of fringe order, and evaluation of stress in models are reviewed together with the description of the new equipment developed especially for an application of stress-freezing photoelasticity in the industrial environment. The assessment of some new methods of an evaluation of fringe pattern is also offered.
This new methodology is presented in detail using results of an actual application of the method in the design process. The detail timetable, outlining the time needed to accomplish various steps of the procedure, is also provided.

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