



Failure of a heavy-duty hydraulic cylinder and its fatigue re-design

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ABSTRACT

The unexpected in-service failure of a heavy-duty hydraulic cylinder motivated the present investigation. The combined use of fracture mechanics concepts and of the finite element method demonstrated that part failure was due to the specific weld joint solution between cylinder and end-cap and the fatigue life predictions correlated with the estimated service life before crack detection. Alternative designs involving modified end cap geometry were developed and demonstrated to achieve a considerably longer operational life.

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1. Introduction and motivation

A hydraulic cylinder (also called a linear hydraulic motor) is a mechanical cylinder that is used to give a linear force through a linear stroke. Hydraulic cylinders get their power from pressurized oil. Hydraulic cylinders are frequently found in equipments and machinery, such as construction equipment (excavators, bull-dozers, and road graders) and material handling equipment (fork lift trucks, telescopic handlers, and lift gates).

The relative product simplicity, long industrial experience with its use and the large number of manufacturing companies with strong competition reduce the design phase to some standard considerations and previous service experience is often the indirect validation of the design solution.

In some instances, however, a combination of unexpected factors may reveal a potential criticality of the product that requires quick action to overcome the crisis and solve the problem. Such a situation was dealt with by the authors and is summarized in this contribution. A company producing heavy-duty cylinders was called upon by a customer to explain an unexpected and premature cylinder failure by fatigue. Since many identical parts are currently in operation worldwide, the objectives of the activity summarized in this paper were: (i) explanation of the unexpected failure and evaluation of probability for additional failures; (ii) demonstration that the part failure could be predicted and (iii) development of improved and alternative designs to achieve a considerably longer operational life.

The paper is organized as follows: initially the hydraulic cylinder under investigation is presented in terms of structure, function, geometry, material, service load, fabrication, and design details that are critical under fatigue loading. The current design is assessed and the motivation for criticality demonstrated by calculation. Alternative designs are proposed that maintain the critical detail but achieve a considerably longer service life.

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