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New Techniques for Recording Data from an Operating Scotch Yoke Mechanism

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ABSTRACT

During the development phase of a new Scotch yoke compressor it was useful to retrieve strain data from the rotating and reciprocating components. A new "grasshopper" mechanism was developed which follows the Scotch yoke and controls the motion of the strain gage wires. The controlled motion causes mostly torsional and minimal bending loads to be applied to the strain gage wires. This controlled motion vastly increases the mechanism's data recording life and reliability as compared to previously applied techniques.

INTRODUCTION

This mechanism was developed in order to determine the magnitude as well as the timing of forces and stress in the SF compressor yokes (See figure 1). During the conceptual design phase, computer simulations [1] had shown that side forces on the pistons and hence stress in the yoke could be of concern (See figure 2). Potential high stress areas in the yoke were determined by the use of a finite element model (See figure 3). Strain gages were applied to the yoke at locations deemed sensitive to stress. The strain gage wires were then attached to the "grasshopper" mechanism and finally led out of the housing to signal conditioning and recording equipment.

"GRASSHOPPER" MECHANISM

The mechanism [2] is basically a specially designed 3 or 4 bar linkage (See Figure 4). The linkage is designed to prevent the wires from bending which would cause rapid fatigue and failure. The wires are imbedded in channels along the links. Gradual ramps at each end of the linkages curve the wires to enter and pass through the hollow centers of the revolute joints. This causes the wires to be in torsion, but not bending, when the joints rotate. Strain gage lead wires have considerably more fatigue life in torsion than in bending.

Several important considerations should be addressed when designing this mechanism. First, kinematic optimization studies should be conducted in order to determine geometries which limit the rotation a given set of linkages move through. In other words, design a set of linkages whose joints should rotate as little as possible. Less rotation means longer wire life. The SF "grasshopper" mechanism was designed with a custom developed linkage simulation with graphical output to facilitate interference checking. Second, mechanisms which have minimal joint rotation tend to have movements which can result in collinear linkages which can cause "over center" conditions. Bias the mechanism so it can only move in one way. Third, the mechanism should be as light as possible so as to minimize effect on the target mechanism's dynamics. The compact design of the SF compressor insured the small size and mass of the mechanism but in other applications this constraint might be relaxed. Fourth, strain gage or transducer wires should be made of the smallest stranded gauge available. Solid wires fatigue quickly.

RESULTS

The mechanism proved to have adequate life (approximately 8 hours) for calorimeters or load stands to reach equilibrium. Strain gage data was recorded which verified the force timing and stress magnitude predictions of the compressor simulation and finite element model respectively. Figure 5 shows a strain versus crank angle history. Timing of the maximum predicted side force and the maximum experimental strain both occur at approximately 54 degrees BTDC.

CONCLUSIONS

A "grasshopper" mechanism has been developed which allows data to be retrieved from a rotating or reciprocating mechanism in a reliable manner. The mechanism can be designed and fabricated with reasonable ease. The mechanism has also been successfully applied to internal combustion engines [3].

REFERENCES

1) Gatecliff, G.W. , "Analytical Analysis of the Forced Vibration of the Sprung Mass of a Reciprocating Hermetic Compressor, Including Comparison with Experiment", Purdue Compressor Technology Conference, 1974, P221.

2) Private Communication, Professor Donald Patterson, University of Michigan.

3) Private Communication, Todd Carpenter, Senior Research Engineer, Tecumseh Products Research Laboratory.

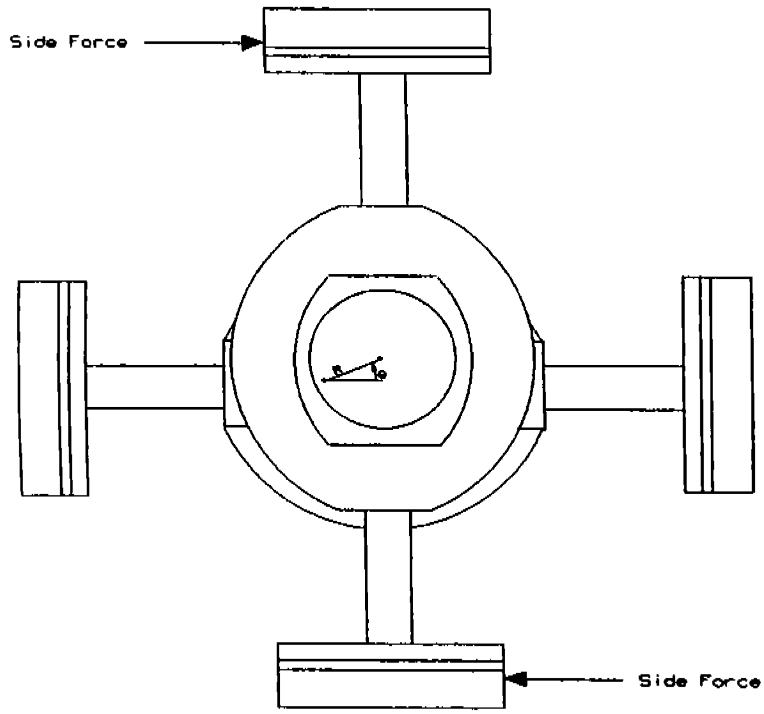

Figure 1 Schematic of Scotch Yoke Mechanism With Piston Side Force

Figure 2 Piston Side Force Versus Crankangle

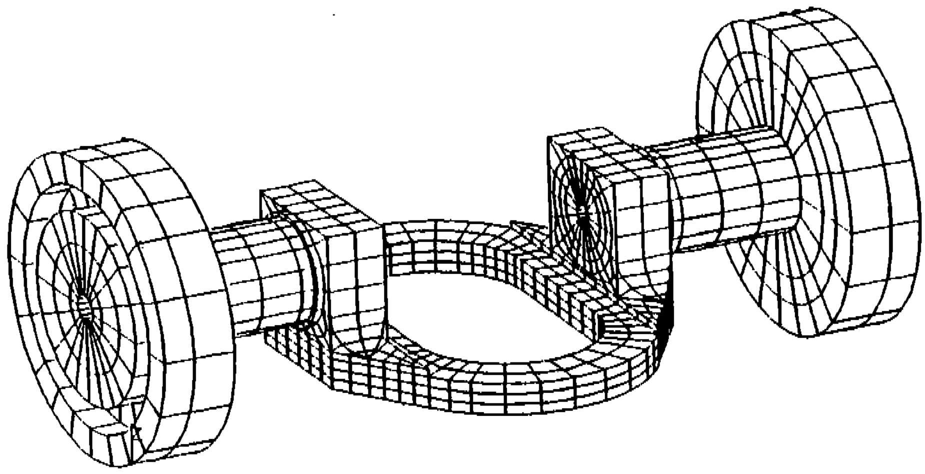

Figure 3 Finite Element Model of Scotch Yoke

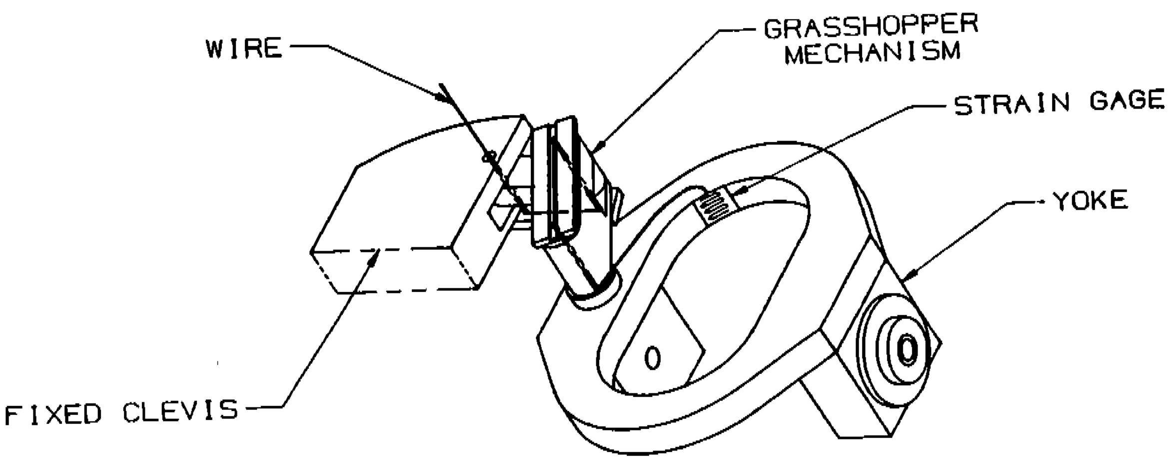

Figure 4 "Grasshopper" Mechanism Attached to Scotch Yoke

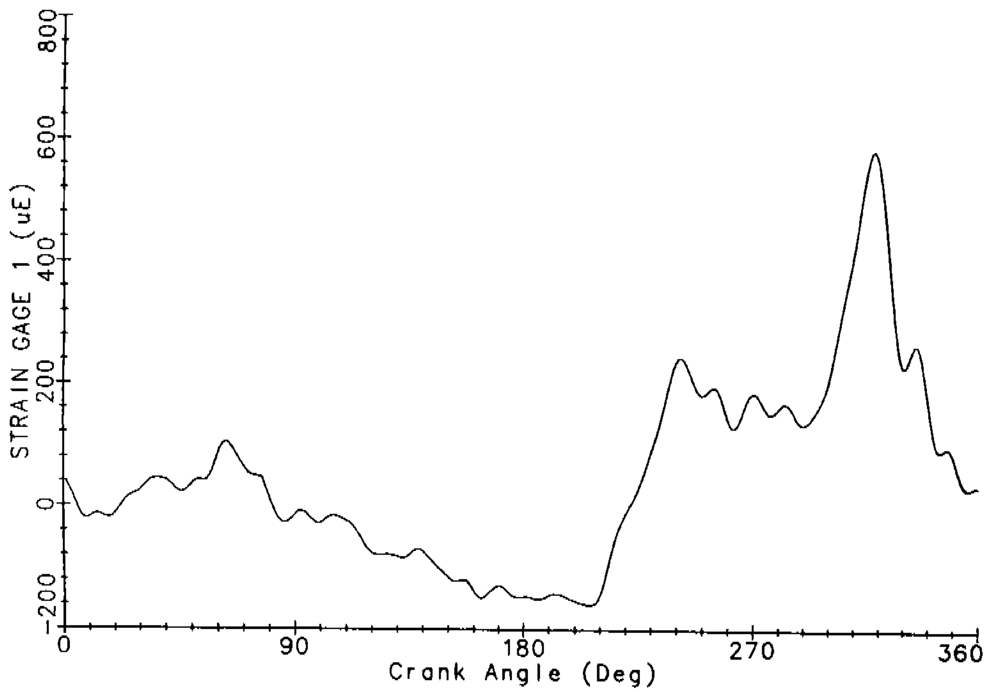

Figure 5 Strain Versus Crankangle