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Introduction

In the summer holidays of 1992, I worked in the Tribology group in the department of mechanical engineering at Imperial College, University of London where I had just completed the 2'nd year of my Physics degree. The group were concerned with lubrication and my particular task was to test the viscosity of synthetic lubricants. The lubricant had to be heated to 250 degrees centigrade and have oxygen bubbled through it, then I had to take viscosity measurements every 30 minutes until the lubricant gave up and became solid. The first problem was that the viscometer was on the 3'rd floor at one end of the building, and the fume cupboard where the bubbling took place was on the 7'th floor at the other end of the building. There was therefore a certain amount of walking up and down involved, too much for my liking. The second problem was that if the lubricant solidified during the night then I had no idea at what time this occurred, and had to start the experiment again trying to time the start so that I would be around when I thought it might solidify. Measuring the viscosity was also a tedious process.

Simple Viscometer

My solution to these problems was to automate. A motor stirred the lubricant using a glass rod indirectly coupled to the motor via a small spring. A contact on the mechanism ensured that the motor speed was just sufficient to keep the tension in the spring constant. Charting the voltage on the motor gave a measure of the viscosity. There was also a timer so that stirring wasn't continuous (which would possibly interfere with the experiment): instead a quick stir took place every half hour or so. In between, a sample and hold chip held the last motor speed so that the chart recorder drew a continuous line. The controller circuit board for this automatic viscosity measurement system is pictured (below right), and the circuit diagram shown below left.

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This machine was surprisingly useful and accurate. Unfortunately it took a while to build (in between all my running up and down the length of the mech eng building with lubricant samples). It was only finished the week before my holiday came to an end, so wasn't much practical use in the experiments which were almost over. However my appetite was whetted and ideas abounded concerning possible improvements. In the final year of the Physics degree an optional practical project could be chosen, or replaced by two lecture courses in theoretical subjects. A list of suggested projects was available, or you could propose your own. I thought a microprocessor controlled viscometer improving on my simple mechanism would be an ideal project and duly proposed it.

Over the following 9 months or so I spent a vast amount of time hunched over a lab bench in the tribology lab, trekking back and forth to the other side of the college campus to the Physics department for lectures. A more advanced mechanism with optical rotation speed and angular 0-180 degree displacement measurement was machined to my specification by a technician in the physics department. I designed and built a Z80 computer to control the motor, make measurements and do the calculations. Then came the software to control everything: all written in Z80 assembly language, using an assembler in my ZX Spectrum home computer. Once assembled the machine code was sent into the EEPROM of the viscometer computer via a short cable from an interface I built which plugged into the back of the ZX Spectrum. The software had to control the motor, read pulse widths from the optical measurement system, read the numeric keyboard and store and display results. I had to write a set of floating point arithmetic routines, and a least squares best fit approximation algorithm to determine the viscosity. Not surprisingly this huge development effort took the majority of my time in that 3'rd year. I was though rewarded, eventually, by a successful and perfectly working project. The write-up below was completed only 3 days before the first final examination in my chosen theoretical subjects.

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Development of a portable, automatic, microprocessor-controlled viscometer

Abstract

The theory of viscosity measurement is considered and development of a portable, automatic, microprocessor-controlled viscometer described. Experiments to verify correct operation, establish the instrument's accuracy, and investigate the temperature dependence of viscosity are presented. Full circuit diagrams, program listing, and engineering drawings may be found in the appendices.

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{gallery}viscometer/2{/gallery}

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Development of a portable, automatic, microprocessor-controlled viscometer

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