Save Time and Increase Profits by Improving the Performance of Your GC Oven

Technical Note 001
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Zip Scientific   Fast GC
Good People, Top-notch Products and Excellent Service

Introduction

GC test methods and equipment are an integral part of nearly every field of chemical testing. A scientist might view GC as a very mature endeavor because both theory and practice are well understood. A lab manager, however, sees his fleet of GCs as a financial resource because test results and sample analysis generate revenue. As a result, managers are always on the lookout for faster and more cost-effective ways to streamline operations and maximize the earning potential of their equipment. Fast GCs, new methods, techniques and accessories that can achieve higher sample throughputs are important tools for attaining higher profitability.

Oven performance plays a major role in the ability to process samples faster and maximize GC earning potential. Thermal agility is a term that describes the ability of an oven to heat up and cool down fast. Both steps comprise the complete cycle time and together determine sample throughput. GC manufacturers continue to develop improved oven designs in this regard. Additionally, new technology has also become available to significantly enhance the thermal agility of both new and older GCs. Fast temperature programmers that employ accessory heaters can boost temperature programs dramatically. Fast oven cool-down accessories are now available that can shave minutes from oven cool-down times.

Fast Oven Cool-Down

The GC Chaser is designed to speed up the cool-down step prior to the next sample injection. Shown in Figure 1, the GC Chaser consists of a centrifugal blower connected to the GC oven and controlled by an electronic circuit. The unit can be placed on either side of the GC, mounted on a shelf behind the GC or simply placed on the floor. The flexible aluminum duct slides onto the blower box and can be adjusted from 2.5 to 8 feet long. A GC specific flow adapter slides into the GC oven intake vent and the duct is placed onto the adapter. The blower augments the oven ventilation process by pushing ambient air into the intake vent of the GC oven. Several minutes can be saved simply by increasing the airflow

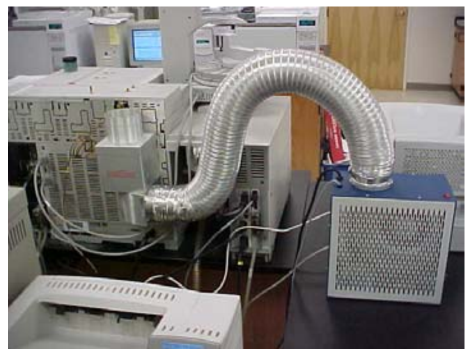

Figure 1. GC Chaser installed on an Agilent 6890 GC/MSD.

through the oven in this manner. The interface from the GC Chaser (and/or the GC Racer) to the GC is highly innovative and surprisingly simple. A current transformer, as shown in Figure 2, is installed around one of the oven heater wires in the back of the GC. That's it! The electronic circuit contained in the Blower Box monitors the GC activity be sensing the current applied to the oven heater. Basic logic programmed into the circuit determines when the blower should turn on and cool the oven down. The blower turns off automatically when the starting temperature is re-established at which point the next sample is processed.

Figure 2. Current Sensor

Fast Temperature Programming

The GC Racer is a fast temperature programming device that seamlessly integrates into existing GCs. It features fully automatic operation. The new programming rates are entered through the GC keypad or GC operating software already in use. As depicted in Figure 3, the GC Racer includes an accessory convection heater that is placed on the floor of the GC oven. The heater wires are passed through oven cutout holes to the top of the GC.

Figure 3. GC Racer Heater placed on the oven floor.

Modified column hangers are supplied to position the column for optimal performance. Sufficient space remains for two columns. Chromatographic integrity is maintained because standard capillaries are connected to the injectors and detectors in the same manner as before, i.e. no special columns or interfaces are required. The circuit is housed in a control box that is placed on top of the GC. The heater wires are easily connected to the circuit with banana plugs. There is an on/off switch, a power light and a heater activity light that indicates that current is being applied to the heater. The interface from the GC Racer (and/or the GC Chaser) to the GC is highly innovative and surprisingly simple. A current transformer, identical to that previously shown in Figure 2, is installed around one of the oven heater wires in the back of the GC. That's it! Whenever current is applied to the GC oven a signal is sent to the GC Racer control circuit and it applies a proportional amount of current to the accessory heater. In one simple and easy step the heating power of the oven has been doubled.

Experimental

Fast temperature programs and accelerated cool-down cycles were performed with a GC Racer and GC Chaser (Zip Scientific, Hudson NH) fitted onto an Agilent 5890 or 6890 GC (Agilent Technologies, Wilmington Delaware). Capillary columns and chemical standards were obtained from Restek Corp, Bellefonte PA.

Results and Discussion

Fast Temperature Programming

Some sacrifice in performance must be made in order to speed up a separation. This can come in the form of reduced sample capacity with the use of microbore columns or loss of resolution in the case of fast temperature programming. Sample capacity is important because enough sample must be injected in order to detect trace level analytes without overloading the column. Conversely, the separation suffers if critical peaks are not sufficiently resolved as a result of fast temperature programming. Fortunately, capillary columns are so efficient and peaks are so well separated that some loss in resolution is acceptable. Fast temperature programming is an attractive approach to higher sample throughput for many methods.

All manufacturers feature air bath GC ovens and convective heating is the predominant means of running temperature programming. There is a small segment that employs resistively heated columns for either portability and/or fast temperature programming at rates mare than 1000 degrees per minute. The convective accessory heater featured in the GC Racer is comparatively slow at 120 degrees per minute. These rates, however, are sufficiently fast to result in significant sample throughput improvements without much loss in resolution. On the other hand extraordinarily fast ramp rates can ruin the separation and can result in co-elution problems for many peaks of interest.

The following points highlight some of the advantages of the GC Racer compared to other FTP accessories.

1. Easy to implement: Installs in minutes and uses standard columns from any vendor.
2. Chromatographic integrity: Zero dead volume. Does not require specialized columns or interfaces to connect to the injector and detector.
3. Fully integrated: Is fully controlled by the GC keypad or operating software.
4. Completely transparent: no operator training required.
5. Rugged: Employs the same type of "hot wire" heater used in the GC oven.

6. Utility: One system can be used for dual column GCs.
7. Versatile: can run on 110 - 240 V and installed on GC running on 110 – 240 V.
8. Cost: One-fifth the purchase price and no expensive specialized columns.

Many test labs use GC to analyze hydrocarbon samples. Figure 4 shows the separation of a collection of even numbered hydrocarbons ranging from C8 - C40. The conditions were:

GC Conditions

- *GC Chaser and GC Racer installed on Agilent 5890 GC/ 5971 MSD*
- *Column: Rtx-5 10M X 0.25 mM X 0.25 uM*
- *Carrier: He at 80 cm/sec constant flow*
- *Injector = 325°C, Xsfer line = 350*
- *Detector: MSD operating SIM at 57 amu*
- *Temperature Program: 40°C (1 min) to 350°C at 60 °C/min hold 1.3 min*
- *Inj 1 uL splitless (purge on at 45 sec)*
- *Sample: Florida PRO C8 - C40 in hexane*

The run time is 7.5 minutes including a short bake out after C40 has eluted. The first peak C8 is well resolved from the hexane solvent front which is not seen because the ion source is not turned on until the solvent front passes.

Fast Oven Cool-Down

Shaving minutes from the cool-down time can benefit many GC methods. There is no impact on the separation, therefore, methods do not have to be re-validated. Historically, liquid CO_2 has been used to cool ovens down fast. Two problems have prevented this method from wide spread acceptance. First is the cost of maintaining an inventory of liquid CO_2 tanks. Second is the tedious task of constantly changing the tanks. The result is that lab managers have opted to purchase additional GCs when faced with increased testing demands. The GC Chaser speeds up the cool-down step significantly without using any consumables such as liquid CO_2. Instead, it uses room air to enhance the ventilation performance of the oven during cool-down. Since the system runs completely unattended all costs associated with purchasing and maintaining liquid CO_2 inventory and changing tanks are eliminated.

The typical time savings are shown in Table 1. Cool-down times depend on the ambient temperature and the ventilation conditions surrounding the GC. Sometimes GCs are installed on a bench top where the space behind the GC prevents good circulation of the vented air from the oven. Outlet vent ducting can also cause some restriction of vented air. The GC Chaser circumvents these problems by blowing room air through the GC oven's normal vent system. The cooling times are significantly reduced because the ambient air source is not close to the exhaust vent and it is a forced flow that overcomes any restrictions caused by surroundings and/or exhaust ducting.

Data shown in Table xyz were obtained from a GC operating under optimal conditions, i.e. on an open bench without an exhaust duct. In many cases the real world installation will not be optimized and the time savings should be greater than depicted here.

Table 1. Typical Time Savings for Common Cool-Down Temperature Ranges

Temp Range (°C)	Time Savings (min)
220-32	7.3
350 - 40	6

When the GC Chaser was used together with the GC Racer the total cycle time was reduced from 34.0 minutes to 12.5 minutes from injection to injection. As a result productivity was increased from roughly 2 to almost 5 samples per hour.

Conclusion

The GC Racer and the GC Chaser provide an easy way to significantly increase productivity without the costs of new GCs and support equipment such as columns, autosamplers, computers and syringes. They can be used alone or together on most conventional GCs, including the Agilent 5890, 6890 and 7890. Each can be operated alone or in tandem as situation dictates. Each system augments the performance of the GC in a manner consistent with the GC design. The GC Racer's convective heater doubles the heating power of the GC regardless of the operating voltage. A 240V GC coupled with a 240V GC Racer can run 120C/min up to 300 C. The GC Chaser's centrifugal blower augments the ventilation system of the GC and dramatically reduces the oven cool-down time.

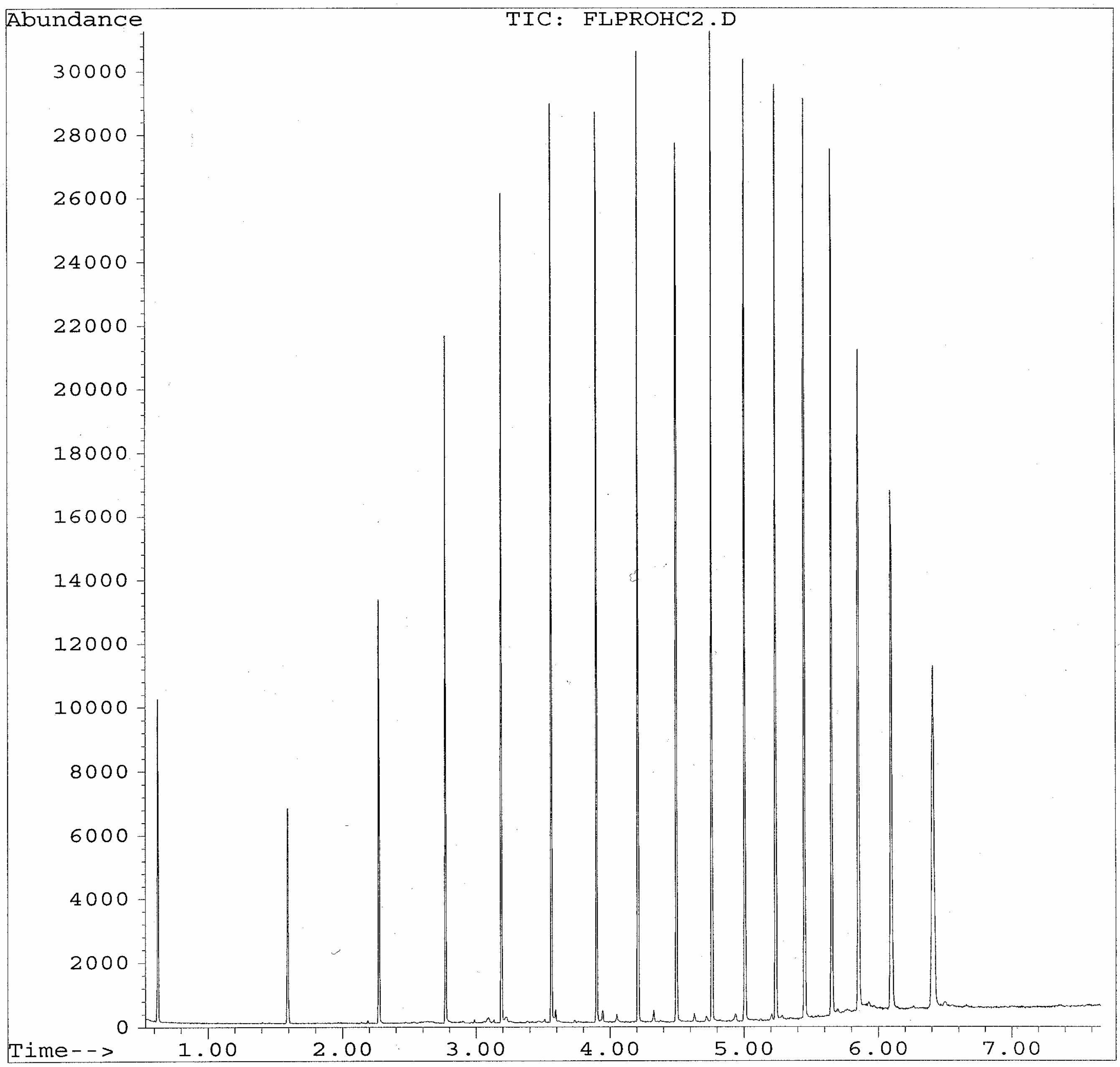


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Figure 4. Fast Temperature Programmed Run of Hydrocarbons