EPNER TECHNOLOGY

PILOT LINE INFRARED FLASH-OFF OVEN

EFFICIENCY COMPARISON TEST REPORT

PREPARED FOR

FORD MOTOR COMPANY

WIXOM, MICHIGAN

AUGUST 13, 1992

EPNER TECHNOLOGY INCORPORATED

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TEST OBJECTIVES

The purpose of the experiment was to determine the efficiency gain in an automobile paint curing tunnel by the conversion of the tunnel's oven walls from the aluminum, as originally manufactured, to Laser Gold ™, a proprietary, electro-chemically applied cladding over polished steel.

BACKGROUND OF THE TEST

Laser Gold is a development of Epner Technology Inc., a New York based high technology plating company. The coating was originally intended as a hard (i.e. cleanable) ultra-high reflective finish for infrared optical guidance missile systems and for IR reflective components on devices designed to defeat heat-seeking missiles, (IR counter-measures), and continues to be specified on these programs.

Because of it's ultra- high IR reflective efficiency, combined with it's hardness, Laser Gold is the sole material designated as an Infrared Calibration Standard by the NIST, (formerly, the National Bureau of Standards).

During the five year period prior to the Wixom Test, Laser Gold had been installed in some twenty similar IR ovens in both General Motors and Chrysler assembly plants. Laser Gold was specified for those ovens based solely on the spectrophotometer reflectance curves of Laser Gold vs. polished aluminum and/or polished stainless steel. (Exhibit #1)

TheFacilities Engineering Group of the Ford Motor Company funded an actual A-B comparison with the *reflective efficiency of the oven wall material being the only variable.* This before - and-after test was performed in the same oven, heating the same body, of the same color, and at the same KWH consumption .

STRUCTURE OF THE TEST

The oven used for the test was built by Thermal Designs and Manufacturing, Inc.. Novi MI. (formerly, Thermal Devices). It is 22 feet long (6.7 meters) heated by some 256 medium wavelength IR emitters, 7 feet (2.13 meters) long.

Each lamp envelope has a thin gold coating on the rear reflecting surface applied by a different process. This functions as the primary reflector in the system. The SCR's were controlled by an industrial computer operated by Don King of Northwest Technical Inc.

The installed power base is 500 KW. and the oven power is divided into three zones; roof, sides and rockers. For this test all zones were equally powered.

The test vehicle was a white, previously painted and cured,Lincoln Continental body. Temperature sensing probes were placed on the deck, roof, hood, doors and in a position to measure ambient air. Five probe readings were used to determine average peak temperature which in turn was used to determine efficiency gains. Since this was not a convection oven, probe #1, measuring "ambient air" was ignored.

Probe #5 for the left door indicated erratic results during two of the tests. For the efficiency calculations that follow, the faulty temperature readings for the left door were ignored and were assumed to be identical to those of the right door, when making these calculations. (This was shown to be true from tests where the probes were functioning properly.)

Two tests were run with the oven as originally configured, i.e. with aluminum oven walls. Epner Technology personnel then installed the Laser Gold coated panels in the oven behind the infrared emitters and the test was repeated.

It should be kept in mind that only 80% of the oven was converted to Laser Gold. as some of the Gold clad panels required to convert the complete oven were lost in transit. NO ADJUSTMENTS TO THE DATA WERE MADE TO REFLECT THIS HANDICAP.

Julian Ninichuk, an executive at the Detroit Edison power company, monitoring a dedicated watt-hour meter directly on the oven power supply, calculated the KWH consumed during each test.

After each run, the data were downloaded into the computer and the graphs plotted. (Refer to Exhibits 6,7,8 & 9).

Test time in all cases was 15 minutes and an ambient temperature of 70° F. (21° C.) was subtracted from all chart temperatures so that only the temperature DIFFERENCE from ambient was being considered.

RESULTS OF THE TEST

The most striking result of the test was the actual scorching of the paint on the sides of the body after the High Power run with the Epner Technology Gold installed. The detailed results of both the High Power and the Low Power tests were as follows:

HIGH POWER TEST (99% for 45 sec., 75% for 14 min.,15 sec.)
Exhibit #2 = Aluminum, Exhibit #4 = Gold

	Peak Temp.	Average Temp.	KWH used	Probes 4&5 Amb to 250° F.
Laser Gold	286° F. (141° C.)	264° F. (129° C.)	79.2	240 sec.
Aluminum	263° F. (128° C.)	247° F (119° C.)	79.2	285 sec.
Percent Difference	+8.7%	+6.9%	0%	**Laser Gold, 19% sooner**

LOW POWER TEST (99% for 30 sec, 60% for 14 min., 30 sec.)
Exhibit #3 = Aluminum, Exhibit #5 = Gold

	Peak Temp.	Average Temp.	KWH used	Probes 4&5 Amb. to 250°F
Laser Gold	232° F (111° C.)	218° F. (103° C.)	61.6	330 sec.
Aluminum	178° F. (81° C.)	171° F. (77° C.)	60.8	870 sec.
Percent Difference	+30.3%	+27.7%	1%	**Laser Gold, 62% sooner**

Note: Actual temperatures are determined by adding 70° F (21°C.) ambient
Refer to Exhibits 2 through 5.

SUMMARY AND CONCLUSIONS

The basic physics of infrared radiant heating is well known; we heat the object and not the air. Penetration depth of the energy is wavelength dependent and the shorter the wavelength, the deeper the penetration.

Water has a peak absorption band between 2.5 and 3.5 microns. This is medium wavelength IR and is considered by many to be the ideal wavelength for flashing-off waterborne paints.

Since emitter temperatures can be controlled to generate peak IR energy at these wavelengths, the highest coupling efficiency with the water in the paint can be achieved.

If the "purity" of the original wavelength generated can be maintained, the overall oven efficiency is optimized. The foregoing test confirms that Epner Technology's Laser Gold accomplishes that objective.

LOW ABSORBED ENERGY IS KEY

Because Laser Gold absorbs a mere 2% of the "working wavelengths", i.e. 1 to 3.5 microns, it keeps as much of this energy as possible resonating in the oven chamber.

Skinning-over and paint popping are virtually eliminated since the wavelengths that penetrate the paint film are reflected and re-reflected, ad infinitum, with the greatest efficiency possible; It's somewhat like "closing the cover on a barbecue".

Ordinary gold can absorb as much as 2 to 10 times the energy of Laser Gold. Aluminum, when new, absorbs some 20% of the desireable IR wavelength, but when the surface oxides form in the heat of the oven, that figure can double. Stainless steel is worse yet. Even polished stainless absorbs 30% when fresh. In simple terms this means that Laser Gold reflects more IR energy after ten reflections (or bounces) than aluminum does after the first. (See Exhibit #1)

By putting the energy previously absorbed by the oven walls to work drying paint, power consumption goes down and the exterior oven environment is measurably cooler.

As noted, in the Wixom oven, Laser Gold was not the primary reflector. That function was performed by the gold coating on the rear surface of the lamp envelope as supplied by the oven manufacturer.

(The need for Laser Gold is even greater in an oven using short wavelength emitters, such as those built by such American companies as BGK and Kwik Paint or Infra Rouge Systems in Lyon, France. These ovens use T3 quartz-halogen lamps which burn too hot to permit the gold *primary* reflector to be "built-in" directly on the quartz envelope.)

By "capturing" as much of the secondary (and subsequent) IR energy that radiates and re-radiates off every surface in the oven including the car body itself, Laser Gold's most visible effect is on improved paint quality.

Laser Gold is a cost effective material that permits the automobile manufacturer to combine a higher quality paint finish with dramatically lowered operating costs.

In existing ovens, a simple conversion (installed right over the existing walls) achieves substantial guaranteed power reduction or a shorter dwell time, or both.

In a new installation Laser Gold permits both the shrinking of the oven "footprint" and a lower installed power base with significant capital expense savings.

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