LOWER ZINC IN HOT DIP GALVANIZING **Dr. Thomas H. Cook galvecon@gwtc.net**

Baume'	ACNV	pH	Temperature	Surfactant	Fe+2	SO4-2	NTNV
12	1.4-1.6	4.2	160 F	0.03%-0.06%	<0.5%	<0.5%	<7,000 ppm

Fig. 1 shows the best clean quadraflux (CQ) parameters which gives the lowest %Gross Zinc Usage. %GZU = (Zinc Consumed)/(Steel Galvanized) * 100%. Whenever the parameters in Fig. 1 drift out of specification then necessarily the %GZU increases.

Baume'—A 12 deg. baume' flux with the parameters in Fig. 1 is excellent. A 21 deg. baume' flux doubles the skims, doubles the smoke, and dramatically increases molten zinc spatter upon kettle entry.

ACNV—ACNV = %NH4Cl (numerator)/(%ZnCl2 + %FeCl2 + %FeSO4 + %CaCl2 + %MgCl2 + %MnCl2 + %KCl + %NaCl) (denominator). The "bake (at 160 F) and shake (in an insulated container)" is the best method for testing ACNV. A ventilated oven fan speeds drying. NH4Cl gets cold when dissolved and ZnCl2 gets hot when dissolved. The temperature change is compared with known standards.

pH—The pH must be 4.2 and measured by titration using either 1/10 HCl or 1/10 NH4OH and 0.1% Bromophenol blue sodium salt. 15 drops of BPB indicator is added to 50 mL of flux and titrated to the end point, then proportional calculations are used to get the required volume of conc. HCl or conc. NH4OH to add to the flux. Too high of pH gives black (bare) spots; too low causes steel to dissolve in the flux. **A pH METER OR pH PAPER IS USELESS IN FLUX SOLUTIONS.**

Temperature—Required temperature for flux is 160F. The steel must remain in the flux about 3 minutes to fully heat the steel so that upon withdrawal from the flux it will dry fully before entry into the molten zinc.

Surfactant—Merpol HCS at 0.03% lowers the flux surface tension from 80 dynes-cm to 30 dynes-cm. Merpol HCS gives excellent corrosion protection for steel from the flux to the kettle. At 0.06%, Merpol HCS with a low airline causes foam on the flux with reduces heating costs by 1/2, or causes the flux to be 10 deg. F hotter.

Fe+2—Fe+2 in the flux does **NOT** cause dross. Iron in the flux causes excess smoke and more skims. Iron in flux increases %GZU:

Fig. 2 %GZU = [0.82% * %Fe+2] + %GZUCQ

Fig. 2 is the Geoff Crowley equation relating %Fe+2 to %GZU. For example, if the flux has 1% Fe+2, and the clean quadraflux %GZUCQ is 5.00%, then the contaminated flux with 1% Fe+2 will produce a %GZU of 5.82%.

%GZU = [0.82% *1%] + 5.00% **%GZU = 5.82%**

This is an increased zinc consumption of 16%. For a galvanizer doing 50,000,000 pounds of steel, this is a **$574,000 yearly loss**. Mr. Crowley's equation was developed over a period of 10 years in two galvanizing plants in Glasgow, Scotland. Crowley's equation is valid between 0.1% and 2.1% Fe+2. Iron in the flux is volatile and is given off in kettle smoke and is sucked into the baghouse.

SO4-2—Sulfate in the flux comes from sulfuric acid pickle. To use the Crowley equation simply add the sulfate and iron together. For example, a flux with 1% sulfate and 0.30% iron would show a 1.066% increase in %GZU:

%GZU = [0.82 * (1.00 + 0.30)] + 5.00% **%GZU = 6.066%**

For a galvanizer doing 50,000,000 pounds of steel, this is a **$746,200 yearly zinc loss.** Removing the sulfate and/or iron gives much better product and fewer rejects.

NTNV—The Non-Traditional, Non-Volatiles in flux include: CaCl2, MgCl2, MnCl2, KCl, and NaCl. These are commonly found in fluxes manufactured from recycled starting materials or from "hard" water sources. Some flux additives, and acid additives contain NTNV's. Sodium Chloride (NaCl) causes excess dross and may damage the kettle. Once the total NTNV's (as chlorides) reach 7,000 ppm (0.07%) black (bare) spots become extensive.

Technology—Using an MZR machine, Quadraflux, and NiftyGalv, 85% zinc can be recovered from unworked skims and thus reduce %GZU by a full 1%. This is a $700,000 yearly savings for 50,000,000 pounds of steel. Normal skims/ash coming out of the MZR Machine is 0.10% of production.

0.03% bismuth in the zinc gives four times faster clean-up for hand-rail. More bismuth gives white rust.

Lead in the molten zinc gives three to four times the zinc coating thickness on malleable castings and increases dross dramatically. With lead, coatings on castings are non-adherent.

Lowering the zinc temperature to 820 F overnight followed by using a scoop or shovel connected to the crane, reduces dross by 1/3. Normal dross is 0.40% to 0.60% of production.

Using Percent of Required (PoR) (zinc thickness) is a good way to determine efficiency of galvanizing. For example, if 3 mills are required and 5 mills are measured on the product then PoR is 5/3 times 100% = 167%. PoR takes into account steel thickness.

An effective acid inhibitor at 0.03% allows acid to remove mill-scale but prevents acid from attacking bare steel. A ½ inch dia. short, clean, close nipple pipe is weighed, wired, and put into acid for 1 hour. Then removed, rinsed, dried, and reweighed. Inhibited acid gives a weight loss of about 0.2 grams; uninhibited loss of 2 to 4 grams. Inhibited acid gives twice the acid lifetime and reduces acid fume by 95%.

A long kettle probe is made from a 5/8 inch dia. steel rod 5 feet longer than the kettle depth. The lower end is ground to a point and 5 inches from the bottom, bent at 90 deg. A foot from the top end of the rod is bent at 90 deg. in the same direction as the bottom bend. The long kettle probe can locate cavities in the kettle side walls. If the point gets stuck, and cannot be pulled up without pulling the point out of the cavity, then the cavity is more than ¾ inches deep. A medium long probe is used for the top half of the kettle and a short probe is used for the air-zinc wash-line to profile "dirt". A long probe thermocouple can be put into a cavity to determine how hot the zinc is in the cavity. Remedial action may be required. Monthly kettle probing is recommended. The long probe can also "map" the dross in the kettle. Proper insulated gloves are required.

NiftyGalv—Twelve galvanizers have been using Dr. Cook's NiftyGalv for ten years. Nifty is known to reduce/eliminate black (bare) spots and reduce zinc thickness. A galvanizer had 9,000 ppm NTNV's in his flux and had uncontrolled black spots and was about to dump his flux ($82,000 cost). Rather than dump, he installed Nifty and all the black spots went away. This same flux is being used ten years later. A galvanizer was putting on 11.5 mills with many sharp spikes on class 1, number 10 rebar. After installing Nifty the rebar shows 5.5 mills with no spikes and the surface is exceptionally smooth. (Number 10, class 1 rebar requires 5.2 mills.) Ten years later the produced galvanized rebar still has 5.5 mills and is still smooth and bright. Another galvanizer doing structural steel had 6 to 8 mills of zinc on the product. He started using Nifty and the product has 3 to 4 mills (50% less zinc on the steel). Short ¼ inch thick angles were sent to Dr. Cook's 12 Nifty clients and to 5 Non-Nifty users and an angle was galvanized for exactly 20 seconds in each kettle. With Nifty the zinc coating was perfect and 1.5 mills thick. One of Dr. Cook's clients using Nifty, even had 9.5% Fe^{+2} in his flux. The Non-Nifty angles had many black (bare) spots, pimples, and ash inclusions. NiftyGalv provides good galvanizing even with bad flux. Nifty gives excellent quality product; it has been mistaken for electroplate.

SpinExpress—SpinExpress was invented by Dr. Cook and provides excellent spin products with decreased (adjustable) zinc on the product along with increased production. A spin galvanizer, using conventional methods was galvanizing 25,000 pounds of caps/day for chain-link fence posts. He was putting on 8 mills of zinc, with a reject rate of 80% (rejects were black (bare) spots) inside the caps. He had 22 inspectors deciding rejects. Using Dr. Cook's SpinExpress, production increased to 100,000 pounds/day, with 2 mills of zinc and a reject rate of less than 1%. Inspectors were reduced from 22 to 2. Caps perfectly fit the posts. Total savings is more than $5,000,000/year.