Eddie Bell
NEUTEC USA, Albuquerque,
New Mexico USA

Eddie Bell is the President of Neutec USA and founder of the Santa Fe Symposium on Jewelry Manufacturing Technology. He is an expert in the goldsmith industry, and is considered one of the most highly qualified experts in the process of lost wax casting. He participates at the most important international gold conferences, consistently presenting original papers from a very practical approach.

There are many false beliefs regarding precious metal loss during casting. But are these always actual losses? And if they are not losses, where is the gold going? This paper will discuss these points, and will give suggestions on how to reduce precious metal losses.

Controlling Melt Loss when Melting Gold Alloys

Introduction

There are many misconceptions surrounding melt loss. We are often asked how much melt loss is normal or how to recover the gold that is lost during melting.

Just about anyone who has cast gold has experienced melt loss. In the simplest terms, melt loss is a shortage in the total weight recovered versus the total weight melted. Melt losses can occur in any melting operation including smelting, alloying, casting and grain making, but is the gold really lost? If it isn't lost, where is it and can it be recovered? And most importantly, what can be done to minimize melt loss? The goal of this paper is to discuss the various causes for missing metal (aside from theft) and suggest some solutions.

Causes for Melt Loss

The three melting operations common to most casting shops are alloying, melting sprues and other clean scrap to make casting grain, and casting. Following are 11 areas that need to be managed to control and minimize melt loss.

Porous Crucible

It is possible for a caster to experience a large loss from a high karat alloy containing no zinc and very small loss from a high zinc, low karat alloy. How can this be, you might ask, for the reverse would seem more logical, wouldn't it? Gold will seep into pores too small to see in any kind of crucible, ceramic or graphite, but the problem is seen more often with graphite crucibles bought for a little less by someone thinking they are saving money. Cheap graphite is no bargain if it sucks up some of your gold. Don't get the idea that ceramic crucibles are better; graphite is still the preferred crucible material for gold and silver; you just need a high grade of graphite. It turns out that the higher the gold content in an alloy, the denser the crucible needs to be. Gold can be recovered from graphite crucibles by burning them in your burnout oven while ceramic crucibles require the services of a refiner.

Flux

Flux is used to reduce the amount of slag produced during melting and to make the metal more fluid.[1]

Usually we use fluxes that are based on boric acid or borax that melt below the liquidus of gold and silver alloys and make a glassy film on the metal. In open melting condition this film serves to protect the metal from air, and by preventing oxidation will greatly reduce zinc loss[2]. Impurities in the metal can be removed by flux, however the metal would have to be badly contaminated before the weight difference could be measured on normal scales. Little beads of metal can be caught in flux and remain in the crucible. The more viscous the flux is and the thicker the flux layer, the more likely some metal will be trapped. Also the low karat alloys are more likely to be trapped and silicon alloys seem to stick to flux better than alloys without silicon. This is not normally a problem with modern closed casting systems because flux is not necessary and therefore not used. Casters who use centrifugal casting machines might see odd variations in weight such as weight loss on three or four trees and then weight gain on the next tree. This odd variation can be easily explained: if the flux is not skimmed before casting, you can get flux inclusions in the tree that will give it weight gain. Beads of metal trapped in the flux will make the cast tree a little light. With subsequent melts little beads of trapped metal combine making larger beads that eventually are cast out making that tree weigh a little more than the charge. If the flux is water soluble, i.e. boric acid, metal can be recovered from the flux in crucibles by boiling the crucible in water until the flux is dissolved and then filtering the metal out of the water. The kind of flux, the amount of flux used, the condition of the alloy and the kind of alloy all can have an influence on how flux contributes to apparent melt loss. The word apparent is used because flux is not really responsible for melt loss but needs to be managed.

Boron and Silicon

Silicon is added to gold alloys to reduce the sensitivity to oxygen and increase fluidity[3]. It is not soluble in gold or silver, so the amount of silicon in a gold alloy is dependent on the amount of copper there. Silicon is much more active to oxygen than copper or zinc. It protects the melt by combining with any oxygen available to become silicon dioxide (silica), which precipitates leaving a visible glassy slag in the crucible and an invisible layer on the surface of the casting. Obviously, whatever precipitates will be missing when the metal is weighed after casting and a melt loss can be recorded.

Silicon was originally added to gold alloys to solve casting problems that are the result of melting and pouring them in the presence of air, forming oxides of copper and nickel[4]. In open systems where air is present and gold alloys containing silicon are melted and poured it is expected that about 20% of the silicon will be lost. The silicon loss rate is very process dependent where higher temperatures and longer exposure to air will increase the amount lost. Open melt processes are usually not very repeatable so the silicon loss is likely inconsistent. In any case, the depletion of silicon causes the alloy to become gold enriched to some extent. When alloys intended for open melting are cast in a closed casting machine that is absent of air or oxygen, the silicon does not get used up at the expected rate.

Because zinc is lost and it is possible for the silicon content to go up when the metal is recycled several times. Silicon enrichment can have several bad effects including brittleness, hard spots, non-filling[5] and coarse grain. This is called silicon creep and is solved by changing to an alloy with lower silicon content in the range of less than 200ppm for 18K up to 500ppm for 9K versus 350 to 2500ppm silicon[6]. In closed system casting we sometimes see slag deposited in the bottom of graphite crucibles. What causes the silicon to precipitate if there is no oxygen? In systems that rely on vacuum to draw the air out before back-filling with argon or nitrogen there could be a small leak and as long as the pressure in the machine is less than atmospheric pressure, air will always be leaking into the machine. Or if for some other reason the system isn't oxygen free as it should be; for example, cover gas that is not oxygen free. It could be that silica or silicates were already in the alloy before it was placed in the crucible.

Why do some alloys appear to precipitate more slag than others with similar silicon content? I say appear because the variable may not be the alloy but some other factor such as the casting machine parameters having been changed; such as shorter purge time or a higher temperature was set which also increased the melt time. According to Dieter Ott[7]; it could also be because, "...the material contains different amounts of oxides, so different alloys give different amount of silicates. Also the type of alloying procedure plays a role. Alloying using a master alloy is different from alloying with the metals separately. Copper can contain a lot of oxide; silver usually contains oxygen in solution. And the type of alloy itself might also show some influence. Alloys with low solubility for silicon (e.g. copper poor) might lead to segregation of a low melting compound, which can easily be oxidized."

A thin film of silica on the surface of a melt is said to inhibit zinc loss, however how well this works may be dependent on such things as temperature, pressure, agitation and melt size; as we will discuss later. Silicon reduces the solidus temperature more than the liquidus and silicon increases the time required for an alloy to solidify[8]. These factors may offset any benefit as far as zinc loss is concerned, but no studies have been done to my knowledge.

In any casting system, silica that collects in the crucible can trap little beads of metal in the same way flux does, and should not be overlooked. Metal trapped in silica or silicate slag is difficult for a caster to recover and is best done by a refiner.

Boron is often mentioned in the literature to be a beneficial additive to gold alloys as a powerful deoxidizer and a grain refiner. However, it is not likely to precipitate in measurable quantities because it is a light element and usually very little is in the metal from the start.

Thermocouple Sheaths and Stirring Rods

On graphite, which is considered to be non-wetting by gold alloys, flux and silica can

cause metal to stick to a sealing rod or thermocouple sheath in the same way as the crucible. Metal will wet most ceramics and any metal clinging to a stirring rod is lost from the melt, but not impossible to recover.

Quench

All investment and water from flask quenching should be filtered through a fine screen. Little beads of metal can be washed from the sprue button and the surface of the investment and parts of cast patterns can be broken off the tree during quenching and lost in the investment mud[9]. After scraping the button area of each flask to recover the high-grade material, Schneller reported recovery of between 40 and 50 grams of precious metal per ton of investment. If it is not recovered and accounted for, it will become part of the so-called melt loss, but if managed most of the metal can be recovered.

Contamination

Trees that are not completely free of investment cause a weight loss when the metal is melted. Slag in the crucible after melting is a sure sign that the metal was not completely clean. The same people who are careful not to weigh wet metal will weigh dirty metal. Do you wonder about that?

Scale Error

When casting grain is weighed into batches for each tree being cast, sometimes the total of the weights does not match the weight of all the trees weighed together. This is because electronic scales round the weight up or down and the error may cancel or accumulate. Get an accurate tare weight on each container and on all the containers together. Then weigh the total of each alloy together before and after casting. Make sure the same scale is used to weigh in and out and check the calibration of the scale often.

Carelessness

I will not dwell on this, but careless behavior can fill casting machines, drains and garbage cans with precious metal worth large amounts of money per year.

Splash and Spatters

Depending on the equipment used, there might be more or less splash or spatter of metal during the various melting processes. The newest generation machines have special engineering to minimize this problem. Dropping large chunks of metal into a

pool of liquid metal might splash some out and if it isn't carefully collected, it will result in a shortage that generally gets recorded as melt loss. Over-filling a flask or an off-center pour causes metal to go to places where it is hard to recover. Hollow and water filled casting grains increase the weight and then when the grain is melted for casting, little steam explosions spatter metal out of the crucible. The water and any bits of metal that get out of the crucible are lost and this gets recorded as melt loss.

Sprue Cutting

How often do you see little flakes of metal at the sprue cutting station? I think most people collect that metal, but do they attribute it to the melt or report it as melt loss? It is not unusual for sprue cutting pliers to shoot a piece of metal across the room. Of course these are picked up, but be sure that the trees are weighed before sprue cutting to formulate melt loss figures.

Evaporation

So far we have explored 10 possible causes of metal shortage that could be attributed to melt loss, but could be easily managed; and most of them, if properly managed, would result in no metal loss attributed to that reason, but evaporation is another thing. I am not talking about something misplaced and not found, like the child who can't find one sock and tells his mom that it just evaporated. I am talking about the process where a liquid makes a phase change and becomes vapor. The biggest offender in melting jewelry alloys is zinc, but silver can also be lost to evaporation.

Silver

Silver is used in gold alloys to control color and strength, is easily soluble in gold and copper and it has been favored since ancient times as an alloying agent. It has been known for many centuries that using the proper balance of copper and silver produce an alloy that can be hardened to improve mechanical properties. Today we are making alloys that include silver and platinum group metals, specifically platinum and palladium, and in the alloying process it is necessary to heat the silver to temperatures that silver normally never sees. Between 961°C and 1230°C the vapor pressure increases by 3 orders of magnitude[10] and at about 1300°C a noticeable amount of vapor is generated from silver. As the temperature is increased, the amount of vapor also increases. When silver is kept below 1020°C the evaporation is not noticeable.

The Role of Zinc in Melt Loss

The most common reason for melt loss from gold alloys is evaporation or the vaporization of zinc. An alloy is a mixture of solid solutions. This means that each

element in the alloy retains some of its physical properties. One of the physical properties of metals is they all have a boiling point, i.e., they have a temperature at which the vapor pressure equals the atmospheric pressure and they boil. The boiling point of zinc at one bar pressure is 907°C, which is lower than the alloying or casting temperature of most gold alloys that contain zinc. When the zinc becomes liquid it begins to give off vapor. As the temperature of the melt is increased, the amount of zinc vapor increases until the boiling point of the zinc is reached and then the evolution of vapor becomes much faster. The amount of zinc evolved is a function of four parameters: temperature, concentration, time and pressure. We have already discussed the effect of temperature on zinc evaporation, so now we will consider the influence of time and pressure. It stands to reason that the longer a metal is kept liquid, the more evaporation will take place. When pressure goes down, the boiling point and the temperature required to rapidly vaporize zinc go down with it. Melting and casting a zinc-bearing alloy in a vacuum or partial vacuum increases the amount of zinc evaporation. In fact the zinc can continue to evaporate after the metal is cast. Evidence of zinc vapor can be found everywhere. Whitish deposits on torch tips and in casting machines and the visible vapor rising from the metal can be seen in any casting shop.

Karat Creep

Melt loss caused by evaporation of zinc results in something we call karat creep. Karat creep is the enrichment of a gold alloy that results when less noble metals volatize out during melting. When the karat creeps up, the manufacturer is giving away gold and often doesn't even know it.

The Advantages of Zinc

If zinc is the main culprit in karat creep, there must be some reason for adding it to gold alloys. Therefore, it should be useful to discuss how zinc affects various aspects of karat gold. It could be argued that after gold content, color is the most important characteristic of jewelry gold. Zinc can play an important role in the color of a gold alloy[11]. In the case of white gold, zinc has a significant whitening effect. In yellow gold, zinc can be exchanged for silver at an advantageous ratio to produce an alloy with a desired color and lower density.[12]

Zinc's Influence on Density

Since gold is sold by weight, variations in density affect the cost to produce a gold object and zinc can have a strong affect on density.
The Handy Book of Precious Metals[13] lists several 14K yellow gold alloys (Table 1) that have about 7% difference between the highest and lowest density. Presumably, this density variation within a karat value and general color is typical

of most suppliers. However, when color matching and hardness are considered the density difference is more likely to be 3 to 4%. If an item made from alloy 212 weighed 10 grams, then the same item in alloy 29, would only weigh 9.34 grams and the value of the fine gold required to make it would be $4.71 less. In volume production that is a lot of money.

Table 1

Handy Alloy #	DENSITY Tr. Oz./Cu. In.	RELATIVE WEIGHT Grams	FINE GOLD VALUE @ $380.00 Tr. Oz	VARIANCE IN GOLD VALUE
212	7.22	10	$71.47	--0--
660	6.95	9.63	$68.83	$2.64
515	6.93	9.6	$68.61	$2.86
2	6.9	10	$71.47	--0--
516	6.88	9.52	$68.04	$3.43
Satin	6.76	9.36	$66.90	$4.57
29	6.74	9.34	$66.76	$4.71

Don't assume that adding zinc reduces density and therefore price. The effect zinc has on the apparent density of a gold alloy can be tricky. In fact small zinc additions seem to make the density go up. Table 2, shows two gold alloys that rapidly increase in density with a little zinc added and then stabilize.[14] We know gold is denser than zinc, so how could this be? The answer to this puzzle lies in the effect zinc has on the reduction of interdendritic microvoids caused by volume contraction during solidification. In other words, a little zinc reduces the amount of porosity in a casting enough to make the density of the casting increase.

Table 2

ALLOY 14K	ZINC WEIGHT %	DENSITY
1	-	13.2
2	0.44	13.8
3	1.10	13.8
4	1.80	13.7
ALLOY 18K	ZINC WEIGHT %	DENSITY
1	0	15.0
2	0.52	15.4
3	1.10	15.3
4	1.80	15.3

Zinc's Influence on Melting Temperature

Zinc's effect on the melting temperature of yellow gold was well known even in ancient times. The alloys shown in Table 3 illustrate that the melting temperature is driven down as zinc is exchanged for silver in 14K and 18K alloys. The melting range is also increased making the alloy less sprue-sensitive. Lower melting temperature helps reduce the required system temperature, which can help reduce gas porosity. A lower melting temperature also reduces the energy cost of melting and shortens the cycle time labor for casting.

Table 3

GOLD	SILVER	COPPER	ZINC	SOLIDUS	LIQUIDUS	MELTING RANGE
wt. %	wt. %	wt. %	wt. %	°C	°C	°C
58.5	30	11.5	0	860	880	20
58.5	29.5	11.5	0.5	805	860	55
58.5	28.9	11.5	1.1	810	840	30
58.5	28.1	11.5	1.9	790	820	30
75	16	9	0	890	910	20
75	15.5	9	0.5	870	900	30
75	14.9	9	1.1	850	880	30

Zinc's Influence on Surface Tension

Zinc lowers the interfacial tension of gold alloys. According to Ott and Raub, additions of 1 to 2 percent zinc in 14K and 18K alloys greatly improves as-cast surface roughness. 2% zinc is enough to get complete wetting of the investment, enhancing detail reproduction. At 1.5%, zinc wetting is spotty and below 1.5% no wetting occurred. The graph (Figure 1) shows remarkable surface quality improvement when only 1% zinc is added to an alloy.
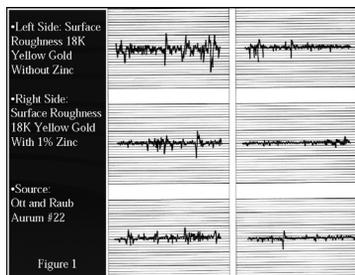

Figure 1 - Left side: Surface roughness, 18 k yellow gold without zinc - Right side: Surface roughness, 18 k yellow gold with 1% zinc - Source: Ott and Raub - Aurum # 22

Zinc's Influence on Fluidity

A 14K alloy with 2% zinc is more than twice as good at form filling as the same alloy without zinc as seen (Figure 2) in the difference between two cast grids.
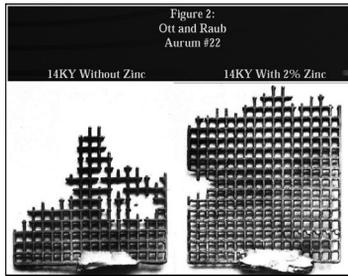
Figure 2 - Form filling of a grid - Left: 18 k yellow gold without zinc
Right: 18 k yellow gold with 1% zinc - Source: Ott and Raub - Aurum # 22

Zinc's Influence on Porosity

We saw earlier that the density increased slightly with small additions of zinc because there were fewer microvoids between the grains. Lower surface tension, higher fluidity and wider melting ranges all work to help the caster avoid shrinkage porosity. Ott and Raub report that porosity is reduced by the addition of zinc if adequate gates or feed sprues are provided.

Zinc's Influence on Strength and Hardness

Small additions of zinc can improve tensile strength and give the alloy greater as-cast hardness. This is because when porosity and grain boundary microvoids are reduced the metal becomes denser, and denser metal is stronger, takes a better finish and resists tarnish better than less dense alloys of similar composition.
We can see there are many advantages of adding zinc to a gold alloy, but zinc has a big disadvantage too, which is melt loss leading to karat creep.

How Do We Know What is Lost

When we experience melt loss how do we know what is missing and that karat creep is indeed occurring? The simplest means to measure karat creep is to assay your gold before and after casting. If the percentage of gold is going up, you have karat creep, but a fire assay will not tell you what is missing. You could have a complete analysis of the alloy done or you could try and find what was lost. Since elements cannot be destroyed, we must be able to find what is missing from the melt somewhere. You will not have to look very far if your melting was done in a closed system. The vapors rise from the crucible and condense as a fine powder in the crucible chamber hood. We also found and analyzed some powder from the bottom of the crucible chamber, just above the flask chamber. An energy dispersive X-ray (EDX) analysis was done on these samples of powder to see what was in it. In Table 4 you can see that ten elements were found in measurable quantities, and there is a difference in what was found above the crucible and above the flask.

Table 4

	EDX of Powder	
Element	Average Wt % From Hood	Average Wt. % Flask Chamber
Zinc	91.47	64.18
Silicon	1.45	17.11
Sulfur	0.76	0.84
Chlorine	3.37	0.52
Silver	0.53	1.54
Potassium	0.73	0.2
Calcium	0.29	1.2
Nickel	0.27	1.3
Copper	1.11	10.82
Gold	0	2.17

Notice that there was no gold found in the hood powder. This means that no gold was vaporizing and therefore there was no gold lost by this means and hints that the alloy may be getting richer in gold. Clearly, the main ingredient in both powder samples is zinc. The EDX analysis together with assays of the gold alloy before and after casting proved that karat creep was occurring and zinc loss was the main culprit. The EDX analysis deserves more discussion and should be the subject of further research.

So far, we have talked about 14K and 18K alloys that contain 2% zinc by weight or less. Many gold alloys have zinc content of 4 to 16 %. The increased popularity of white gold is swinging the balance toward alloys with higher zinc as well. When casting process controls are not carefully maintained, it is not unusual to see melt loss of 1% or higher. But it can be controlled to a lower level too.

To calculate the cost of karat creep I will start with an example of 0.6 grams per 1000 melt loss for a 14K gold alloy.
The starting weight of the metal cast is 1000 grams and the after-cast weight is 999.4 grams; after doing the math we see that the cost of gold enrichment per kg cast is $4.27 at $380.00 per troy ounce.

After Cast Wt. (g) / Before Cast Wt. (g) x 100 = % Remaing
999.4 / 1000 x 100 = 99.94

% Fine Gold Start / % Remaining x 100 = % Fine Gold New

% Fine Gold New - % Fine Gold Start = Karat Creep Factor x 100
58.5 / 99.94 x 100 = 58.535
58.535 - 58.5 = .035
Karat Creep Factor = .035/100 = 0 .00035

Karat Creep Factor x Fine Gold Value per g = Cost of Karat Creep per g.
00035 x $12.21* = .004274

Cost of Karat Creep per g x 1000 = Karat Creep cost per kg Cast.
004274 x 1000 = $4.27

*Gold Price $380.00 Troy Ounce1

Figure 3 - Calculating karat creep cost for a 14 K alloy

A factory that had kept careful records made it possible to do a before-and-after case study on cost savings related to upgrading their factory equipment. The figures will show that significant savings can be gotten for a medium size company. I have endeavored to express the information so any factory could apply their own experience to them by extrapolating the numbers for smaller and larger production.

Some critical factors for reducing cost are: good alloy homogeneity, excellent atmospheric protection, ability to cast large trees with short melt cycle times and precise control of the melting process, and the ability to alloy and convert sprues to casting grain without contaminating the metal.

A major change in the operation was converting sprues to casting grain before recycling the metal back to the casting crucible. Melt loss involved with converting sprues to casting grain is consistently less than 0.01%. The labor cost of converting sprues to grain was offset by lower casting labor cost. With the correct equipment, making grain from sprues takes less time than cutting them up and melt loss is reduced, even though the metal is melted twice.

Table 5 shows the labor cost per flask depending on the number of flasks cast per hour. Going from 6 to 20 flasks per hour will save 70% of the time required for casting. What ever your labor costs are, consider that saving 70% is substantial. For example on a production of 20 flasks per day and labor cost at $15.00 an hour times 250 casting days would save over $8,700.00 per year. There is an added benefit of reducing work in process by getting the castings into the finishing process earlier in the day, and one fast machine can do the work of two and a half slower machines, reducing capital requirements.

Table 5

Cast per hour	Labor cost per flask @ $15.00 per hour	Cumulative time saved as percent
6	$ 2.50	0
8	$ 1.88	25%
10	$ 1.50	40%
12	$ 1.25	50%
14	$ 1.07	57%
16	$ 0.94	62%
18	$ 0.83	67%
20	$ 0.75	70%
22	$ 0.68	73%
24	$ 0.63	75%

Table 6 shows the effect the flask size has on the cost of investment and the amount of gold needed to make a days production. Assume the same item is cast, 10 items are attached per inch of productive height of the main sprue. Twelve millimeters of investment is required above the wax patterns and 37mm are below the wax patterns. One year equals 250 casting days. A 300mm high flask will yield the same throughput as two and a half 150mm high flasks and uses about 20% less investment. Since fewer than half as many flasks are cast and the new equipment is faster than the old, the casting labor is only 30% of what it was.

The most important change is the reduction in the amount of metal needed to make a day's production. The 6-inch flasks required 300 grams of metal and had 150 grams of yield. The 12-inch flask yields 375 grams of product from 600 grams of metal cast. This is an improvement in yield of 12.5% and a 20% reduction in the metal in process, and because 20% less metal was melted, melt loss is reduced and you have 20% less karat creep.

Table 6

Items cast per day	Flask size in	Items per tree @ 10 per inch	Trees needed	Investment per flask	Investment cost per year* ($1.32 kg)	Metal needed per day (grams)
1200	4x6	40	30	630 g	$ 6237.00	9000
1200	4x12	100	12	1260 g	$ 4989.00	7200
				Saving	$1248.00 19.8% less	1800 g 20% less

Based on 250 casting days per year

In Table 7 the melt loss was extracted from records for the year before the process change was made and adjusted to current gold prices. It shows significant dollars lost because of karat creep. High zinc content, small melt size, long melt cycle, lack of atmosphere control and overheating of metal all contributed to melt loss. 4.9 grams lost per 1000 grams melted is only 0.49%. It is amazing how much that small amount can cost.

Table 7 - Karat creep cost before upgrade

Alloy	Total cast (kg)	Melt loss (g per kg)	Karat creep factor	Gram price gold @ $ 380.00	Cost of carat creep per kilogram
1 Y	1518	4.9	0.00288	12.21	$ 35.16
1 W	746	6.1	0.00359	12.21	$ 43.83

In the year after upgrading their processes and following careful metal management procedures the picture is much different. In Table 8 we see that the karat creep is very low considering the high zinc content of their alloy and the fact that the metal was recycled many times.

Table 8 - Karat creep cost in year following upgrade

Alloy	Total cast (kg)	Melt loss (g per kg)	Karat creep factor	Gram price gold @ $ 380.00	Cost of carat creep per kilogram
2 Y	1780	0.2	0.000117	12.21	$ 1.43
2 W	1203	0.6	0.000351	12.21	$ 4.29

The mix of virgin grain to recycled grain will depend on the alloy used. It is important

to monitor the gold for content on a regular basis and keep very strict mix ratios.

Similar results to these are reported to me, casting a 10K yellow gold with zinc content about 6%, and using a 60% new and 40% recycled grain.

In both cases the variation of gold content stabilized at about 0.02% with a maximum variation of ±0.03%.

This tight gold content control made it safe for them to reduce the gold content in their virgin alloy by 0.04% and still maintain the required karatage. Statistical analysis shows that with modern melting equipment and intelligent process management, when the ratio of virgin grain to recycled grain is carefully maintained, the variation in gold content can be held to 0.02%. In contrast, the old practices produced much higher melt losses. Although a major factory upgrade can be somewhat expensive, the payback can be reasonable for a relatively modest production.

This factory was averaging about 9 kg of gold usage per casting day. At that rate, if you calculate the difference between the old system and the new, the savings would add up to over $80,000.00 in the first seven months against the previous year. It is amazing how much profit opportunity exists from such a seemingly small number like 0.49% karat creep due to melt loss.

Conclusion

Controlling melt loss requires that the metal be carefully managed through every step of the manufacturing process. Zinc is by far the leading cause of melt loss and evaporation of zinc cannot be altogether eliminated. The real cost of melt loss is karat creep. The study shows however, that it is possible to manage it to be a low level manufacturing cost and that the investments required to properly manage karat creep due to melt loss can produce significant payback in increased profit.

The critical factors for managing karat creep due to melt loss for reducing cost are:

The study showed that labor cost for casting is related to melt cycle time and quicker melt cycle time can also add up to significant savings. Melt cycle time is measured from flask to flask. A 2.5 to 3 minute melt cycle reduces melt loss if the control of metal temperature versus crucible temperature is perfect. When a short melt cycle is tried with conventional temperature control systems, overheating the metal at the crucible interface is difficult to avoid. On the other hand, when the melt cycle is slowed to gain better control the time factor works to increase melt loss. Like a pot of water boiling on the stove, the longer zinc boils in the crucible, the more zinc evaporation. The ideal is critical temperature control and very short melt time.

The study also shows that additional savings are gained through increasing the size of the melt.

Generally, the larger the melt the less melt loss you will experience. Small melts have an unfavorable surface to volume ratio that promotes the evaporation of zinc. Casting larger trees is better than casting smaller trees because larger trees require larger melts and save money in every respect.

Small uniform grain melts the quickest and most consistently from batch to batch and transfers heat from the crucible more quickly and therefore heats more evenly than larger pieces would. It is clear that recycled metal must be converted to casting grain. Casting quality always improves when all the metal used is in grain or shot form.

Atmosphere control is of great importance. Zinc readily combines with oxygen, which is good from the standpoint that it protects the copper from forming copper oxide. However, melting in the presence of oxygen promotes very rapid zinc loss and therefore karat creep. Melting in an oxygen free atmosphere gives better metal quality and less melt loss.

And finally, one of the most important factors in melt loss prevention is the pressure in the melt chamber. The lower the pressure the higher the rate of evaporation of zinc. It is better to have pressure higher than atmospheric than to have a vacuum or partial vacuum as long as the atmosphere is free of oxygen.

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