FOUNDRY

SHELL FORMULATION FOR STEEL CASTING BASED ON ZIRCON-MOLOCHITE™

INTRODUCTION

This report specifies a shell moulding systems for high temperature alloys such as steels, nickel-based and cobalt-based alloys.

Usually foundries adapt their shell system to suit the peculiarities of their product range and casting techniques.

This shell system can be viewed as general purpose formulation suitable for a wide range of products shapes and sizes, or as a basis for further modification to fine-tune shells for more specific requirements.

SHELL FORMULATION

Table 1 shows the materials used in primary and back-up layers of shell.

COAT	BINDER	FILLER	STUCCO
Primary Coat	**26 - 30% Colloidal Silica**	**Zircon 325#**	**Zircon Sand**
Secondary Coat	**24 -26% Colloidal Silica**	**Molochite -200**	**Molochite™ 30/80DD Zircon sand**
Back-up Coat	**24 -26% Colloidal Silica**	**Molochite -200**	**Molochite™ 16/30DD**
Seal Coat	**24 -26% Colloidal Silica**	**Molochit -200**	

1 - Primary Slurry

The primary slurry consists of colloidal Silica and 325# Zircon flour. This used to be a standard primary slurry formulation in the Investment Casting industry. However, the current trend is the replacement of zircon silicate with white fused alumina even in the Investment Casting of steel and stainless steel (see Imerys technical paper IC-001: "Shell Formulation with fused Alumina primary")

Slurry Characteristics	
Filler loading	80%, i.e. 4Kg zircon flour to every 1kg of binder
Slurry Specific gravity	3,00 g/m
Plate weight	10-11g (70 µm) on a standard 6" square brass plate
Viscosity	30-35 seconds using a Zahn 4 flow cup

Zircon based slurries deteriorate over time, resulting in a gradual reduction in viscosity relative to both SG and plate weight (or conversely an increase in SG and plate weight relative to viscosity).
Slurry control is achieved by correcting either SG or plate weight to a set point each day using de-ionised water. The control variable, SG or plate weight, is set to within a small tolerance band. The top level at which the slurry must be discarded is found through experience, often around 13-14 seconds on Zahn cup.

FOUNDRY

2 - Primary Stucco

The primary stucco is Zircon sand sometime called granular zircon. Particle size is largely dependent on batch selection by the supplier as this is a naturally occurring mineral. As reported for Primary slurry, the current trend is to replace Zircon sand with White corundum, which provides better consistency, higher heat resistance and contributes to avoid the delamination of the primary coat.

3. Back-up Slurry

The back-up slurry consists of Molochite –200# flour and colloidal Silica binder containing 24-26% silica.

Slurry Characteristics	
Filler loading	64%, i.e. 1.78 Kg Molochite to every 1kg of binder
Slurry Specific Gravity	1.75 - 1.80 g/m
Viscosity	9 -12 seconds using a Zahn 4 flow cup

The viscosity / SG relationship is more stable over time with Molochite back-up than it is with Zircon prime slurry, particularly as back-up slurry is used up and replenished more frequently. The slurry can be controlled by adjusting viscosity or SG to a set point at the start of each shift and only checking the other variable on a weekly basis to monitor the health of the slurry.

Most modern investment casting binders are "polymer modified" which means that they contain organic additives. The additives are claimed to fulfil several functions including enhancing green strength, speeding up the shelling process and increasing shell permeability. This type of additives is not strictly speaking essential, but it simplifies the task of producing consistently good quality moulds.

N.B. It should not be necessary to add wetting agent or anti-foam to a back-up slurry.

If ease of shell removal is an important issue, a proportion of Molochite –120# can be blended with –200#. This will reduce the shell strength and should therefore be done carefully. A blend of 1 part –120# to 3 parts –200# should be sufficient. Creep resistance will not be adversely affected. Indeed, the larger particle size will help reduce shell bulge in larger castings.

4. Back-up Stucco

Fine stucco grade is usually preferred for the first back-up coat. Occasionally Molochite 50-80 dd is used, but by far the most common grade in the industry is Molochite 30-80 dd. This helps avoiding breakdown in sharp internal angles and areas of fine detail in the shell. The rest of the sanded coats employ Molochite.

There is no universal rule as to the number of coats to apply, but the table below is a rough guide :

Pour weight	No of shell coats (including primary and seal coat)
< 25 kg	7 - 8 coats
25 - 40kg	8 - 10 coats
40 - 80 kg	10 -14 coats
> 80 kg	14+