Introduction of Reconstituted Wax into an SPC Foundry

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Blayson Olefines Ltd
Investment Casting Wax

INTRODUCTION OF RECONSTITUTED WAX INTO AN SPC FOUNDRY

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By R. B. Williams, D. P. Bond and D. Morson, Blayson Olefines Ltd, and K. Walker, Centaur Precision Castings Ltd.

Synopsis

A filled pattern wax and a reconstituted wax for pattern production have recently been introduced into an investment casting foundry that utilises SPC techniques. The results of trials within the foundry will be presented and the economics and practical aspects of the development will be discussed.

Introduction

The use of reclaimed wax for runner systems within the investment casting industry is understood and well established.

Reconstitution of waste wax, using the sophisticated technological approach at Blayson Olefines, has now become well established within the investment casting industry worldwide.

Today I would like to show how Centaur Precision Castings of Sheffield, over a period of seven years has moved from using a traditional virgin pattern wax/reclaim cycle to a complete system of reconstitution.

Before we do this, however, we must consider the following points: -

What is reconstitution?

Reconstituted wax is a process the company operates whereby a foundry's used wax of a known quality can be thoroughly cleaned and blended or reconstituted to an agreed specification and returned for use on pattern production. Reclamation has become a way of life for Blayson Olefines and unfilled, emulsified and filled wax can all be reclaimed and reconstituted in this way.

Quality Control on Wax for Reclamation

It is important for both wax manufacturer and foundry to have a general appreciation of wax reclamation and quality control for the process to be completely successful. A foundry should develop controls on the quality of wax it generates for reclamation and some of the examples are shown in Table I.

Routes to Wax Reclamation

When reviewing the concept of wax reclamation there are three main routes to consider. These are shown in Table II.

Reclaim of Wax for Runner Systems Only

Here we are considering a process that has been in operation for a number of years. A foundry returns a quantity of autoclaved wax to the wax reclaimer. The material is melted down and water and extraneous matter are eliminated from the wax. If necessary, additives are made to the wax to achieve the required degree of strength, melting point and fluidity etc. The greater the emphasis placed upon the quality control guidelines listed in Table I, the greater the quality of reclaimed wax that will result.

Reclaim of Wax for Runner Systems and Pattern Production

In the past, if in the foundry wax process mixed pattern wax or unfilled runner wax was used; it was almost impossible to reclaim these mixed materials into a suitable pattern wax blend. With the improvement in reclamation technology it is now possible to reclaim mixed wax to a defined specification. The autoclaved wax follows a route similar to that of reconstituted wax for quality control purposes, with testing taking place throughout its production. This method of reclaiming pattern wax can prove to be more expensive than the preferred route of reclaim and reconstitution.

Whilst costs differ depending on the individual foundry's mixture of wax, reasonable savings can be made on total wax cost, as well as savings on waste disposal of surplus wax produced by the foundry.

Reclaim and Reconstitution of Wax for Runner Systems and Pattern Production

The development of the process of reclaim and reconstitution of wax has proved a major advancement in wax technology. It has enabled Blayson to reclaim and reconstitute autoclaved wax (unfilled, emulsified or filled) within a specification to that of virgin wax. Although all three categories of wax can be reclaimed and reconstituted, it is the reclaim and reconstitution of filled wax that provides the greatest advancement to the industry. It also represents the greatest cost and environmental savings a foundry can make when reviewing wax.

To achieve the most satisfactory result, a series of critical points must be considered. These are shown in Table III. At this point it is necessary to mention that all work on filled wax referred to in this paper has been carried out on Blayson Olefines FR range of filled wax.

(a) As a start it is necessary for the foundry to approve a filled wax compound that will of course contain the necessary materials that will allow reconstitution.

(b) It is imperative to use a virgin filled wax that will resist oxidation. If a wax is to be reclaimed and reconstituted and used again for pattern production, it is important to use a wax that will not oxidise with heating or continuous use. It should not separate and break down causing dimensional variation, surface finish problems and changes in flowability etc.

(c) Use of a non-sticky virgin filled wax is a further major consideration. It is an advantage to use such a non-sticky wax from the FR range to enhance easy removal of

the wax pattern from the die, but equally importantly it reduces or in some cases eliminates the need for silicon release agent. This reduction in the use of silicon cuts down on a potential source of contamination during the reclaim and reconstitution stage. It must be stressed however, if a silicon is used then it must always be thoroughly washed from the wax before being re-used or sent for reclamation.

(d) Having decided on the most suitable grade of FR filled wax for use it is necessary to ensure that only one base wax material is in the foundry's wax system. Mixing pattern wax with different wax bases will contaminate the reconstituted blend and therefore cause possible variations in the specification of the material. Of course mixing pattern wax compounds of the same base wax will not present such a problem.

(e) A separate runner wax should not be used in the system unless it is of an FR base. All material for reclamation should be sent to Blayson for processing, so as to avoid contamination form elsewhere, and then specific quantities of the used wax can be divided into material for reclamation as runner wax and/or material to be reconstituted fro pattern wax.

Processing of Autoclaved Filled Wax for Reclaim and Reconstitution

The flow chart shown in Fig. 1 indicates the way in which autoclaved wax can be treated during the process of reclaim and reconstitution.

Quality control procedures are no different to those applied to virgin wax except for some additional tests required by the reclamation route. Wax from the foundry is firstly melted down and water and extraneous matter are eliminated from the wax. The filler material is thoroughly cleaned and blended back into the final compound. The reclaimed wax can then follow one of two routes. It can either be returned as runner wax or be reconstituted to a pattern wax specification and then returned to the foundry.

(a) Reclaim wax for runner systems.

When considering reclaim for runner systems, Blayson usually recommends reclaiming and retaining the filler material still suspended in the final product. This gives the following advantages to the runner wax as shown in Table IV.

If it is necessary the runner material can be modified in agreement with the foundry to reduce melting point and to give flowability of the wax when dewaxing.

(b) Reclaim and reconstituted wax for patterns.

Providing the guidelines as previously stated are followed at all stages then results of reconstitution are very good. A complete variety of wax patterns can be produced in reconstituted wax and examples of these are shown in the slides.

(c) Monitoring reclaim and reconstituted wax.

It is of course extremely important that the wax manufacturer maintains total quality control over the process. The incoming material from a foundry would be tested and

any recommendations necessary would be made regarding the general condition of the wax. During the subsequent processing of the wax, various standard tests would be carried out. For example, ash content, congealing point, penetration, viscosity, filler and water content would all be determined. From the results additions are made in order to reconstitute the wax back to the specifications of the original virgin material. Dimensional test results obtained for reclaim and reconstituted wax have proved that it has the same dimensional repeatability as the virgin FR range of wax.

ECONOMICS OF CHANGING PATTERN AND RUNNER WAX

Introduction

Without wishing to repeat what has been said many times before, those people who have been involved in a change of a critical raw material such as wax will know that in the past, once you have validated a part in a certain wax, it was difficult to change.

As the words 'PRECISION CASTING' imply, the wax plays a vital part, to say the least, in the dimensional stability of the end product, but unfortunately, gone are the days when to change would never be considered.

With the help of your wax supplier and the use of statistics, the change can be made to a more stable and cost effective wax.

At CENTAUR PRECISION LTD we have changed pattern/runner wax twice in the last twelve years, with the view to improving pattern quality and a more dimensionally stable product and course, the reduction in the cost.

The waxes used over this period were A7-DER/10/E, A7-FD/74 and our current wax A7-FR/60 Reconstituted. All supplied by BLAYSON OLEFINES LTD.

Due to a management re-organisation in 1980 and at the same time, Sheffield Polytechnic promoting coursed on S.P.C, the first seeds were sown that would change the way we approached Control; changing Process Control to Statistical Process Control.

Why change?

CHANGE IS A MATTER OF VIEW.
Our old view was about inspection.
The new view would be about the design of the process.
CHANGE IS A MATTER OF APPROACH.
The old approach says if quality remains the same, everything will be O.K.

The new approach says you should have continual improvement.
CHANGE IS ABOUT METHOD.
The old method says used go, no go gauges.
The new method says it is careful detailed measurement.
CHANGE IS ABOUT OWNERSHIP.
The old says it is the job of the Process Controller or quality section to control the process.
The new says it is everyone that is involved with the process and the ownership of the quality.
The first data collection system used vernier callipers to check wax patterns. After manually recording the mean and standard deviation hand control charts would be produced.
Selection of parts from production being carried out on a random basis ensuring some of the more critical parts included. Initially, dimensions were taken over the whole of the batch – 100%, until enough data was available to take samples. This evolved into 100% checks on batches of 50 parts or less. Larger batches having 25-30% of parts checked. Due to the rapid accumulation of data and the associated problems of hand created control charts, an electronic data logging system was very quickly introduced.

Prior to the introduction of an SPC System, cast scrap (due to dimensional problems) equated to approximately 3% of Scales Value. Now in 1995 with a fully networked P.C controlled system, this figure is 0.3%.
Coupled with the data collection on wax patterns, an investigation into the variation of machine control parameters was instigated.

A “stepped” test block die was produced as a vehicle for testing the variables. Appendix 1.

Parameters investigated

	Parameter	**Variable**
1.	Wax pattern temperature	Standard 70 Deg. C
2.	Injection pressure	200, 300, 400 psi
3.	Wax flow rate	Valve Setting 200
4.	Acceleration	50 – 150 – 250
5.	Cycle time (dwell)	20, 40, 60 seconds
6.	Die temperature	Patterns produced until die stabilisation then record (24 to 26 Deg. C)

With data being collected in each area coupled with the database information on dimensions, a picture gradually emerged on how further gains could be made in productivity by closer control on these parameters.

The minimum size recorded was 149.04 and the maximum size of 149.55, the difference being 0.51mm. This information was then used in a training module for wax injection, which puts emphasis on what changes can do to the wax pattern size. Appendix 2.

At Centaur, our injection technique not only carries information on machine settings but also the method of die strip and die build to assist in the repeatability irrespective of operator.

We do realise that at times, operators will “Tweak” the machine settings. These changes are recorded on a “DEVIATION FORM TECHNIQUE” sheet and sent for checks against control charts.
As and when any change is made, the start point must be from some sort of database. In our case we have the advantage of a “Statistical Process Control” network throughout the factory. At a later stage, the information gathered from the test was fed into a design case experiment software; from this we could then view interaction plots and interpret two factors. Appendix 3.

The initial evaluation

The reasons for the replacement of A7-DER/10/E by A7-FD/74 were listed, discussed and tabled in December 1986.

A7-FD/74 being a neutral filled wax would give the following improvements or benefits: -

1) Less machine corrosion and hence better machine life.
2) No water to evaporate, which alters the composition of the wax and requires consistent
   parameter changes during a shift, which should maintain capability thereby giving better
   quality and yield.
3) Possible quicker start time.
4) Elimination of bubbles caused by water, therefore reduction in trim and assembly time.
5) The possibility of total reclaim to produce a consistent product for both patterns and runners,
   the goal being to save 20K per year.

The above was good enough incentive to change, although item 5 was not achieved as the reconstituted wax at this time was not suitable for producing consistent size patterns. A7-FD/74 was used for production of all wax patterns from early 1987.

Pattern quality was much improved using A7-FD/74, the wax being more tolerant to variations in machine parameters due to the elimination of the water content and the introduction of new materials.

In late 1992, first trials with A7-FR/60 pattern wax started. This material having several performance advantages over A7-FR/74: -

1) Improved surface finish.
2) Very stable compound suitable for reconstitution.
3) Suitable for paste injection.

From July 1993, all patterns were being produced in A7-FR/60, trials with reconstitution being well advanced.

Today, reconstituted wax produces 47% of pattern requirement. This figure will continue to increase. In June 1995, Centaur started to use on production the reclaimed wax for runners. This wax can be de-waxed as normal and returned to Blayson for returning back to reconstituted wax.

Having developed a very comprehensive database using SPC methods, the process of changing pattern waxes twice and the rapid introduction of full wax reconstitution without any modification to pattern die cavities, shows what can be done when working in conjunction with the wax supplier and equally the understanding of change, not only a raw material change but also a change in the way we think.

APPENDIX 4. CENTAUR'S MUELLER PHIPPS PASTE INJECTION MACHINE.
APPENDIX 5. THE WAX SPC STATION.
APPENDIX 6. X BAR CONTROL CHART.

Table I: Controls criteria for wax for reclamation

a) Waste products must not be mixed with the wax, e.g. foundry floor waste, boots, gloves, bottles, cans and broken shell etc should be kept.

b) The amount of silicon used in the process should be reduced as far as possible.

c) Water mixed with the wax during dewaxing should be kept to a minimum.

d) The use of a simple filter cloth placed over the autoclave tray can prevent ceramic sand entering the wax during the dewaxing process.

e) The size of autoclaved wax blocks should be considered to enable easy packing onto pallets and to make optimum use of transport.

f) The wax blocks should be strapped and wrapped to further reduce the chance of contamination while being stored or during transportation.

Table II: Routes to wax reclamation

1) Reclaim of wax for runner systems only.
2) Reclaim of wax for runner systems and pattern production.
3) Reclaim and reconstitution of wax for runner systems and pattern production.

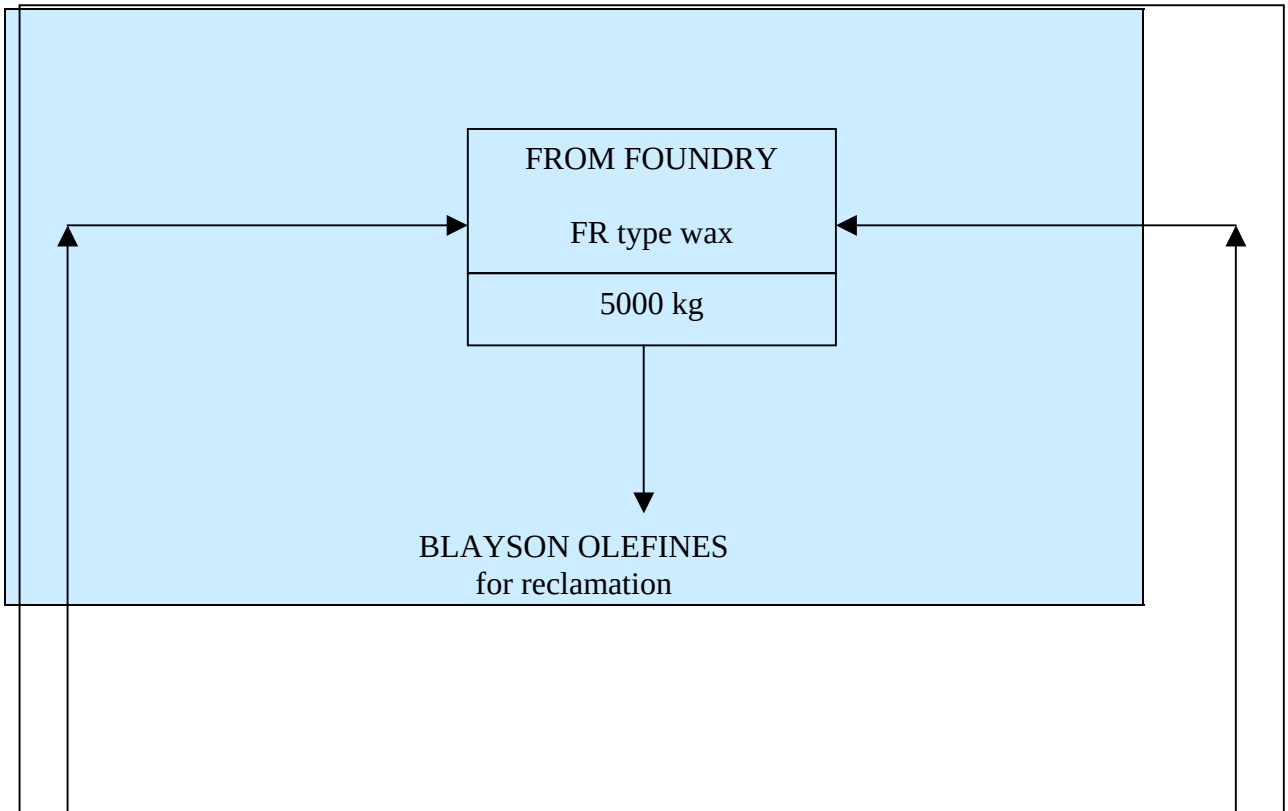
Table III: Critical points when considering reclaim and reconstitution of wax

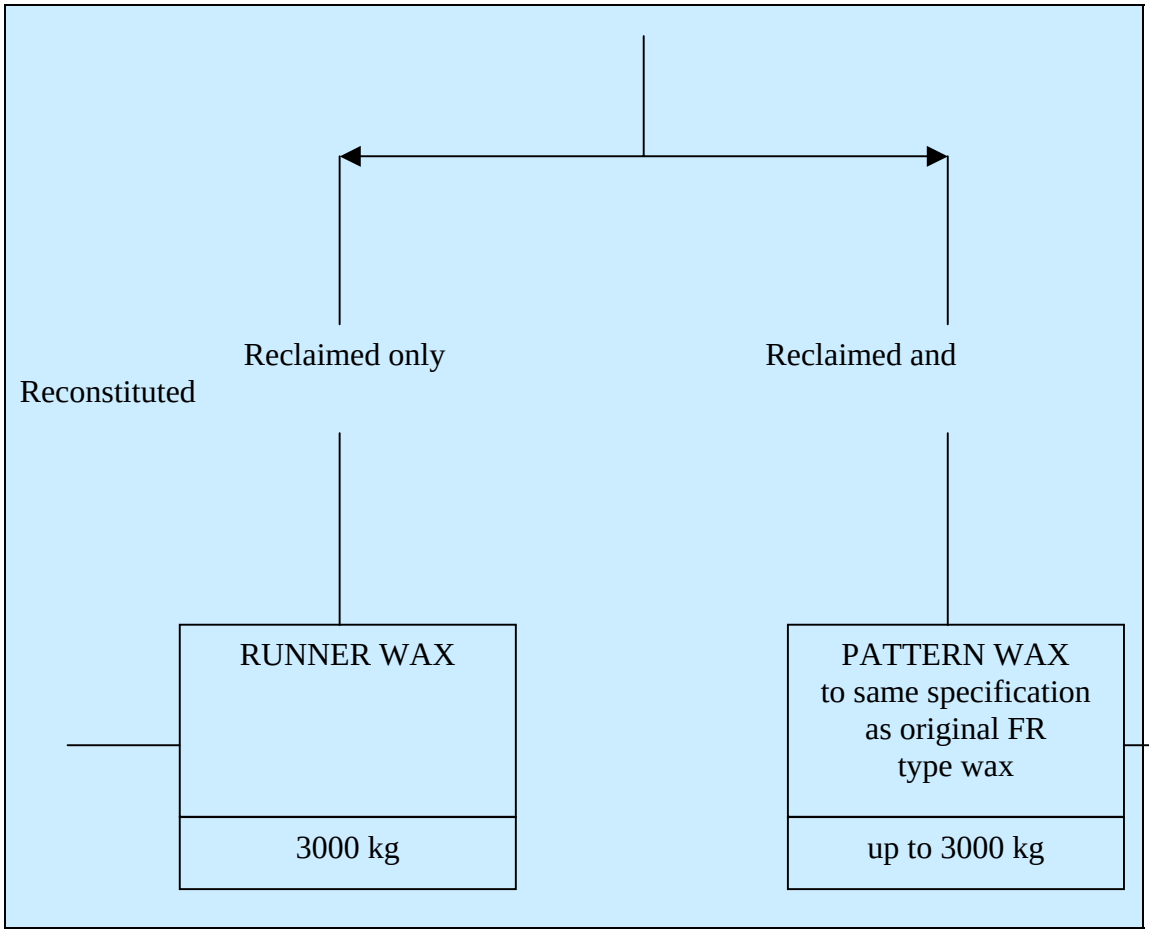
a) Approve a wax that contains necessary materials for reconstitution.
b) Imperative to use virgin wax that will resist oxidation.
c) Use non-sticky virgin wax to help reduce silicon reduce requirement.
d) Ensure only one base wax is used in a foundry's wax system.
e) A separate runner wax of different base should not be used in the system.

Table IV: Advantages of runner reclaim wax with retained filler material

a) Improved injection flowability
b) A quicker setting wax
c) A more stable wax with less distortion

Flow Chart (Fig. 1)




Reclaimed only
Reclaimed and
Reconstituted
RUNNER WAX
3000 kg
PATTERN WAX
to same specification
as original FR
type wax
up to 3000 kg

Blayson

Blayson Olefines Ltd
Investment Casting Wax