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INVESTING AND CASTING TECHNIQUE

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Recent impression techniques provide the opportunity for making working models and dies with extremely small dimensional changes.

The procedure that yields accurate dies demands similar precision in the work of making the cast so that correction on trying in the mouth should rarely be necessary. The waxing, investing and casting processes must therefore be such as may be relied upon to provide accurately fitting castings.

The evolution of the technique described in this article has been based on the following requirements.

(1) The die should never be deformed by the casting.

(2) The casting should be a little too large, leaving a gap of 20—50 μ for the cement between the inner surface of the casting and the tooth preparation.

(3) The technique should not involve unnecessary loss of time or excessive material costs.

(4) The technique should be standardized over all critical stages.

MANIPULATION OF THE WAX

The pattern which is made in inlay casting wax must fit the die accurately and reach to the margin of the preparation. If the wax is placed in an undercut it will rupture at the widest part when the pattern is removed. If the pattern slides over such a point without rupturing it will be distorted. The wax is then too soft and plastic. A casting wax should therefore be hard and fairly brittle.

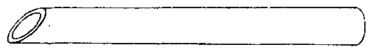

Fig. 1. The tubular sprue pin.

If the thickness of the walls of a pattern is greater than the stated above wider sprues must be used since the canals from the reservoir must always be wider than the widest part of the wax pattern.

In such cases it is possible to make tubes of convenient diameter by rolling copper sheet into tubes and soldering. Another way is to melt low-fusing wax on 2 mm tube to the required thickness with the aid of a Miller loop.

Attaching the sprue pin. The sprue pin should always be placed in the thickest part of the wax pattern. The last of the melt in the mould may then harden and draw sufficient molten

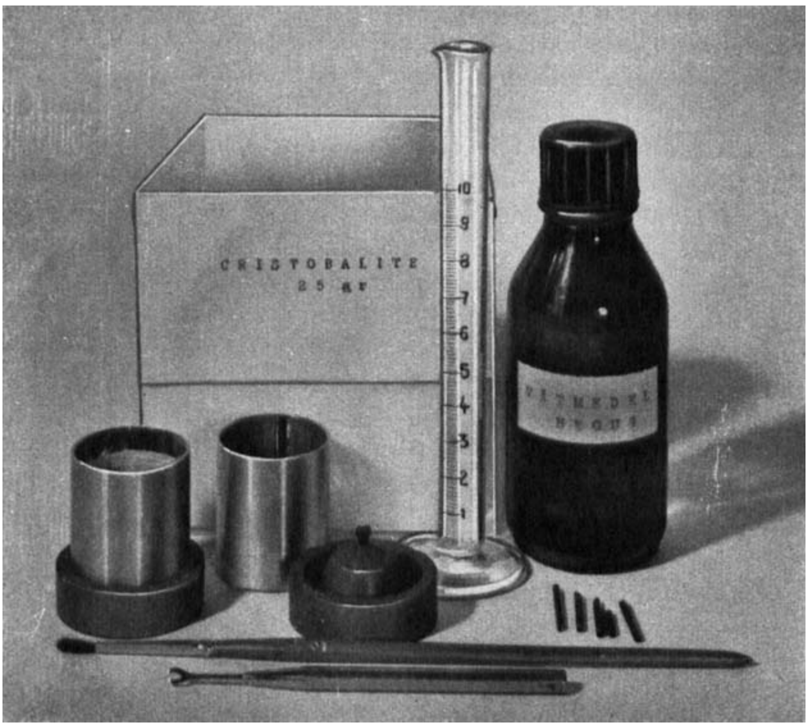

Fig. 2. Accessories for waxing up and investing.

alloy from the excess to compensate for contraction on cooling. If there are two or more wide parts connected by narrower parts, each of them should have a wax sprue pin; all of them are joined to a main copper pin.

The sprue pin is placed in such a direction that the stream of molten metal is not forced to deviate greatly from the direction of the pressure applied in casting.

When the pattern is to be removed from the die the sprue pin should be so located that the tension does not cause deformation of the pattern.

The sprue pin on attaching should be *carefully warmed* and placed on the pattern. One should avoid pushing the pin right through the wax. If it is necessary to melt on further wax for fixing the sprue pin, a Miller loop is used.

INVESTING THE PATTERN

Flask. The flask used for this technique consists of a steel cylinder with external and internal diameters of 32 and 29 mm, respectively. The standard length is 38 mm, but other lengths may be used. The distance from the bottom of the cylinder to the wax pattern should be 6—8 mm. So thick a bottom layer will withstand the casting pressure but still be porous enough to allow air to pass easily on casting.

Asbestos liner. The cylinder has an asbestos liner, the compressibility of which permits expansion of the investment. For standard flasks an asbestos rectangle of 93×31 mm is used. It is laid in the flask, dampened and pressed lightly against the wall. If maximum expansion of the investment is required a double thickness of asbestos may be used. The flask should be free of asbestos a 5 mm space at the top of the cylinder and 2—3 mm at the bottom. If the asbestos covers the whole surface asbestos fibre may be worn off and lie in the mouth of the sprue on boiling out the wax.

Investment. Gold alloys of various types have a linear casting contraction of 1.5—1.7 per cent. (*Hollenback*, 1951). Most sources (*Appel*, 1938, for example) give a total value of 1.60—1.65 per cent. for setting and thermal expansion of different investment materials. The contraction of gold alloy can thus be compensated completely under favourable conditions. Kerr, Christobalite, which is used by the authors, has the highest expansion and most uniform quality.[1]

So as to have always the same value for expansion, constant quantities of investment material and distilled water are used (25 g[2] *and 10 cc). The investment powder is weighed accurately and kept in dry airtight bags.*

The water should be distilled or boiled so that dissolved gases do not form bubbles in the spatulated mix or the chemicals present in the water supply influence the hardening of the investment and its expansion.

The ratio of the quantities used is chosen to give the highest expansion with a mix of workable consistency.

In variation in expansion are required it is best to increase or decrease the quantity of water, small changes in which give proportionate changes in the expansion values (*Moore*, 1952; et al.).

If the maximum setting and thermal expansion of the investment is used, contraction of the metal alloy is just compensated. As mentioned above the casting must be slightly too large and the authors require a linear expansion of the investment of 2.0—2.2 per cent., a figure obtained be making use also of the *hygroscopic expansion*, the value of which is partly dependent on the time between the beginning of the spatulation and placing the filled flask in water (Fig. 3).

The investing process. For the outlined technique an elastic rubber cone similar to that illustrated in Fig. 4 is used.

The sprue pin is placed in the cone so that the length of the sprue canal is not more than 2 mm; a short sprue ensures utilization of excess metal as a reservoir. The pin may be waxed to the cone. If greater width of the sprue canal is required more low-fusing wax is melted on the tube with a Miller loop.

If Kerr Microfilm is used for lubricating the die the wax pattern need not be washed. In any case it is necessary to avoid using fatty substances of any type (vaselin, mineral oil, etc.) as a die lubricant. The rubber cone is brushed with a lubricant to facilitate removal from the investment.

[1] *Kerr* Christobalite appears to undergo some changes on prolonged storage; it is therefore advisable to replenish stock frequently.

[2] 25 g is convenient quantity for the flask in question.

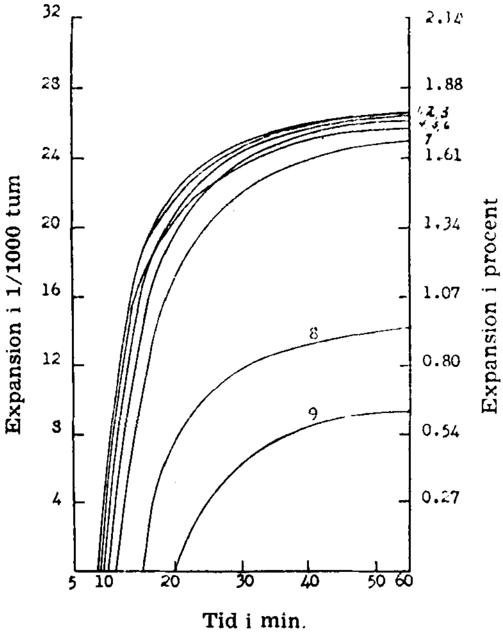

Fig. 3. The dependence of the hygroscopic expansion on the interval between beginning of the spatulation and placing it in the water-bath. (Landgren & Peyton, Journal of Dental Research, 29: 469—481).

The weighed quantity of investment powder (25 g) and (10 cc) water are mixed under vibration and stirred carefully with a spatula for one minute. The mix is then vibrated in the plaster bowl for 15—30 seconds.

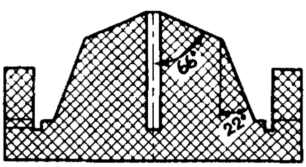

Fig. 4. The rubber cone.

Fig. 5. Rubber cone with finished wax pattern.

Fig. 6. The wetting agent is brushed over the surface of the pattern.

A thin layer of wetting agent[1] is painted over the whole wax pattern.

During vibration a layer of the investment is brushed over the damp wax pattern (Fig. 7); this layer will then be bubble-free.

The flask with its asbestos liner is placed on the cone.

During vibration the investment is poured in the flask so that it flows down one side of the flask and fills it from the bottom. When the wax pattern has been covered with investment the flask is filled without vibration.

Hygroscopic expansion. Immediately after filling the flask it is placed in a thermostatically controlled water bath at 37—40° C. The water should cover the flask which should remain in the bath for at least 30 minutes, and preferably one hour.

[1] The wetting agent should prevent the formation of foam as well as reduce the surface tension.

Fig. 7. During vibration the investment is brushed over the pattern.

REMOVAL OF WAX

The casting cone and sprue pin are removed and the flask placed in a saucepan with a 10 per cent. soda solution (40—60° C.). The vessel should have a grid in the bottom on which the flask stands. The solution, which should cover the flask to some depth, is brought to boiling point, and after 1—4 minutes the wax will flow out of the flask. This method of removing the wax does not impair the investment and ensures a smooth surface for the casting.

BURNOUT

The furnace should be electrically heated and fitted with a rheostat and pyrometer. It should be very close to the casting apparatus. The flask having been removed from the boiling water, it is placed in the cold furnace. For the first 15 minutes the temperature is raised gradually to 120—130° C. Too rapid heating at this stage results in violent boiling of the excess water and incurs a risk of rupturing the investment, with rough castings as a result. The furnace door is left open during the first 15 minutes to allow unimpeded escape of the steam.

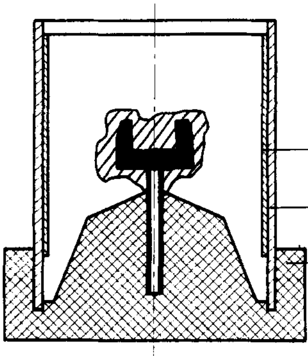

Fig. 8. Sectional diagram of cone and flask after the latter has been placed in the cone. Note that the asbestos liner does not reach the rim of the flask.

The temperature is then slowly increased so that 550° C. is reached after 60—75 minutes and this level is maintained for at least 20 minutes,[1] after which the casting may be proceeded with. At 550° C. the rapid thermal expansion of the investment will have reached its maximum. It has been found empirically that the greatest dimensions of the casting are reached at this temperature of the investment.

In restorations where wrought retention pins are used the temperature is raised to about 650° C. This ensures a strong joint between the gold alloy and the metal pin.

CASTING PROCEDURE

Casting apparatus. For casting, a specially designed horizontal centrifugal machine is used (Fig. 9). It is driven by a rubber band which provides considerably greater acceleration than a

[1] The authors have found, that there is a delay of 18—20 minutes before the inner part of the investment reaches the temperature of the outer surface of the flask.

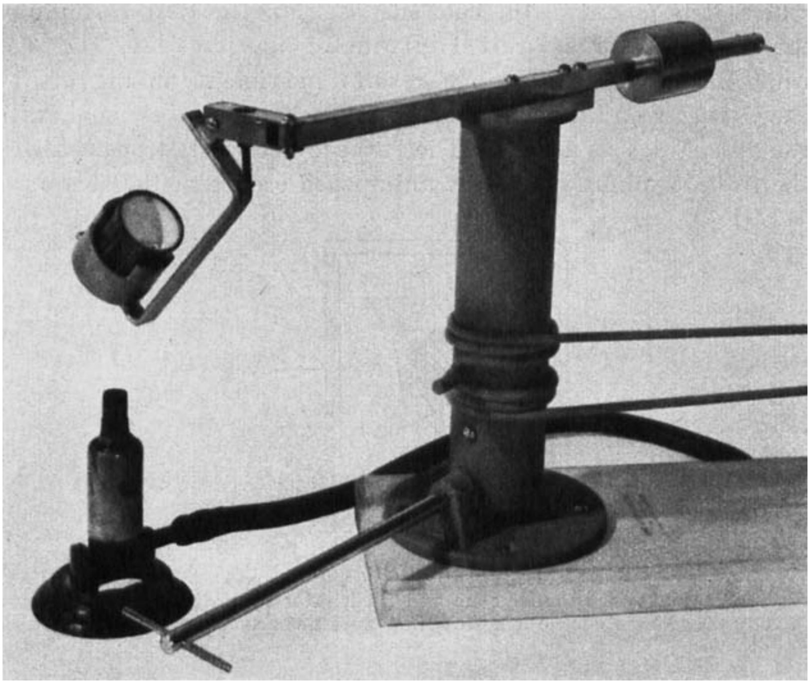

Fig. 9. The casting apparatus.

metal spring. The initial speed may be very high. Ball bearings are used.

The arm which supports the flask holder is articulated to the rotary arm. It oscillates through a maximum angle of 240° with no resistance other than that due to friction in the suspension. (Fig. 10.)

The flask holder, which is a continuation of this arm, makes an angle to the horizontal which may be varied between 30 and 45°. By virtue of this inclined position of the flask and the shape of the cone — an obtuse angle at one half the height of the cone — the metal alloy will melt in the angle area without covering the mouth of the sprue. For this reason the diameter of the sprue is not limited by the presence of the melt and it can be made wide enough for the excess casting metal to function as a reservoir. (It is important to use a large excess of alloy as the casting pressure is then increased).

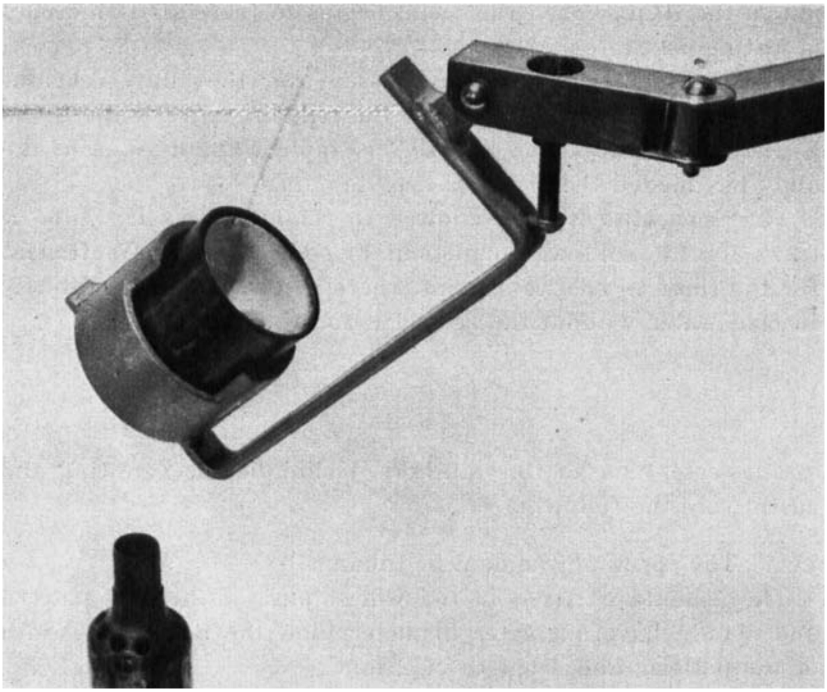

Fig. 10. The flask-holder and the rotating arm.

Since the metal is melted in the flask there is no risk that the flask will be cooled to any great degree, as is the case with the usual designs of horizontal casting apparatus, where the alloy is melted in a separate crucible. During the whole melting procedure heat is supplied to the flask from the flame.

Moreover, the molten metal has a short distance to travel so that it is unable to cool off so much as in the crucible before reaching the mouth of the sprue. It need not, therefore, be overheated as much as when using these earlier types of horizontal casting apparatus. The short distance also involves less contact with the air, with the result that the casting will be denser.

Casting. The heated flask is placed in the casting apparatus after winding it up. Under the flask holder is placed a small gas flame (from a bunsen burner, for example,) that prevents the temperature of the flask from falling while the alloy is being put in the flask. When the metal begins to fuse this flame may be extinguished.

The melting flame is firstly passed over the alloy. When it begins to take on a light red hue the reducing part of the flame is directed on the metal. The flux is applied and as soon as the alloy has melted the arm is released.

The apparatus is then allowed to rotate freely. The time it takes for the rotating component to come to rest is sufficient for the flask to cool to a point where it may be placed directly in cold water without the risk of deforming the cast.

SUMMARY

The essentials of the authors' technique for investing and casting are the following.

(1) The sprue pins should be tubular.

They should be fixed in the widest part of the wax pattern and should have a greater diameter than the maximum width of the pattern, and a length of 2 mm.

After fixing the sprue pins the wax pattern should be cooled in water at 15—17° C. while it is still on the die.

The pattern with the pins is placed on the cone, the surface of which is painted with a lubricant.

(2) The flask is lined with damp asbestos.

(3) 25 g Kerr Cristobalite investment is mixed with 10 cc distilled water under vibration, until a smooth bubble-free consistency is obtained.

(4) The pattern is brushed with a wetting agent.

While the pattern is still wet the investment is brushed on the pattern during vibration.

(5) The flask is placed on the cone.

(6) The investment is poured into the flask during vibration. The mix runs down along one side of the flask and fills it from the bottom. When the wax pattern is covered the flask is filled by hand.

(7) The filled flask is placed in a thermostatically controlled water-bath at 37—40° C. and left to stand for 30—60 minutes.

(8) The cone and sprue pin are removed.

(9) The flask is placed upright on a grid in a saucepan containing 10 per cent. soda solution (40—60° C.) which should cover the flask liberally. The wax is removed by boiling for 5—6 minutes.

(10) The flask is immediately placed in a cold oven. The temperature is raised slowly during the first 15 minutes to 120—130° C. and then increased to 550° C. over 75 minutes (to 650° C. if wrought clasp pins are used) and held at this level for 20—25 minutes.

(11) The casting apparatus is wound up and fixed.

(12) The flask is placed in the flask-holder and the flame placed beneath it.

(13) The cast alloy is placed in the flask and the fusion performed with a special flame.

The fusion should be carried out fairly slowly — over 1—1½ minutes.

(14) As soon as the alloy has melted the rubber spring is released. The apparatus is allowed to rotate freely.

(15) When the rotating component has stopped the flask may be cooled directly in cold water.

(16) The sprue is sawn off (Pliers should not be used).

ZUSAMMENFASSUNG

STANDARDISIERTE EINBETTUNGS- UND GUSS-TECHNIK

Die heutigen Abdruckmethoden geben uns die Möglichkeit, Arbeits- und Präparationsmodelle mit ausserordentlich geringen dimensionellen Abweichungen herzustellen.

Die Technik, die uns exakte Modelle gibt, fordert eine solche Genauigkeit in der Arbeit bei der Herstellung einer Konstruktion, dass eine Korrektur beim Einpassen in den Mund nur in Ausnahmefällen vorkommen soll. Die Wachsbehandlungs-, Einbettungs- und Guss-Technik, die man anwenden muss, soll daher so sein, dass die erzielten Güsse genau die gewünschte Passform haben.

Beim Ausarbeiten der Technik, welche die Verfasser im folgenden beschreiben, sind nachstehende Forderungen aufgestellt worden:

1. Der Guss darf nie mit Gewalt auf das Präparationsmodell gepresst werden.
2. Die gegossene Konstruktion muss um so viel zu gross sein, dass sie einen Spielraum von 20—50 μ für das Zement zwischen der Innenseite der Krone und der Oberfläche des Pfeilers gewährt.
3. Die Technik darf weder grösseren Zeitverlust noch grössere Materialkosten mit sich führen.
4. Die Technik soll so standardisiert sein, dass sie auf alle kritischen Momente Rücksicht nimmt.

Die folgende schematische Übersicht ist eine Zusammenfassung der von den Verfassern vorgeschlagenen standardisierten Einbettungs- und Guss-Technik.

1. a) Als Gusskanalstifte sollen Röhrchen verwandt werden.
   b) Der Gusskanalstift soll am dicksten Teil des Wachsmodelles befestigt werden und soll einen Durchmesser haben, der grösser ist als das Mass der dicksten Stelle des Modelles, sowie eine Länge von höchstens 2 mm.
   c) Das Wachsmodell soll nach Fixierung des Gusstiftes und während es noch auf dem Präparationsmodell sitzt, in Wasser von 15—17° C gekühlt werden.
   d) Das mit Gusstift versehende Wachsmodell wird auf einen Gusskegel gesetzt, dessen Oberfläche mit Seifenspiritus bepinselt wird.
2. Die Küvette wird mit feuchtem Asbest ausgefüttert.
3. 25 g Kerr Christobalite werden mit 10 cm^3 abgekochtem destilliertem Wasser unter Vibration gemischt bis man eine blasenfreie, gleichmässige Konsistenz erhält.
4. a) Das Wachsmodell wird mit einer oberflächenspannungherabsetzenden Flüssigkeit gepinselt.
   b) Während das Wachsmodell noch hiervon feucht ist, pinselt man unter gleichzeitiger Vibration Einbettungsmasse auf die Wachskonstruktion.
5. Die Küvette wird auf den Gusskegel gesetzt.
6. Die Einbettungsmasse wird unter Vibration in die Küvette gegossen. (Man beachte, dass die Masse an der einen Küvettenseite entlang herabfliessen soll und die Küvette vom Boden her gefüllt wird. Wenn das Wachsmodell bedeckt ist, wird die Küvette ohne Vibration aufgefüllt.)

7. Die gefüllte Küvette soll in einem thermostatisch regulierten Wasserbad von 37—40° C 30—60 Minuten stehen.
8. Gusskegel und Gusstift werden entfernt.
9. In einem Topf mit warmer 10 %-iger Sodalösung (40—60° C) wird die Küvette stehend auf einem Bodengitter placiert. Die Sodalösung soll die Küvette gut bedecken. Das Wachs wird durch 5—6 minütiges Kochen der Lösung eliminiert.
10. Die Küvette wird unmittelbar in den kalten Ofen gestellt. Die Temperatur wird während der ersten 15 Minuten langsam auf 120—130° C gebracht und dann im Verlauf von 75 Minuten auf 550° C gesteigert (bei Verwendung von Goldplatin- oder Pontostiften auf 650° C) und 20—25 Minuten gehalten.
11. Der Gussapparat wird gespannt und fixiert.
12. Die Küvette wird in den Küvettenhalter gebracht und eine Flamme unter diesen gestellt.
13. a) Die Gusslegierung wird in die Küvette gelegt und die Schmelzung mit spezieller Flamme ausgeführt.
    b) Das Schmelzen soll verhältnismässig langsam erfolgen; 1—1,5 Minuten.
14. a) Sobald die Legierung geschmolzen ist, soll der Guss erfolgen.
    b) Der Apparat soll ohne Bremsung rotieren.
15. Sowie der Apparat zum Stehen kommt, kann die Küvette direkt in kaltem Wasser abgekühlt werden.
16. Der Gusskanal wird abgesägt (keine Beisszange verwenden!).

RÉSUMÉ

STANDARDISATION DE LA TECHNIQUE D'ENROBAGE ET DE COULÉE

Les méthodes d'empreinte actuelles nous ont donné la possibilité de produire des modèles de travail et d'élaboration avec des écarts dimensionnels excessivement faibles.

La technique qui nous donne des modèles exacts nécessite une telle précision de travail dans la production de la construction que les retouches, lors de l'adaptation dans la bouche, doivent appartenir aux cas exceptionnels. La technique du traitement

à la cire, de l'enrobage et la coulée à utiliser doit donc être telle que les lingots obtenus ont exactement la forme d'adaptation désirée.

Au cours de l'élaboration de la technique décrite ci-dessous par les auteurs, nous nous sommes basés sur les facteurs suivants:

1. Le modèle d'élaboration ne doit jamais forcer avec le lingot.
2. La construction coulée doit être assez grande pour pouvoir laisser un intervalle de 20—50 μ pour le ciment entre la surface intérieure de la couronne et celle du pilier.
3. La technique ne doit pas impliquer un accroissement des pertes de temps ou des frais de matière.
4. La technique doit être standardisée de manière à couvrir tous les moments "critiques".

L'aperçu schématique suivant est un résumé de la technique standardisée d'enrobage et de coulée, proposée par les auteurs.

1. a) Des pivots tubulaires de canal de coulée doivent être utilisés.
   b) Le pivot du canal de coulée est fixé dans la partie la plus épaisse du modèle de cire et doit avoir un diamètre supérieur à la plus grande épaisseur du modèle et une longueur de 2 mm au maximum.
   c) Après la fixation du pivot de coulée, la construction de cire doit être refroidie dans de l'eau à 15—17° C, pendant qu'elle est encore sur le modèle d'élaboration.
   d) Le modèle de cire pourvu du pivot de coulée doit être placé sur le cône de coulée dont la surface est badigeonnée avec du liniment savonneux alcoolique.
2. La cuvette est revêtue intérieurement d'amiante humide.
3. 25 gr de cristobalite Kerr sont mélangés à 10 cm^3 d'eau distillée bouillie, avec agitation et jusqu'à ce qu'une masse uniforme et libre de bulles d'air soit obtenue.
4. a) Le modèle de cire est badigeonné avec un agent humecteur.
   b) Le modèle de cire toujours humide, la masse d'enrobage est badigeonnée sur la construction de cire, tout en effectuant des vibrations.
5. La cuvette est placée sur le cône de coulée.

6. La masse d'enrobage est mise dans la cuvette. Cette opération s'effectue avec des mouvements vibratoires. (Il faut veiller à ce que la masse coule sur l'un des côtés de la cuvette et remplit cette dernière à partir du fond). Lorsque le modèle de cire est recouvert, la cuvette est remplie à la main.
7. La cuvette pleine est placée dans un bain d'eau à 37—40° C (température réglée par un thermostat) et y séjourne pendant 30—60 minutes.
8. Le cône de coulée et le pivot de coulée sont enlevés.
9. La cuvette est placée sur champ dans une casserole avec une solution de soude chaude à 10 % (40—60°) et avec une grille du fond. La solution doit immerger la' cuvette. La cire est enlevée par ébullition de l'eau pendant 5—6 minutes.
10. La cuvette est immédiatement placée dans un four froid. La température est lentement élevée pendant le premier quart d'heure jusqu'à 120 130° C, pour atteindre ensuite 550° C pendant les 75 minutes suivantes (jusqu' à 650° C si des pivots "clasp" ou "ponto" sont utilisés). Cette température est maintenue pendant 20—25 minutes.
11. L'appareil de coulée est tendu et fixé.
12. La cuvette est mise sur son support et placée sur la flamme.
13. a) L'alliage de coulée est mis dans la cuvette. La fusion est exécutée avec une flamme spéciale.
    b) La fusion doit se faire relativement lentement, 1—1,5 min.
14. a) Dès que l'alliage a fondu, exécuter les vibrations.
    b) L'appareil de coulée peut tourner sans être freiné.
15. Après l'arrêt de l'appareil de coulée, la cuvette peut être directement remplie d'eau froide.
16. Le canal de coulé est scié (Ne pas employer de pince coupante ou de tenailles).

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