GYPSUM PRODUCTS

BY
DR KHAWAJA RASHID HASSAN
HEAD SCIENCE OF DENTAL MATERIALS DEPARTMENT
RAWAL COLLEGE OF DENTISTRY
ISLAMABAD

IMPORTANT TERMS

CAST / MODEL:

A replica of several teeth and their associated soft tissues or an edentulous arch.

DIE:

Replica of a single prepared tooth.

MODEL PLASTER:

Weakest and most porous form of gypsum product used in dentistry.

DENTAL STONE:

A stronger and less porous form of gypsum product used in dentistry.

DIE STONE:

The densest form of gypsum product used in dentistry.

IMPORTANT TERMS

DIAGNOSTIC CASTS:

The casts generally used for patient education, treatment planning or tracking the progress of treatment. (e.g. orthodontic models)

WORKING CAST:

The cast that is strong enough to resist the stresses of fabricating an indirect restoration or prosthesis.

POURING:

The process of vibrating the flowable gypsum product into the impression.

IMPORTANT TERMS

GYPSUM DENTAL INVESTMENT:

A refractory material, consisting of silica and gypsum as a binder. Used for taking moulds for metal casting process.

HYGROSCOPIC SETTING EXPANSION:

The amount of setting expansion that occurs when the gypsum bonded casting investment is immersed in water.

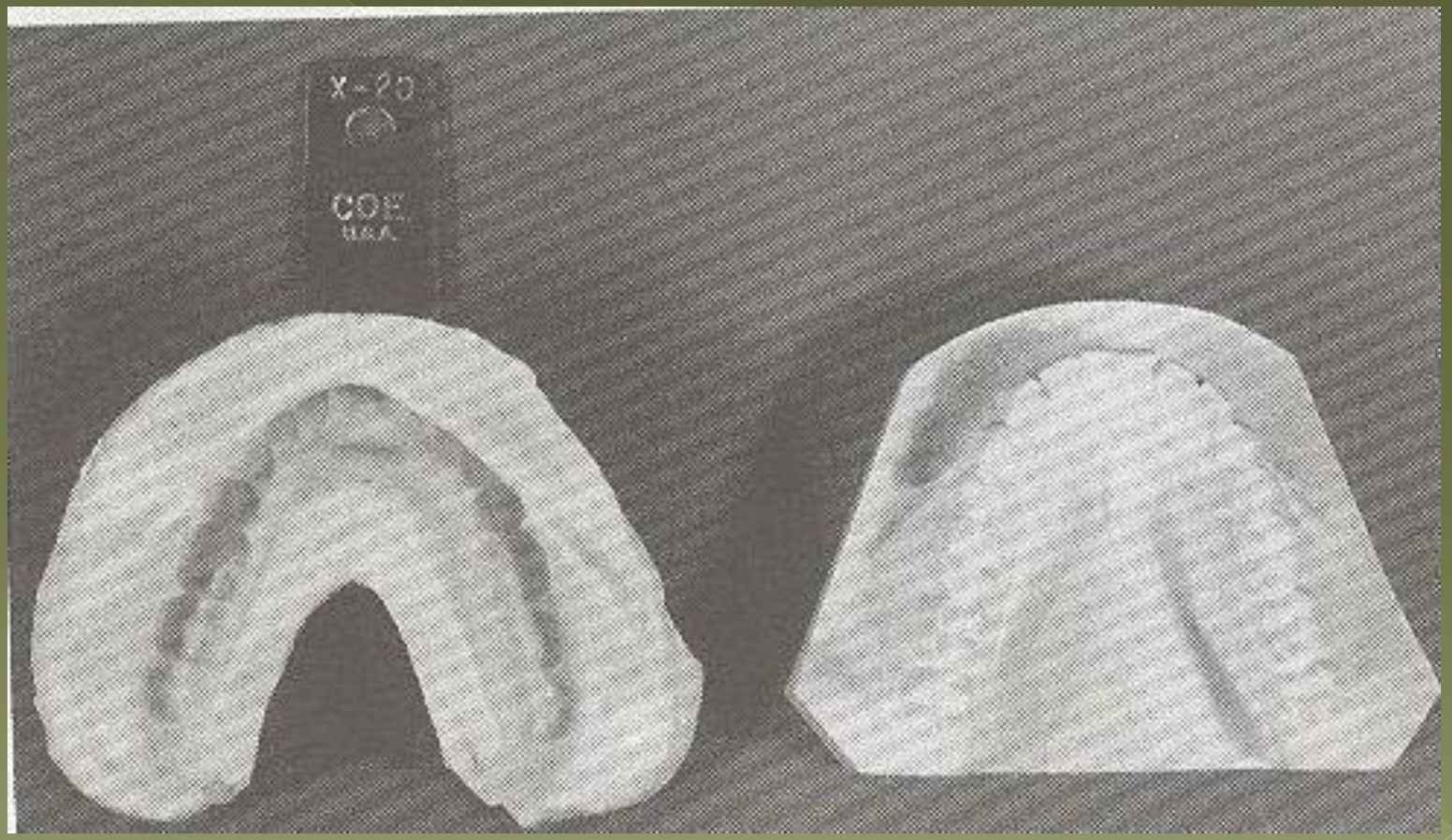
NORMAL SETTING EXPANSION:

The amount of setting expansion that occurs when a gypsum bonded casting investment is allowed to set in air.

INTRODUCTION

- Gypsum is a white powdery mineral widely found in nature.
- Used for making dental casts since 1756.
- Chemical name → Calcium sulphate dihydrate.($CaSO.2H_2O$)
- In dentistry, gypsum is used in the form of Calcium sulphate hemihydrate. ($CaSO.½H2O$)

PLASTER MODEL



Gypsum products

Plaster of Paris

Dental stone

Die stone

TYPES OF GYPSUM PRODUCTS

Current I.S.O standard for dental gypsum products identifies 5 types .

Type 1	**Dental plaster, Impression.**
Type 2	**Dental plaster, model.**
Type 3	**Dental stone, die and model.**
Type 4	**Dental stone, die, high strength, low expansion.**
Type 5	**Dental stone, die, high strength, high expansion.**

BASIC REQUIREMENTS OF DENTAL CAST MATERIALS

- The main requirements of model and die materials are,

1. Dimensional accuracy.

2. Adequate mechanical properties.

Other requirements of dental cast materials

- Should ideally be fluid at the time it is poured into the impression.
- Set material should be sufficiently strong to resist accidental fracture.
- Set material must be hard enough to resist the abrassion during carving of wax pattern.
- Should be compatible with all the materials it comes in contact.
- Should have good colour contrast with various waxes.

Production of Calcium Sulphate Hemihydrate

- Plaster and stone products are formed by calcining gypsum. (calcium sulphate dihydrate)
- Gypsum is grounded and subjected to temperatures of 110° - 120 °c to drive off part of water of crystallization.
- As the temperature is further raised the remaining water of crystallization is removed.

Production of Calcium Sulphate Hemihydrate

$CaSO_4 + 2H_2O \xrightarrow{110 - 130^oC} CaSO_4 + \frac{1}{2}H_2O$

$CaSO_4 + \frac{1}{2}H_2O \xrightarrow{130 - 200^oC} CaSO_4$

$CaSO_4 \xrightarrow{200 - 1000^oC} CaSO_4$

Gypsum $\xrightarrow{110 - 130^oC}$ Calcium sulphate hemihydrate

Calcium sulphate Hexagonal hemihydrate $\xrightarrow{130 - 200^oC}$ anhydrate

Hexagonal anhydrate $\xrightarrow{200 - 1000^oC}$ Orthorhombic anhydrate

METHOD OF MANUFACTURE

- Gypsum is heated to a temperature of 120°C in an open vessel.
- Produces irregular, porous particles.
- Also referred as β-hemihydrate.
- Overheating causes calcium sulphate anhydrate.

METHOD OF MANUFACTURE

May be produced by one of 2 methods

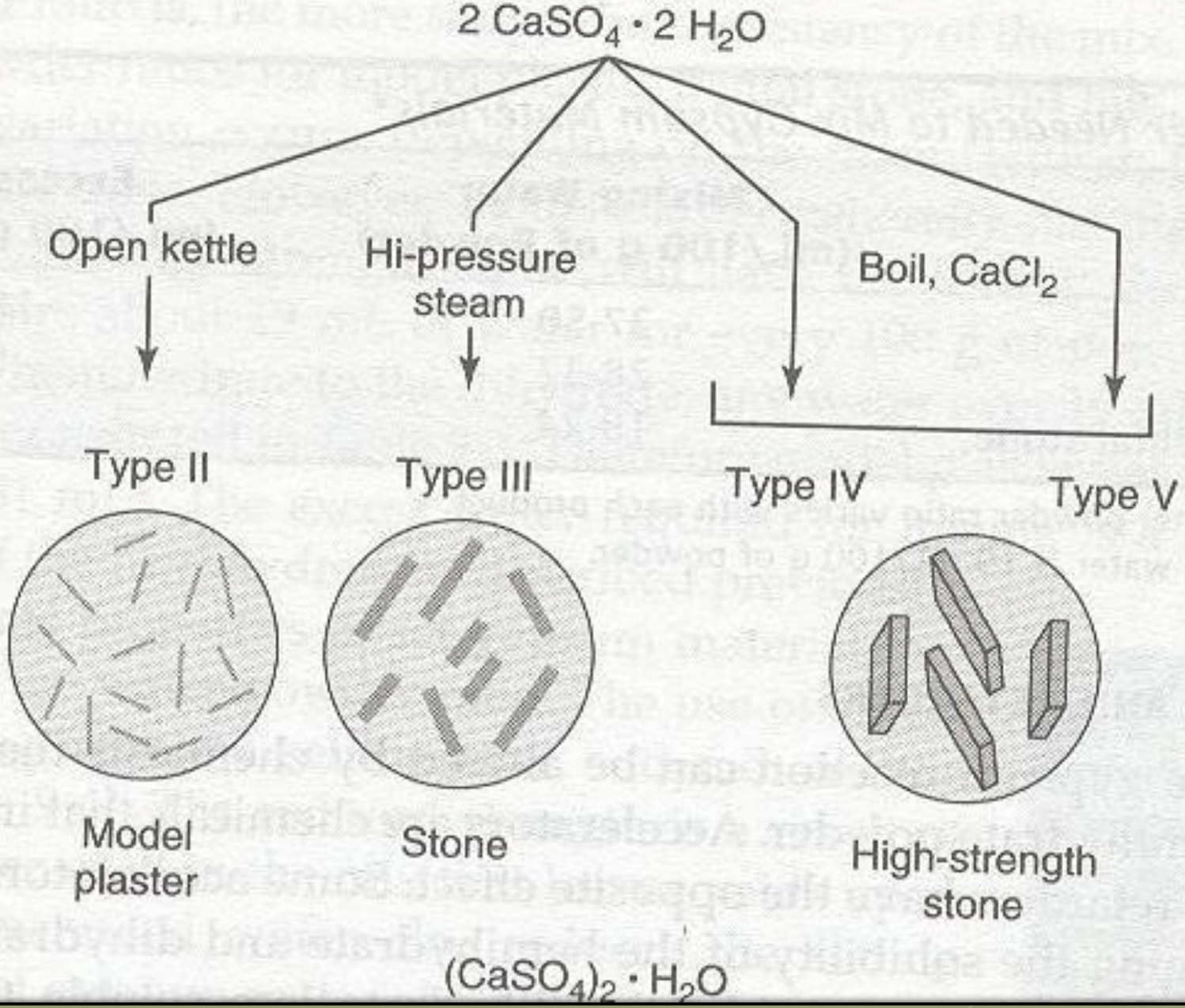
1. Gypsum heated to about 125°C under steam pressure in an autoclave.

   This produces more regular and less porous hemihydrate.

   Referred as ά-hemihydrate.

2. May be boiled in a solution of $CaCl_2$.

   Gives material similar as produced by autoclave but with less porosity.


2 CaSO4 · 2 H2O
Open kettle
Hi-pressure steam
Boil, CaCl2
Type II
Type III
Type IV
Type V
Model plaster
Stone
High-strength stone
(CaSO4)2 · H2O

SCANNING ELECTRON MICROSCOPIC PICTURE OF A SET HIGH STRENGTH DENTAL STONE

SETTING REACTION OF GYPSUM PRODUCTS

- Calcium sulphate hemihydrate powder reacts with water to form gypsum.

$(CaSO_4)_2 . H_2O + 3 H_2O \rightarrow 2CaSO_4.2H_2O$ + unreacted $(CaSO_4)_2.\frac{1}{2}H_2O$ + Heat

- The product formed is gypsum.
- The exothermic heat evolved is equivalent to the heat provided originally.
- The conversion to dihydrate form is never 100%.

Water / Powder ratio:

- The ratio of water to hemihydrate powder is always expressed as W/P ratio.
- Obtained when weight (volume) of water is divided by the weight of the powder.
- E.g. if 100g of plaster is mixed with 60ml of water, the w/p ratio will be 0.6.
- W/P ratio is important for determining the physical and chemical properties of the final gypsum.

DEFINITIONS:

- Mixing time (MT):

  Time from the addition of powder to water until mixing is completed.
  - 20 – 30 sec in case of mechanical mixing.
  - One minute in case of manual spatulation.

DEFINITIONS:

- Working time (WT):

  Time available to use a workable mix.

  Measured from the start of mixing to the point where the consistency is no longer acceptable for the product ‘s intended purpose.

  Generally 3 min working time is adequate.

DEFINITIONS:

- Setting time (ST):

  The time from beginning of mixing until the material hardens.

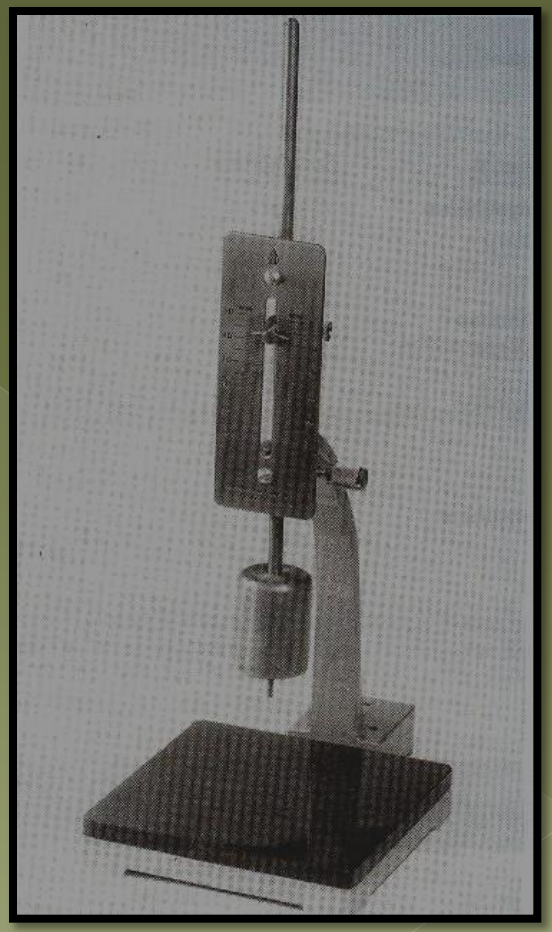
  Measured by some kind of penetration test.

  1 min is indicated for mixing and additional 3 min for working are indicated.

Tests for working, setting and final setting times:

Vicat penetrometer

Used to determine the setting time of impression and other restorative materials.



Tests for working, setting and final setting times:

- LOSS OF GLOSS TEST FOR INITIAL SET:
  - During setting reaction the excess water is taken up in forming dihydrate.
  - The mass does not have any compressive strength.
  - Thus not favorable to remove from mould at this stage.

Tests for working, setting and final setting times:

- **INITIAL GILLMORE TEST FOR INITIAL SET:**
  - The mixture is spread out and the needle is lowered onto the surface.
  - The time at which It no longer leaves an impression onto the surface is referred as the initial set.
  - This initial set is noted as initial **GILLMORE SET**.

Tests for working, setting and final setting times:

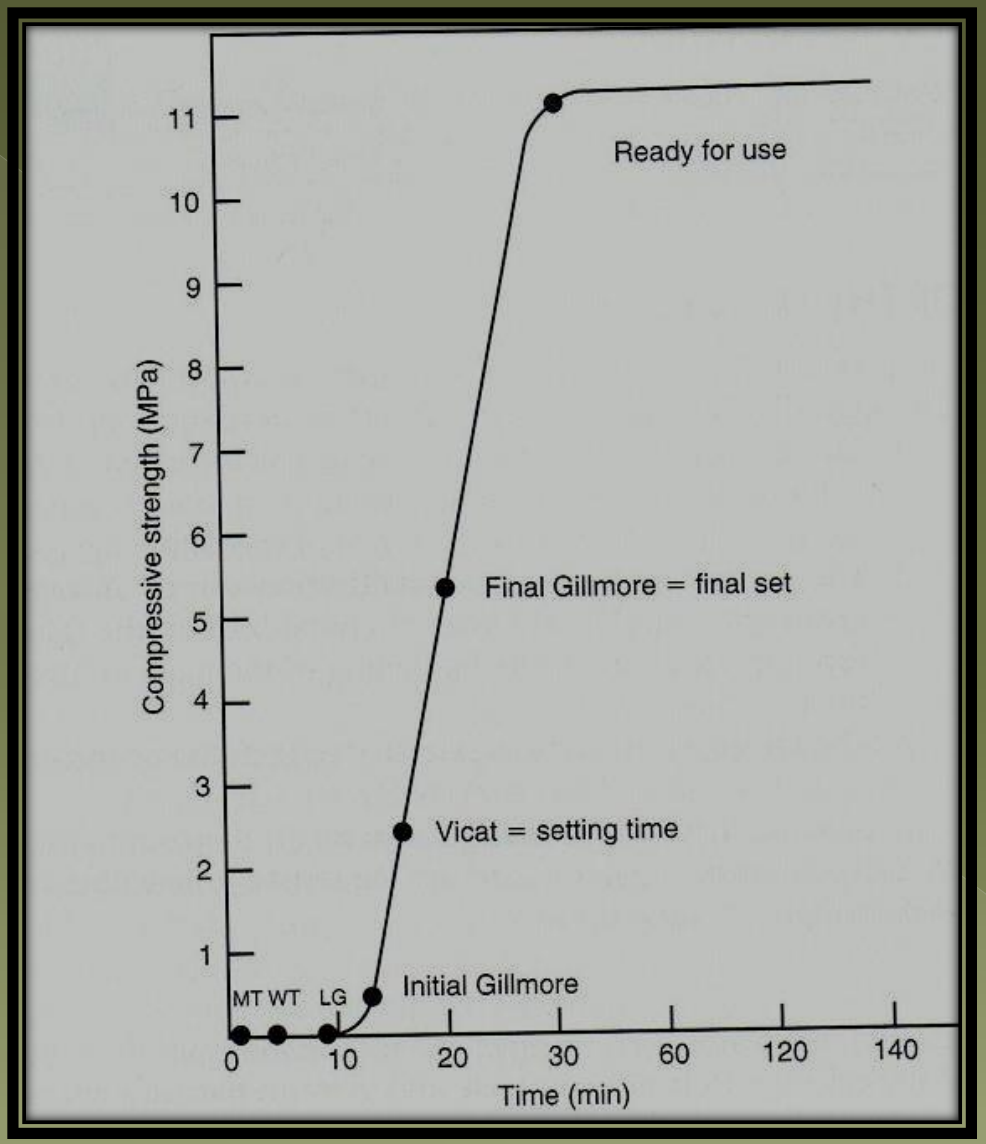
- VICAT TEST FOR SETTING TIME:
  - Vicat penetrometer is used.
  - The needle with a wedged plunger rod is supported and held just in contact with the mixture.
  - Soon after the gloss is lost the plunger is raised.
  - The time elapsed until the needle no longer penetrates to the bottom of the mixture is known as setting time.
  - In some cases, Vicat and initial Gillmore measurements are same.

Tests for working, setting and final setting times:

- GILLMORE TEST FOR FINAL SETTING TIME:
  - A heavier Gillmore needle is used.
  - The elapsed time at which the needle leaves only a perceptible mark on the surface is called final setting time.

READY-FOR-USE CRITERION:

- Ready-for-use criterion is a measure of time at which the set material can be handled safely.
- Ready-for-use criterion is not judged by any specific test.
- Comes with experience.
- Technically set material is considered ready for use when the compressive strength is 80%. (attained in 1hr)
- Modern products reach ready-for-use stage in 30 min.


Compressive strength (MPa)
11
10
9
8
7
6
5
4
3
2
1
Ready for use
Final Gillmore = final set
Vicat = setting time
Initial Gillmore
MT WT LG
0
10
20
30
60
120
140
Time (min)

How to control setting time

1. Changing water : powder ratio

Increasing water	Decreasing water
Retarded setting	Shorter setting time
Weaker model or cast	Mix difficult to manipulate
Inaccurate model	Bubbles inclusion in mix
--------	Inaccurate model

2. Spatulation: rapid and prolonged spatulation accelerates setting and also increases setting expansion.

3. Temperature: increasing water temperature to a certain level will accelerate setting.

4. Accelerators and retarders:
   - Manufacturers add accelerators or retarders to gypsum. These chemicals increase or decrease gypsum solubility respectively which will alter setting time accordingly.
   - Clinicians can add accelerators such as potassium sulfate or set gypsum (slurry water), they act as sites for crystallization.
   - Setting reaction retarders: blood, saliva, alginate. If left on impression, can affect surface details of impression. Impression surface need to be properly rinsed before being poured.

CONTROL OF SETTING TIME:

- Setting time must be controlled for different applications.

1. IMPURITIES.
2. FINENESS.
3. W/P RATIO.
4. MIXING.
5. TEMPERATURE.
6. CHEMICAL MODIFIERS.

SETTING EXPANSION

- Expansion occurs during change from hemihydrate to dihydrate state.
- This expansion is linear expansion.
- Range is 0.06 % - 0.5 %.
- On the other hand the volume of reactants VS products is observed to be decreased.

$(CaSO_4)2 . H_2O + 3 H_2O \longrightarrow 2CaSO_4.2H_2O$

105.556+ 54.211 148.405

159.767 148.405

SETTING EXPANSION

- Expansion occurs by the growth of crystals during crystallization process.
- The outward stress or stress is developed that causes the expansion of the entire mass.
- Setting reaction is greater in external volume but less in crystalline volume.
- Set material is porous.
  For dentists and technicians, setting expansion after the initial set is of concern.

CONTROL OF SETTING EXPANSION

- Setting expansion can be a disadvantage.
- Lower W/P ratio and longer mixing time increases the setting expansion.
- Lower W/P ratio →more nuclei of crystallization →less space between the nuclei growth interaction. (thicker mix)→more outward thrust→more expansion.
- Chemicals are added by manufacturers.
- Potassium sulfate, sodium chloride and borax.

HYGROSCOPIC SETTING EXPANSION

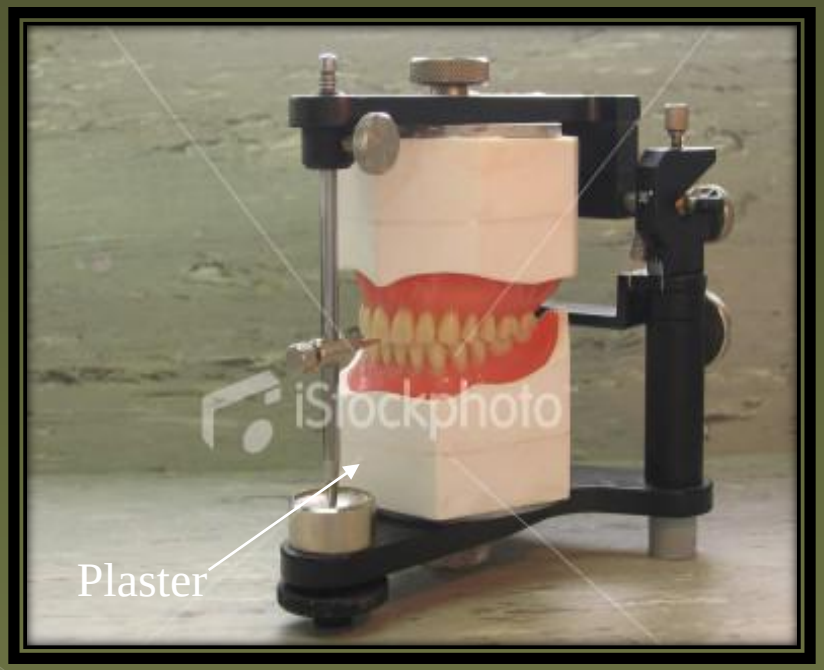
- Setting expansion in water.
- Magnitude is more than double as compared to the setting expansion in air.
- Accepted reason is that the crystals grow more freely in water as compared to air.
- Basic mechanism of crystal growth is the same.
- Reduced W/P ratio increases the hygroscopic setting expansion.
- Increased spatulation increases the hygroscopic setting expansion.

HYGROSCOPIC SETTING EXPANSION

- Hygroscopic setting expansion of dental stone or plaster is generally small in magnitude.

  E.g. dental stone for making cast may exhibit a normal linear setting expansion of 0.15% with maximum hygroscopic setting expansion of 0.30%.

Plaster



Flask

TYPES OF GYPSUM PRODUCTS

- **IMPRESSION PLASTER (Type I):**

1) Composed of plaster of Paris.
2) Modifiers are added for the regulation of setting time and setting expansion.
3) Rarely used now a days for taking impression.

TYPES OF GYPSUM PRODUCTS

- **MODEL PLASTER (Type II):**

1. Also called as laboratory type II plaster.
2. Marketed in white colour.
3. Used principally to fill the flask in denture construction.
4. Relatively weak.

   Compressive strength → 9 MPa.

   Tensile strength → 0.6 MPa.

TYPES OF GYPSUM PRODUCTS

- **DENTAL STONE (Type III):**

1. Introduced in dentistry in 1930.
2. Improved hardness.
3. Type III stone preferred for casts used to process dentures and dies of prepared tooth.
4. Denture is easier to remove after process.
5. 2 methods are used for cast production.

TYPES OF GYPSUM PRODUCTS

- **DENTAL STONE, HIGH STRENGTH (Type IV):**

1. Particles are cuboidal shaped.
2. Hard surface is necessary for a die stone.
3. Surface dries more rapidly so the surface hardness increases more rapidly too as compared to compressive strength (92 Rockwell Hardness).

TYPES OF GYPSUM PRODUCTS

- **DENTAL STONE, HIGH STRENGTH, HIGH EXPANSION (Type V):**

1. Higher compressive strength than type IV.
2. Improved strength is attained by lower W/P ratio.
3. High setting expansion is an advantage.
4. Type V stones should be avoided for making dies for inlays.

SYNTHETIC GYPSUM

- Bi products or waste products of phosphoric acid production can also make ά-hemihydrate and β-hemihydrate.
- Expansive than natural gypsum.
- Properties are either equal or better than the natural gypsum.

PROPORTIONING, MIXING AND CARING FOR GYPSUM PRODUCTS

PROPORTIONING:

- Strength of stone is inversely proportional to the W/P ratio.
- Important to keep the amount of water as low as possible.
- Water and powder should be measured accurately by a graduated cylinder for water and weight balance for powder.
- Pre weighed envelops have become more popular these days.

PROPORTIONING, MIXING AND CARING FOR GYPSUM PRODUCTS

MIXING:

- Bowl must be parabolic, smooth and resistant to abrasion.
- Spatula must have a stiff blade and comfortable handle.
- Air entrapment must be avoided to prevent porosity.
- Automatic vibrator of high frequency and low amplitude is helpful.
- Repeated addition of water or powder is the main cause of inaccuracy in the gypsum products.

PROPORTIONING, MIXING AND CARING FOR GYPSUM PRODUCTS

CARING FOR GYPSUM PRODUCTS:

Gypsum products are sensitive to the change in humidity.

Gypsum surface made with high W/P ratio are effected more.

Hemihydrate of gypsum takes up water from air.

The best way is to seal the product in moisture proof metal container.

PROPORTIONING, MIXING AND CARING FOR GYPSUM PRODUCTS

CARING OF CAST:

- Cast should be an accurate reproduction of the oro-dental tissues.
- Cast should be allowed to harden completely before removal.
- On completion of setting reaction the dimensions will be constant.
- Sometimes required to be immersed in water.
- Linear dimension may decrease 0.1% for every 20 min in case of stone cast.

Trimming

- Plaster bases are recommended since trimming them is easier than dental stone.
- If base is made from stone, it should be soaked in water for 5-10 minutes to soften it before trimming. Important considerations when trimming?

Trimming considerati

- Proportion of base to anatomical part
- Parallelism
- Use of wax bite registration
- Outer border of cast
- Shaping of anterior part of upper and lower arches

INFECTION CONTROL

- Increased chances for the spread of infection.
- Disinfection of both impression and the model or die material is important.
- Disinfectant solutions can be used.
- Alternatively, dental stone containing disinfectant can be used. May lead to slight change in physical and chemical properties.
- Spray disinfectants, hypochlorites and iodophores are useful.

Infection control

- Casts should have set for 24 hours before being disinfected if necessary.
- Spray rather than immerse
- Disinfectants commonly used:
  - Sodium hypochlorite
  - iodophors
  - Chlorine dioxide