Task force Powderfeeder

as part of the pre-acceptance of the machine BIMD-002
2017-11-02 Rev. A by F. SCHEHR

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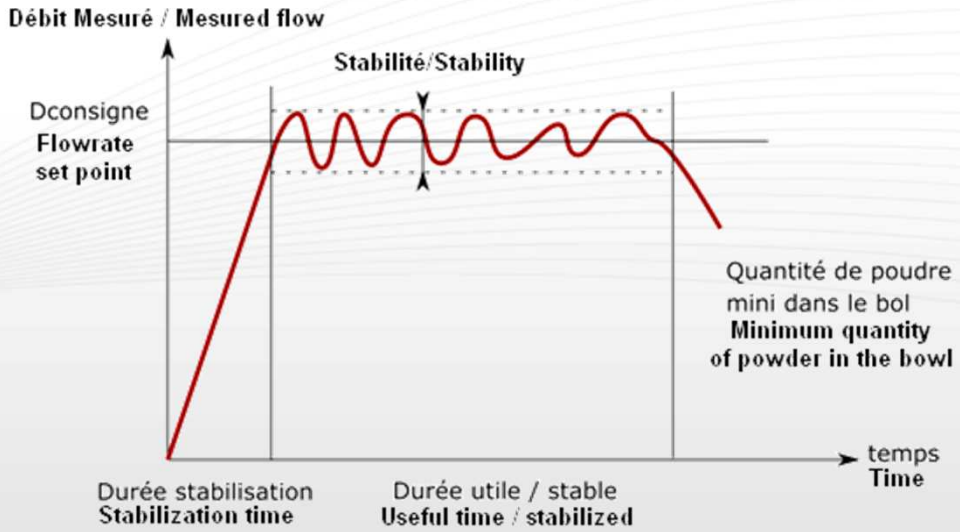
Context

- Objective of the study:
  - Validation of powder flow stability for receiving the machine BIMD-004
  - Achieve, over a representative period of the machine's capacities, a stability of + or - 5% centered on the flow setpoint for the flows proposed by the machine manufacturer “BeAM”



Customer's (SAM) requirements

For the 10Vx Nozzle :

- Representative time :
  6h (corresponding to a long job)
- Flowrate Target for heavy materials :
  6g/min (nickel bases and steels, according to parameters supplied with the Mobile)
  3g/min (refractory nickels, according to study results for SAE)
- Flowrate Target for light materials :
  3g/min (TA6V, according to parameters supplied with the Mobile)

For the 24Vx Nozzle :

- Representative time :
  2h (time to empty the hopper)
- Flowrate Target for heavy materials :
  22g/min (nickel bases and steels)
  BeAM can not advise a rate value for refractory nickels (Inco738), no application has been processed so far with the large nozzle.
- Flowrate Target for light materials :
  15g/min (TA6V)

Stabilization time:

The duration before stabilization must not exceed 30min

Operating mode:

The stability will be evaluated by continuous recording of the values of a balance placed at the outlet of the nozzle and smoothing the values over 60s.

Customer's (SAM) requirements

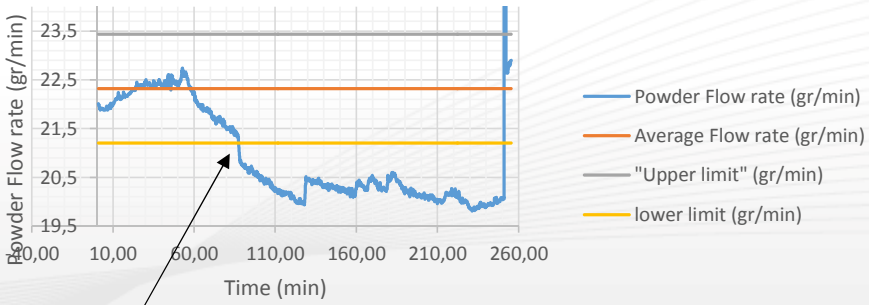
- **To facilitate acceptance testing, with two distribution lines and two distributors, SAM accepts:**
  - All heavy material tests are made with 316L steel
  - It may be necessary to change the scraper on a distributor depending on whether the 10Vx or 24Vx nozzle is used
  - As a last resort, although it is not optimal, the distributors are dedicated to a configuration (10Vx or 24Vx) rather than to a material, especially in the case where the motorization would be different for each configuration.
  - To carry out tests for a duration of only 2 hours if test reports show that the stability criteria could be reached on an identical configuration and that we have a means of concrete registration.
  - That the value of average flow is not centered on the value of target flow, because that can be compensated by a daily adjustment on our part which it will be necessary to explain. This is acceptable in R&D but will be difficult to accept in prod.
- **Compared to the tests already carried out, we observe that: :**
  - **For the 10Vx Nozzle:**
    - the 10RPM configuration, 33%, 15mm, RCH1000 achieves a stability of + -5% around average flow rates close to the target flow rates (3 and 6g / min) over a period of at least 6h (FS test report)
    - the 2.5RPM configuration, 33%, 15mm, RCH1000 achieves a stability of + -5% around average flow rates close to the target flow rates (3 and 6g / min) over a period of at least 6h (summary note on the tests performed at BeAM GM)
    - these two configurations are therefore acceptable, the choice must be made according to the available engines and responding best to the problem of receiving 2 materials and 2 nozzles with 2 distributors according to the criteria mentioned above.
  - **For the 24Vx Nozzle :**
    - the configuration 10RPM, 33%, 15mm, RCH1000 does not achieve a stability of + or - 5% around the flow rates representative of this nozzle (FS test report)
    - the optimum configuration remains to be defined: scraper + motorization <- Main hard point remaining to be treated and requiring additional tests.

The object of this Task Force is to define the configuration (s) (motor and scraper) to achieve a stability of + or - 5% with the 24Vx nozzle (22gr 316L and 15gr / min TA6V) For 2 hours of stable duration and with stabilization time <0.5 hours

Medicoat Measures on Turnplate system

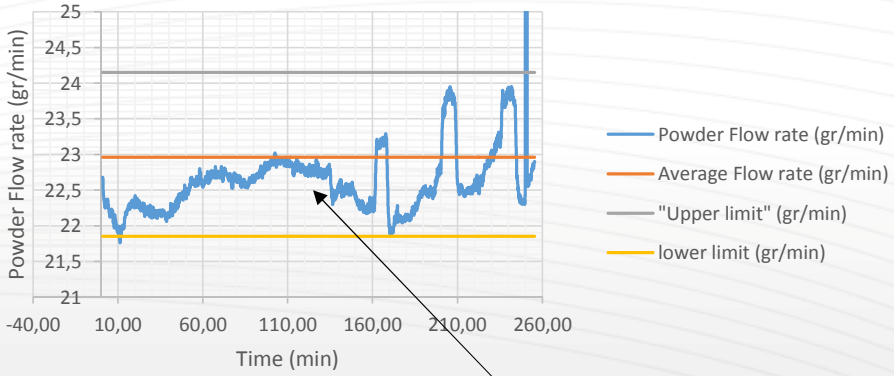
- Firstly, we supposed that the agitator speed has a significant influence on the stability over long periods, so we did some test in the initial configuration and then, without stirrer

02-11-2017 316L Config initiale BeAM (Measured by Medicoat) with stirrer 50% 02-00460-038 33% 15mm motor 10RPM



Instabilities too important

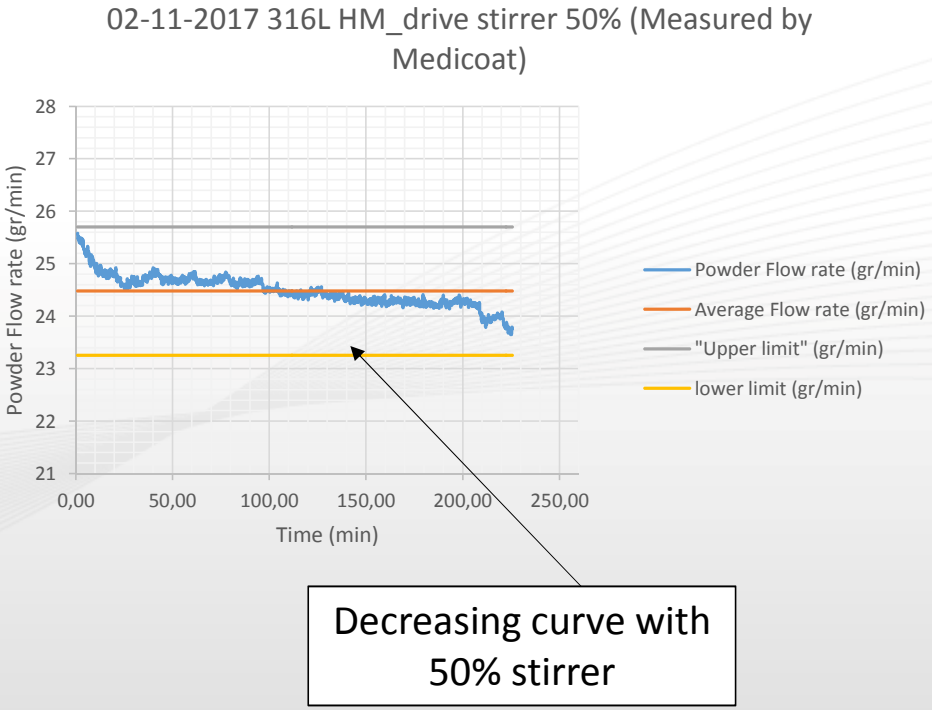
02-11-2017 316L HM_drive (Measured by Medicoat) Without stirrer

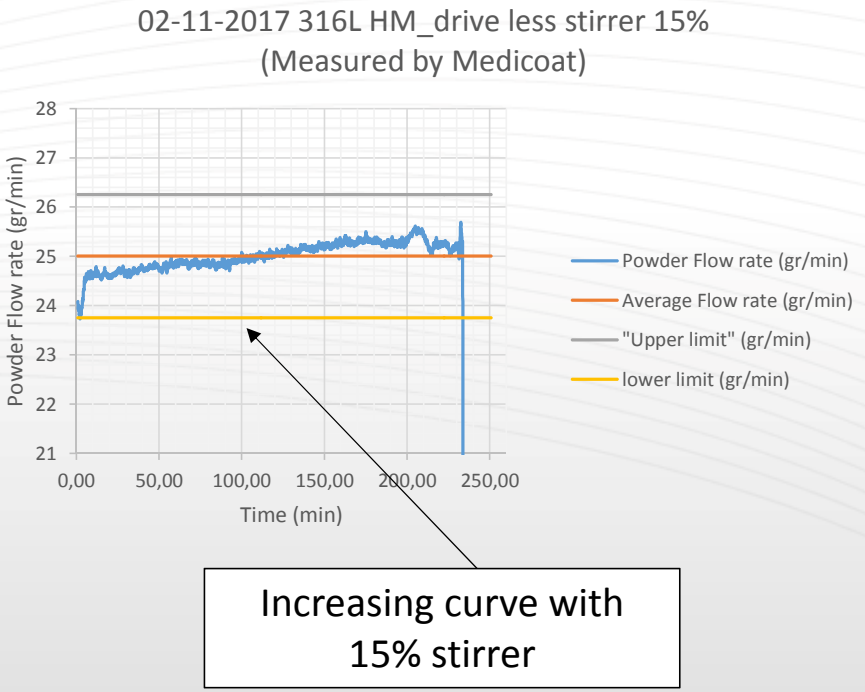


The peaks are due to the absence of movement of the agitator, so it is then necessary to test with low speed stirrer to understand the influence

Medicoat Measures on Turnplate system

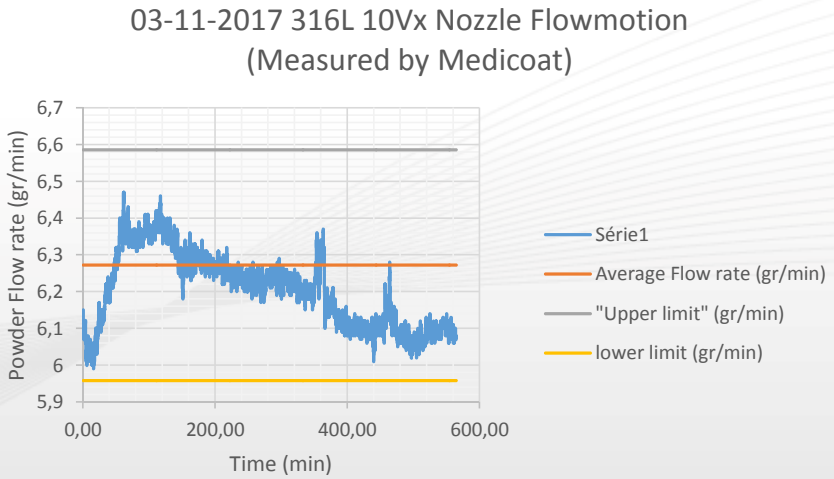
- Finally, we observed that the agitator speed has a significant influence on the stability over long periods



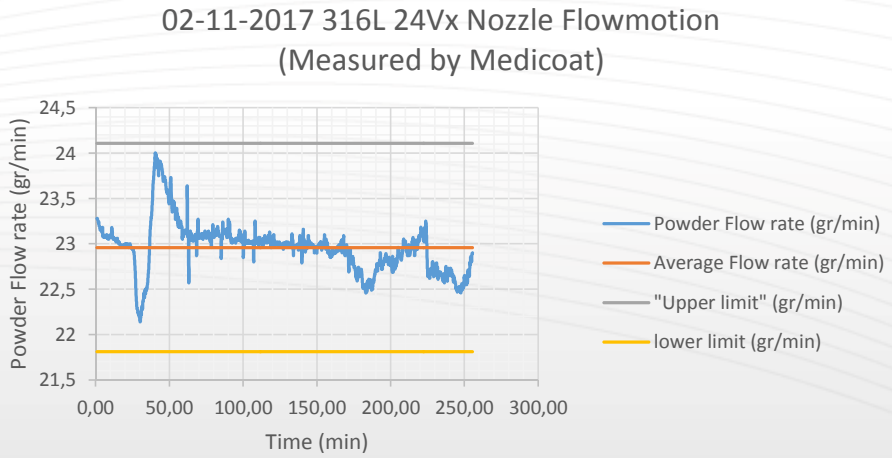


Medicoat Measures on Flowmotion system

- In parallel, we worked a B plan, asking Medicoat for complementary tests with the Flowmotion system
- The difference is that Medicoat measures directly at the output of the powderfeeder (without nozzle and powder line)



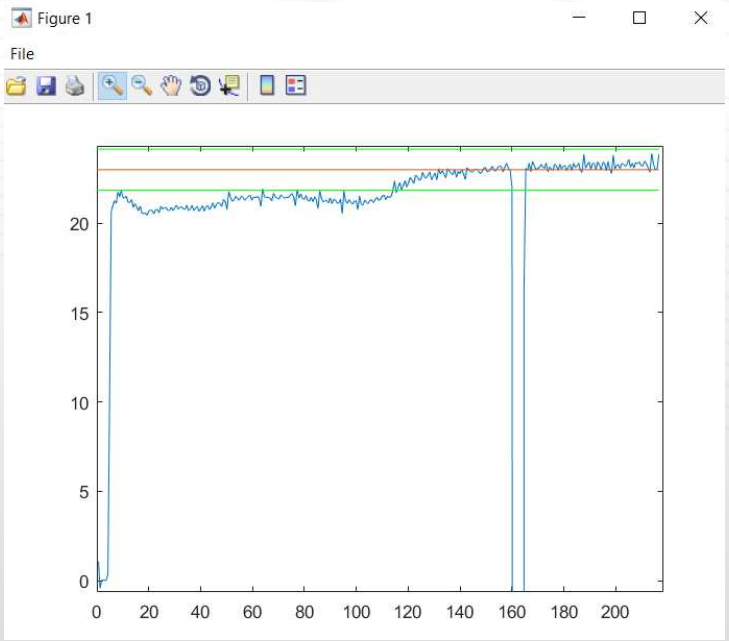
6.2 g/min
± 5% during 10 hours



23 g/min
± 5% during 4 hours

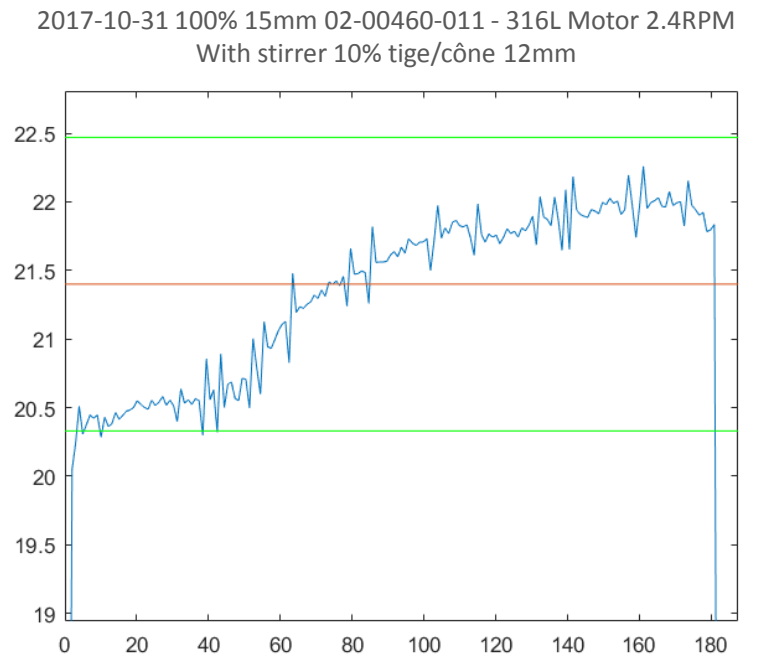
New treatment tool developped by BeAM Fr

- « Balance_data_analyzer » is the software developed by Jonathan Frechard
  - Allows raw data to be processed and interpreted quickly
  - Significant time saving in the procedure for measuring the stability of the powder flow

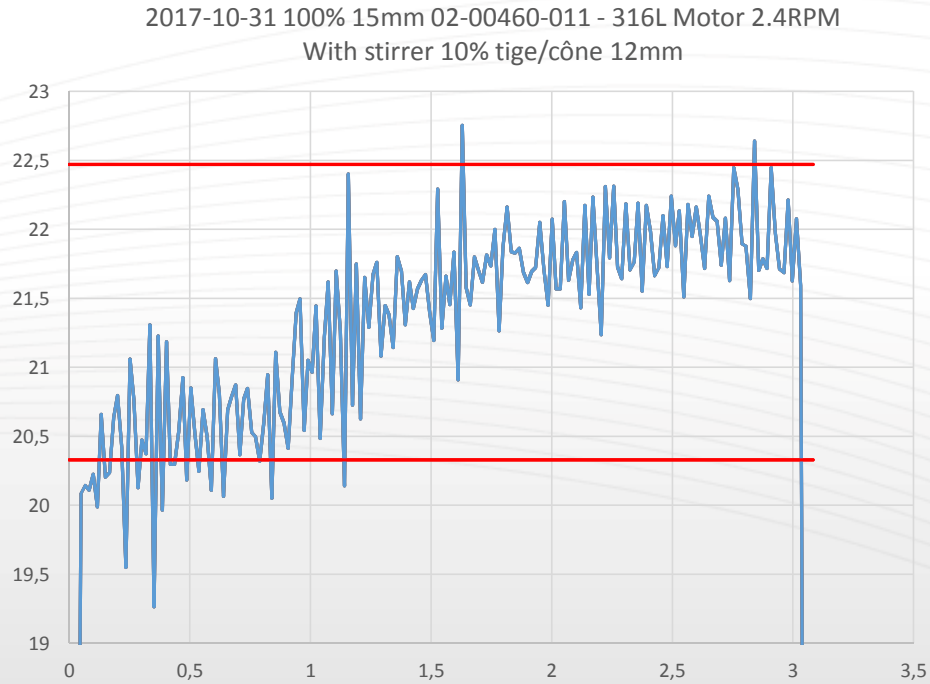


BeAM (Fr) Measures *comparison of data processing solutions*

- Signal processed with JF Soft's (Nov-2017) (Spinner = 1/550 lines)



- Signal processed with Excel (1/550 lines)



This first measurement makes it possible to check that the stability is better with a lower agitator speed (10% against 50% previously)
Also, the space between the cones of the bowl has been reduced (the threaded distance of the rod goes from 8mm to 12mm). It is therefore decided to continue the tests in this same way by further increasing the stem distance.

Parameters taken into account

- If the powder is mixed to fast and for a too long period with the stirrer, the big and fine particules can be seperated, and the distribution of the powder is no longer homogeneous in the bowl.

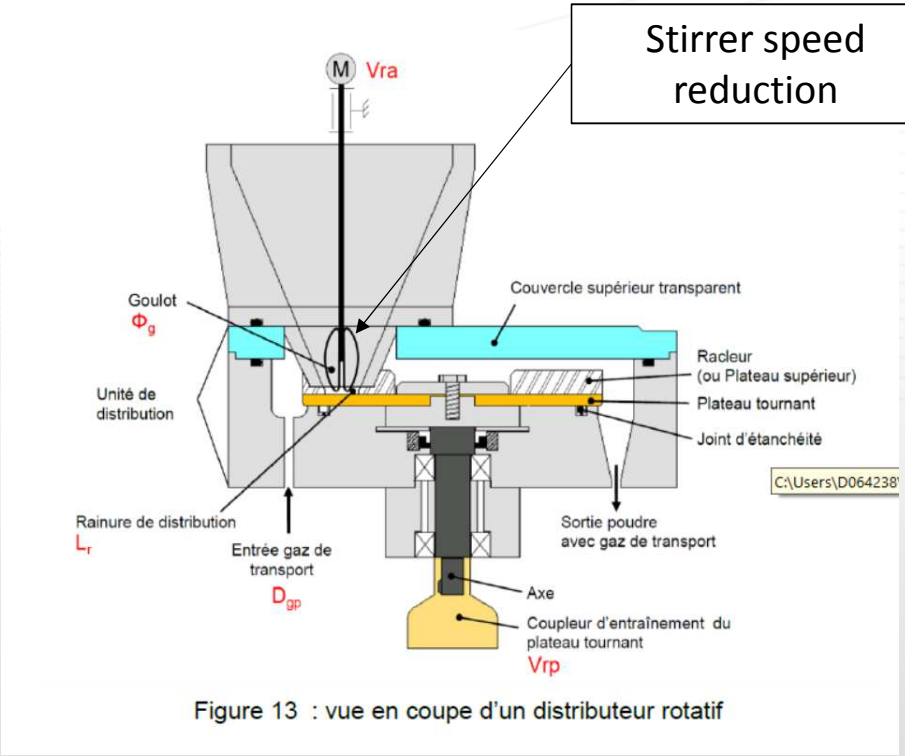


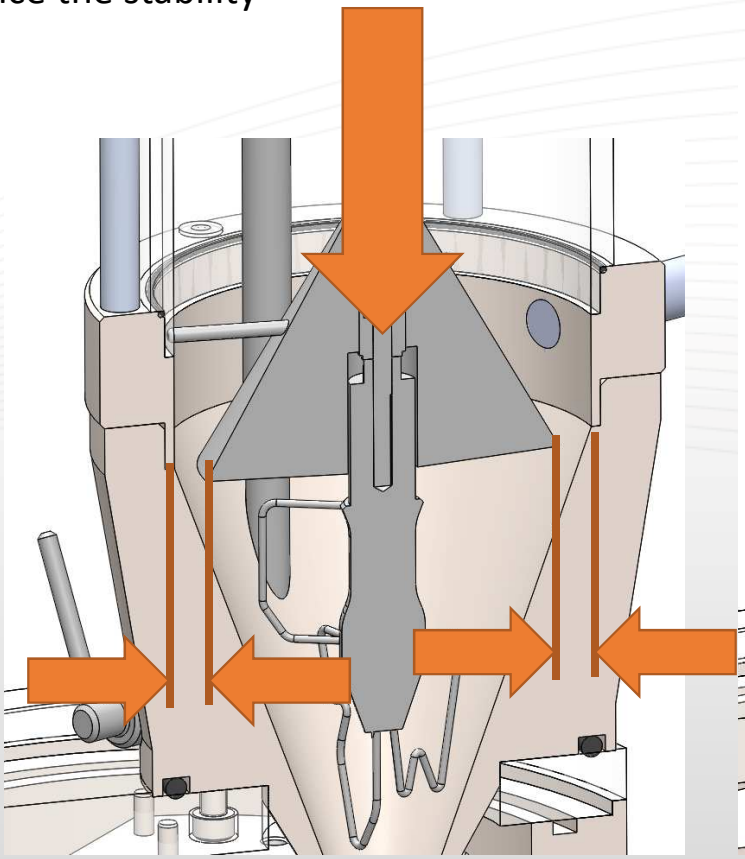
Figure 13 : vue en coupe d'un distributeur rotatif

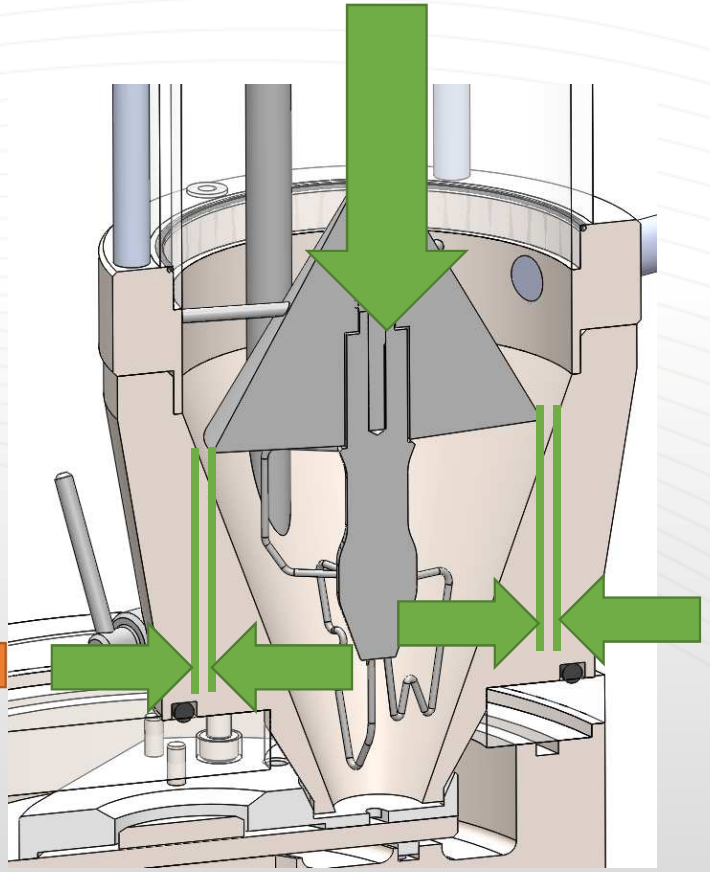
Parameters taken into account

- Distance between cones in the bottom of the Hooper
- The section has to be adapted to the powder used. Because when the section is to big, the weight of the powder inside the hopper will influence the stability

Adjustment

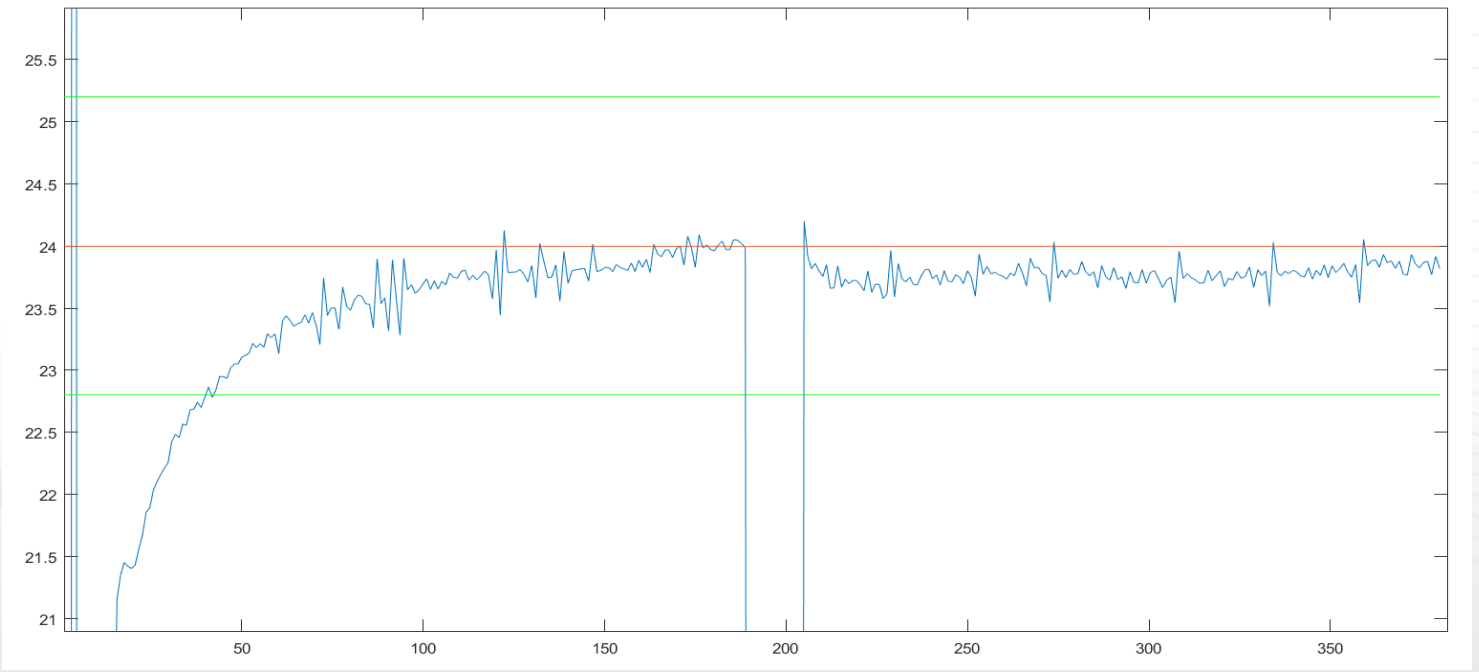
Stirrer





Measures 316L 22gr 24V (02/11/2017)

2017-11-02 100% 15mm 02-00460-011 - 316L Motor 2.4RPM
With stirrer 10% tige/cône 18mm



Stabilization 1 (1er emptying of 4.5 Kg)

Stabilization 2 (after stop and refilling of 4.5Kg)

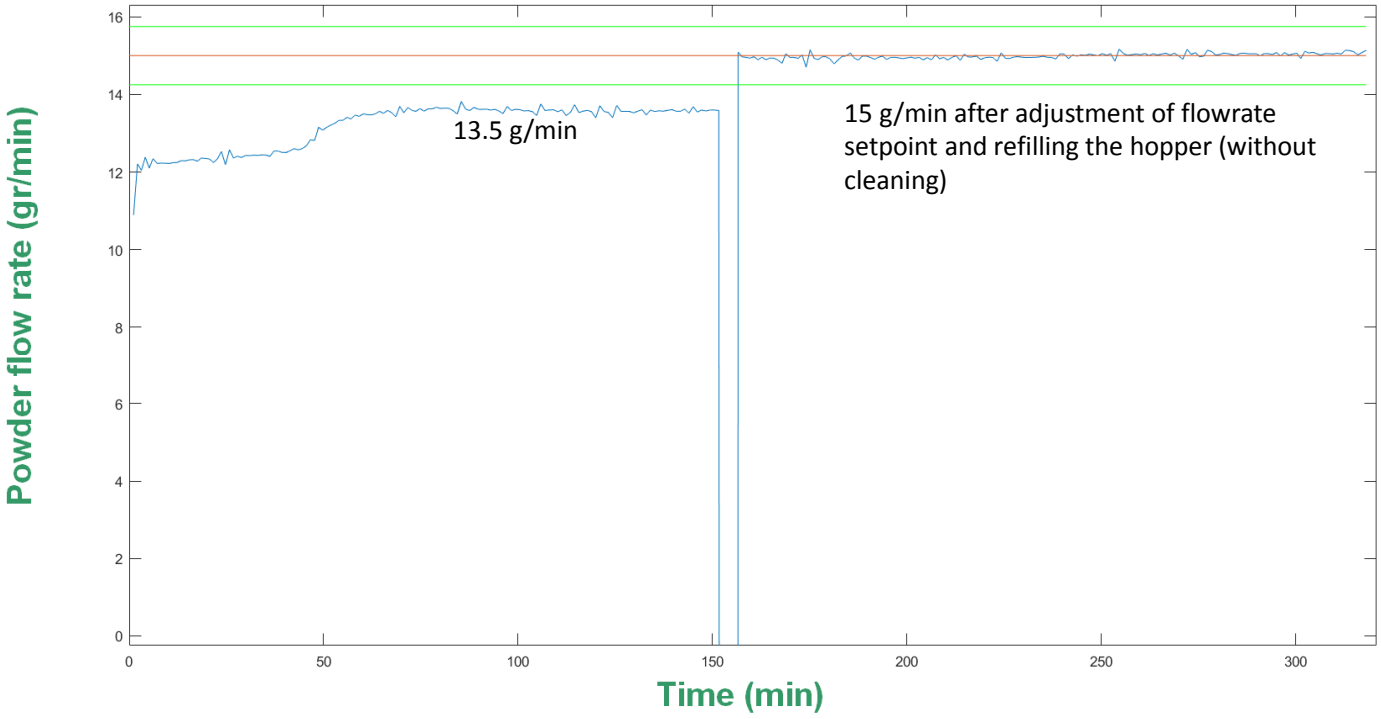
Usefull time (stabilized)

This second measurement makes it possible to check that the stability is better when the space between the cones of the bowl is further reduced (the threaded distance of the rod goes from 12mm to 18mm). With a pause filling the bowl at the minute 190, these two successive measurements show that the stabilization time of the flow is about 180min in this configuration. However, after filling, without cleaning and without changing any parameter, we find the same stable flow, with this time an acceptable stabilization time of approx. 20 minutes.

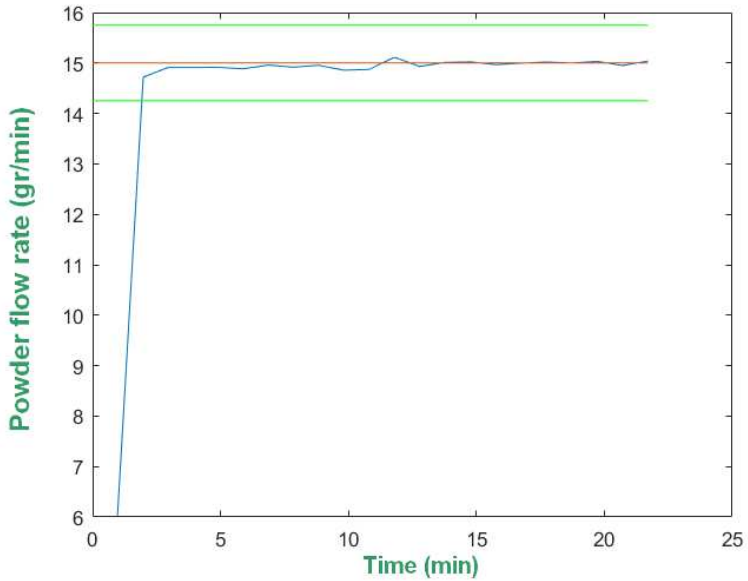
Essais TA6V 15gr/min 24V du 02/11/2017

- Setpoint adjustment after stabilization phase

From stabilization time (13.5g/min) to usefull time (15g/min)



The next day it takes less than 5 minutes to reach the flow stably, with this same configuration and without cleaning

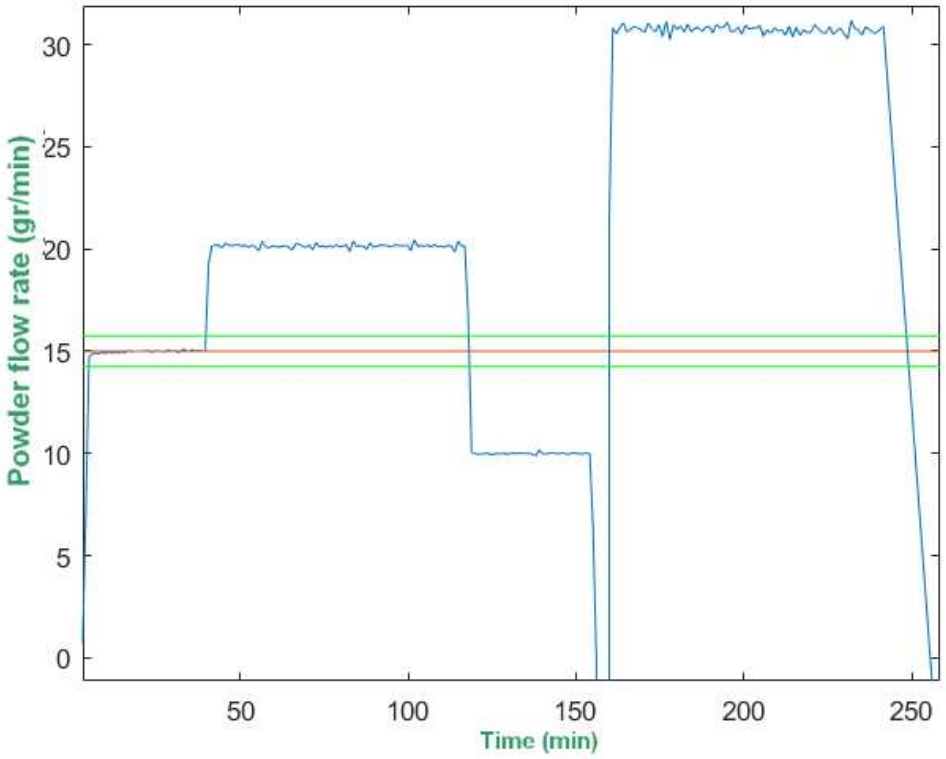


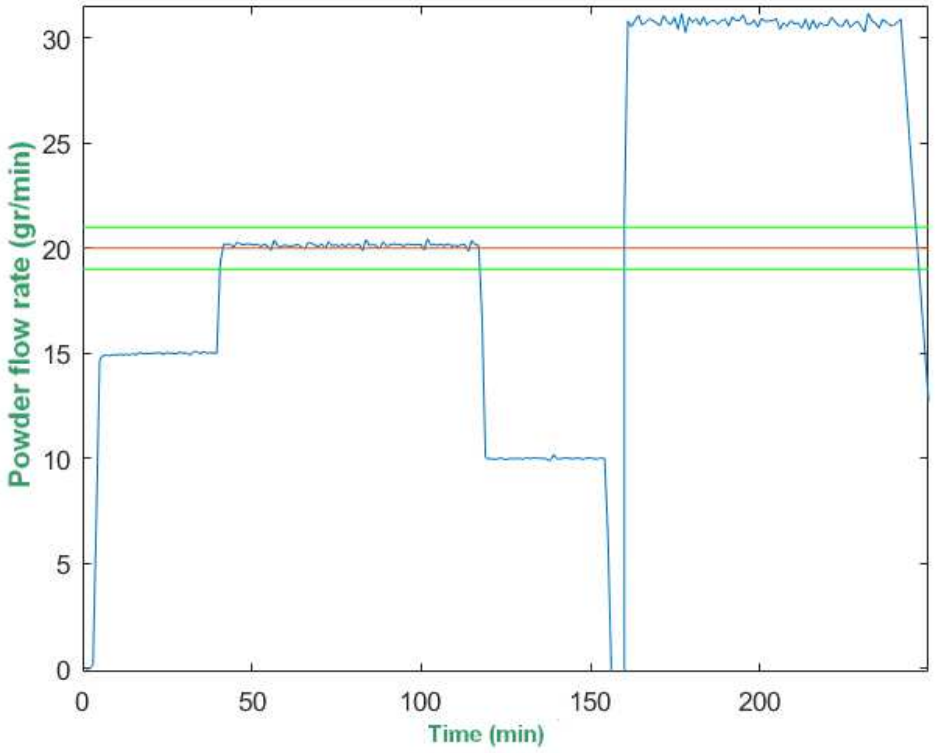
Then, we aim at 20 g/min to check the stabilization time of an adjustment of + 20% of the flow setpoint.

Essais TA6V 15gr/min 24V du 03/11/2017

- Setpoint adjustment after stabilization phase

From one value switching to another
15g/min to 20g/min (the adjustment is linear) that corresponds to +30% set point, new stabilization within 5min

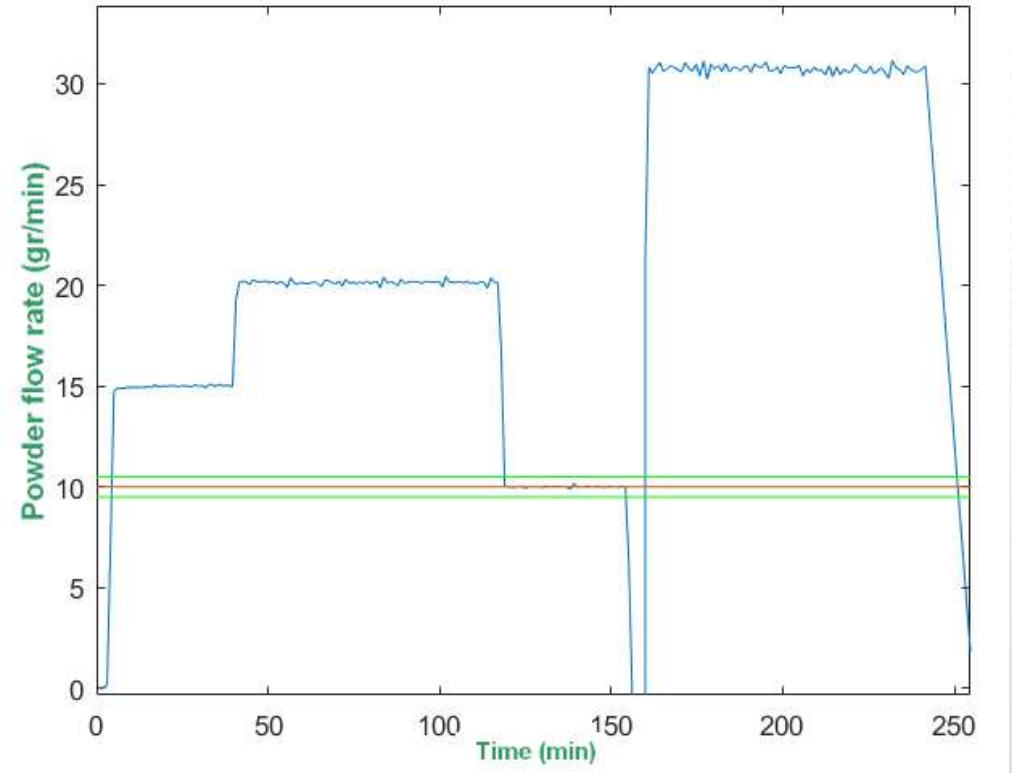


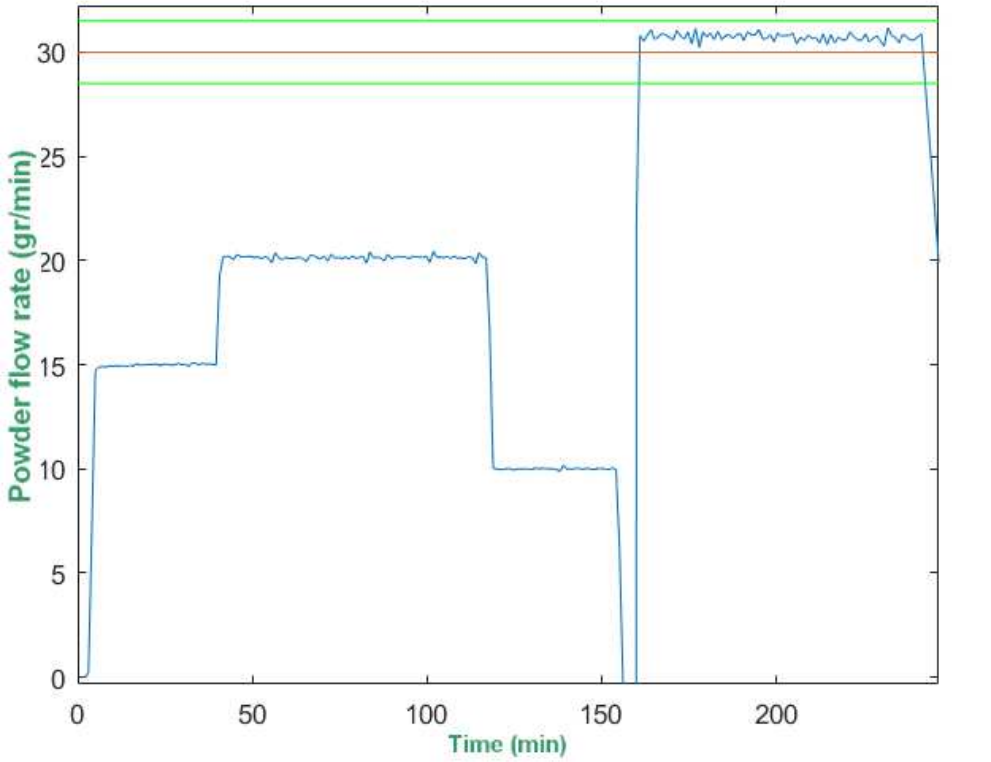


Essais TA6V 15gr/min 24V du 03/11/2017

- Setpoint adjustment after stabilization phase

From one value switching to another
10g/min to 30g/min (the adjustment is almost linear) that corresponds to +200% set point, new stabilization within 5-10min





Adjustment and preparation tips

- 24V flow rates require a first stabilization period of approx. 1 to 2 hours, if the scraper and the table are clean, we can then refill the bowl (without cleaning) and the flow will stabilize then much faster during the second period including when adjusting the rotation instruction from the plateau
- The speed of rotation of the agitator has a very important influence on the stability of the flow. According to our exchanges with Medicoat and following these tests, we recommend to set very low the setpoint of rotation of the agitator (at least with the scrapers 15mm, we must still check if this is true in the case of 4mm scrapers) . Too much agitation over a long period of time can separate small particles from large particles and create a different distribution between the bottom of the tank and the top. This results mostly in a stability curve with increasing or decreasing trend.
- The height of the cone relative to the rod has a significant influence on the stability of the powder flow. It seems that this must be defined for each type of powder and/or configuration of the bowl.

Adjustment and preparation tips

- It seems that the system is more stable when the bowl is very full, it will check this point with additional tests

Proposed Powderfeeder configurations for pre-acceptance of the machine

- **10V Nozzle:**
  - *316L at 6 g/min:*
    - *Top plate: 33% 15mm RCH1000 ref. 02-00460-038 dedicated to 316L*
    - *Motor: 10RPM standard*
  - *TA6V at 3 g/min:*
    - *Top plate: 33% 15mm RCH1000 ref. 02-00460-038 dedicated to TA6V*
    - *Motor: 10RPM standard*

3 heures de rodage + 6 heures de mesure en continue (la 1ère nuit)

Bol 1 (motor 10 RPM)

3 heures de rodage + 6 heures de mesure en continue (la 2nde nuit)

- ***24V Nozzle:***
  - *316L at 22 g/min:*
    - *Top plate: 100% 15mm POM ref. 02-00460-011 dedicated to 316L*
    - *Motor: 2.4RPM (pretested in Strasbourg and temporary installed on the BIMD-004)*
  - *TA6V at 15 g/min:*
    - *Top plate: 100% 15mm POM ref. 02-00460-011 dedicated to TA6V*
    - *Motor: 2.4RPM (pretested in Strasbourg and temporary installed on the BIMD-004)*

2 heures de stabilisation + 2 heures de mesure en continue (la journée)

Bol 2 (motor 2.4 RPM)

2 heures de stabilisation + 2 heures de mesure en continue (la journée)

- **Stabilzation time:**
  - A first period of stabilzation is needed (1 to 3 hours depending to the configuration), after that, the stabilization is faster and < 0.5 hours.