COURTOY MODUL™ Rotary Tablet Press with Multi-Control 4:

Dual Weight and Hardness Control for Improved Tablet Quality: Possible on a Standard Tablet Press?

(Patent Pending)

The controls dilemma facing the pharmaceutical compression industry since its infancy has been resolved by Courtoy's Engineers. Like all great solutions, the answer is amazingly simple: physically separate the two control loops to work on separate areas of the press. Weight is controlled at pre-compression and hardness is controlled at main compression. As a result, weight and hardness can be controlled simultaneously and continuously on a standard tablet press. Yes, it is possible!

The Courtoy MODUL™ tablet press is now available with the enhanced tablet production control principle allowing for simultaneous, yet independent, control of both tablet weight and hardness. The "dual weight/hardness control" principle, based on the existing tablet weight control principle for Courtoy presses, features an extra control loop on the main compression station, in addition to the control loop on the pre-compression station. The control loop on pre-compression monitors and controls the tablet weight; the loop on main compression monitors and controls the hardness of the tablets.
The dual weight/hardness control principle is integrated in the Multi-Control 4 and is available as an optional feature on the MODUL™ tablet press.

Existing Tablet Weight Control Loops – Force Controlled System

Contrary to the control systems on most tablet presses, the control system on Courtoy machines for pharmaceutical tablet production, does not measure the compaction force at the main compression station for tablet weight control. The reason is that the principle of "force measurement under fixed thickness" has some problems and limitations with regard to precision, validation and transfer to other machines.

Indeed, the relationship between tablet weight and compaction force under fixed thickness is:

1) non-linear and must be established empirically.
2) depending on machine stiffness.
3) depending on machine temperature.

Moreover, the sensitivity of this relation (i.e. the variation in force per unit variation of weight) decreases with reduced compaction force. This can lead to unacceptably high tablet weight variations in case of smaller tablets and also in case of bi-layer tabletting, where the compression force on the first layer must be very low to guarantee sufficient bonding between the two layers.

This reduced sensitivity at lower compaction force is also the reason why compression force measurement for tablet weight control is always performed at the main compression station where the compaction force is the highest.

Moreover, when the powder characteristics change during the compression of a batch, the above-described control loop based on main compaction force measurement, needs to be re-calibrated (i.e. the control loop is corrected to bring the real average tablet weight back to the nominal weight) in either of the following ways:

- by changing the input target value for the main compression force, but this can change the hardness of the tablets suddenly and considerably, or
- by changing the main compression height (i.e. distance between punch tips in the main compression station), but this will change the thickness of the tablets.

It is clear that no re-calibration of the primary tablet weight control loop is possible without affecting the thickness or the hardness of the tablets. Diagram 1 shows a tablet weight control system based on measurement of compaction force at the main compression station. The re-calibration loop is called the secondary control loop.

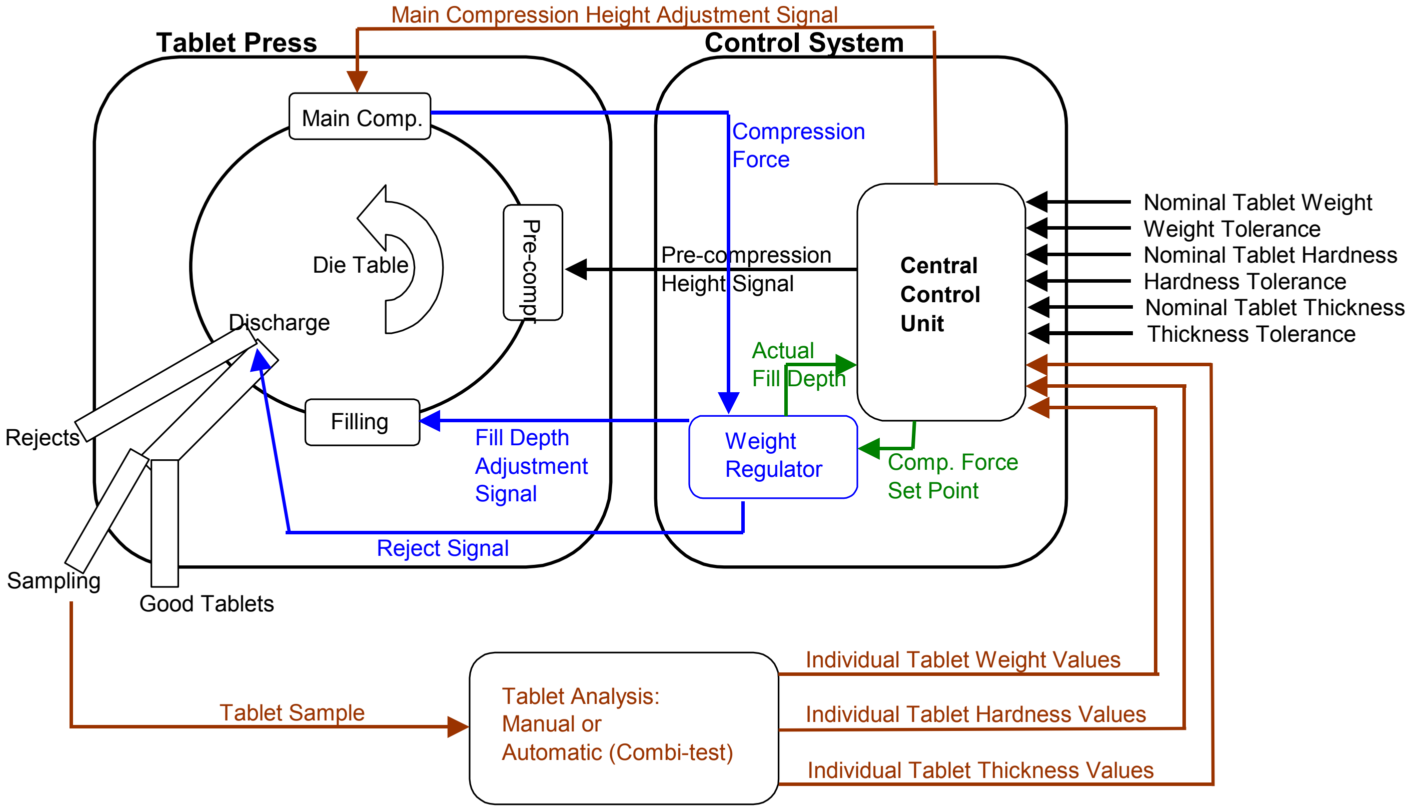


Diagram 1: force control system

Existing Tablet Weight Control Loops – Displacement Controlled System

In the early 70's, Courtoy decided to adopt a different principle for tablet weight control on rotary presses, to eliminate the problems of precision and repeatability as described above. This different principle is based on:

1) measurement of "thickness variations under fixed compression force" instead of "force variations under fixed thickness", and

2) measurement at the pre-compression station instead of at the main compression station.

The most important characteristic of this principle is the linear relationship between what is measured (i.e. thickness variation) and what is to be controlled (i.e. tablet weight). Indeed, the height of the powder slug at pre-compression is linear with its weight when all these slugs are pre-compressed with exactly the same compaction force. It is clear that thickness tolerance limits as a function of weight tolerance can now be established in a straightforward manner. This results in (1) higher precision of the control loop as there are no rounding errors and (2) easier parameter establishment and validation, as tolerance limits are calculated automatically by the control system.

Furthermore, the relationship between tablet thickness at pre-compression and tablet weight is nearly independent of machine stiffness making transfer between machines much easier. The influence of the temperature of the machine is also negligible, which eliminates tablet weight variations due to the machine warming up at the beginning of a production run.

Moreover, this weight control principle based on “displacement measurement at pre-compression” has an increased sensitivity at lower compaction force, making the system particularly suitable for small tablets (where weight tolerance is tighter) and bi-layer tabletting.

Another important advantage is that the primary control loop is re-calibrated by changing the pre-compression height (instead of main compression height in case of force control), not affecting the thickness or hardness of the final tablet at all.

The fixed and constant pre-compression force is exerted by means of an “air compensator” on the upper pre-compression roller. This system provides at the same time a longer compression dwell time, resulting in a better de-aeration of the powder and a more uniform distribution of the granules in the die, prior to the main compression effort. This advantage results in better tablet properties, especially in case of larger tablets.

Diagram 2 shows the primary and secondary control loop for a tablet weight control system based on displacement measurement.

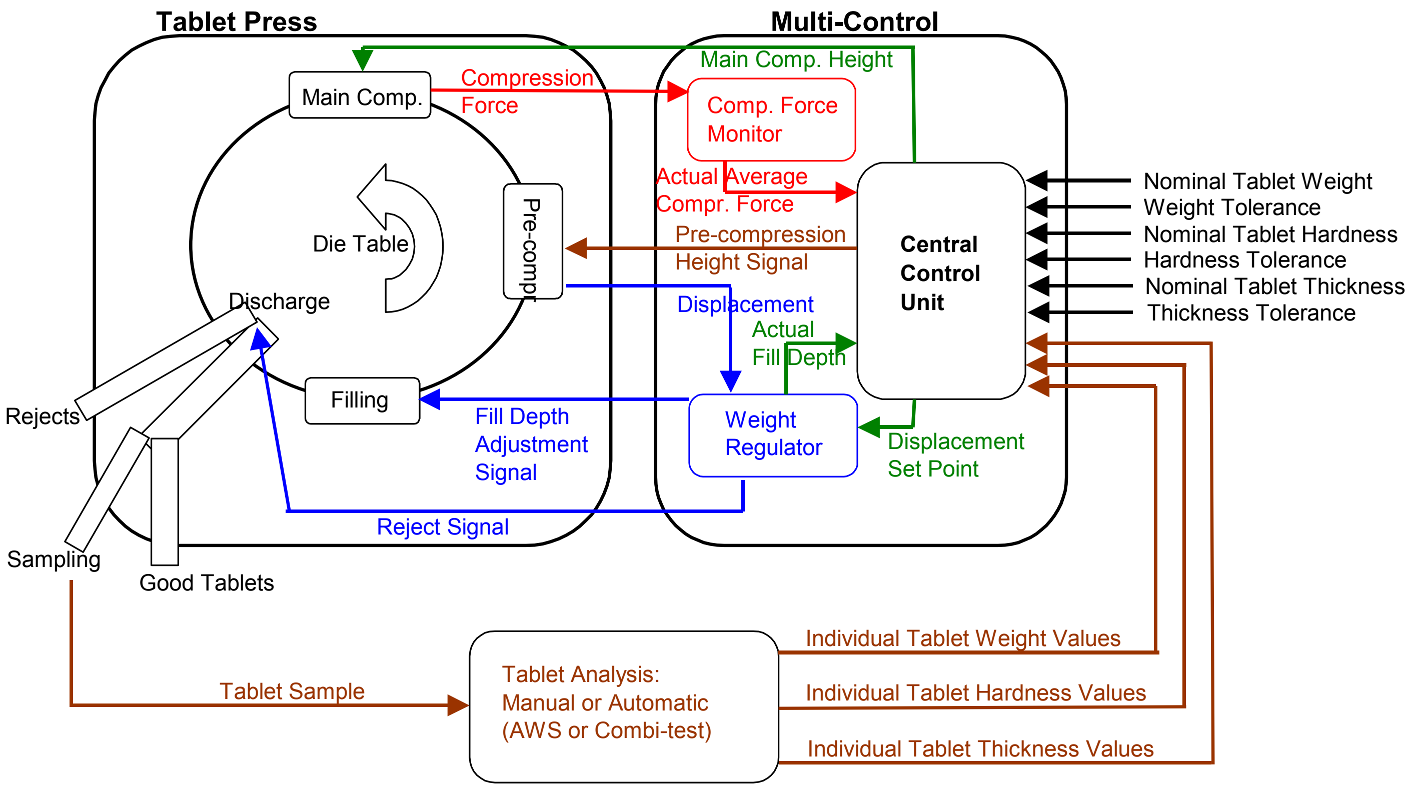


Diagram 2: displacement control system

The Additional Hardness Control Loop in the Courtoy MC4 Control System

As the Courtoy weight control loop requires the measurement of thickness variations (i.e. displacements) at the pre-compression station, the main compression station is left unused. Therefore, the main compression height is set to the correct tablet thickness at the beginning of the batch and can then be left unchanged for the entire duration of the batch. This operation mode is called “tabletting under constant thickness”, whereby main compression force – and subsequently tablet hardness – will vary with powder characteristics. Manual or automatic in-process sampling &

analysis will detect when tablet hardness goes out of tolerance and will stop the press.

Alternatively, the press can run in “tabletting under constant hardness” mode by activating a second primary control loop: a force transducer on the final compression station measures the individual main compression forces and calculates a moving average. This moving average signal is then used to adjust the main compression height in order to maintain this moving average between pre-set limits.

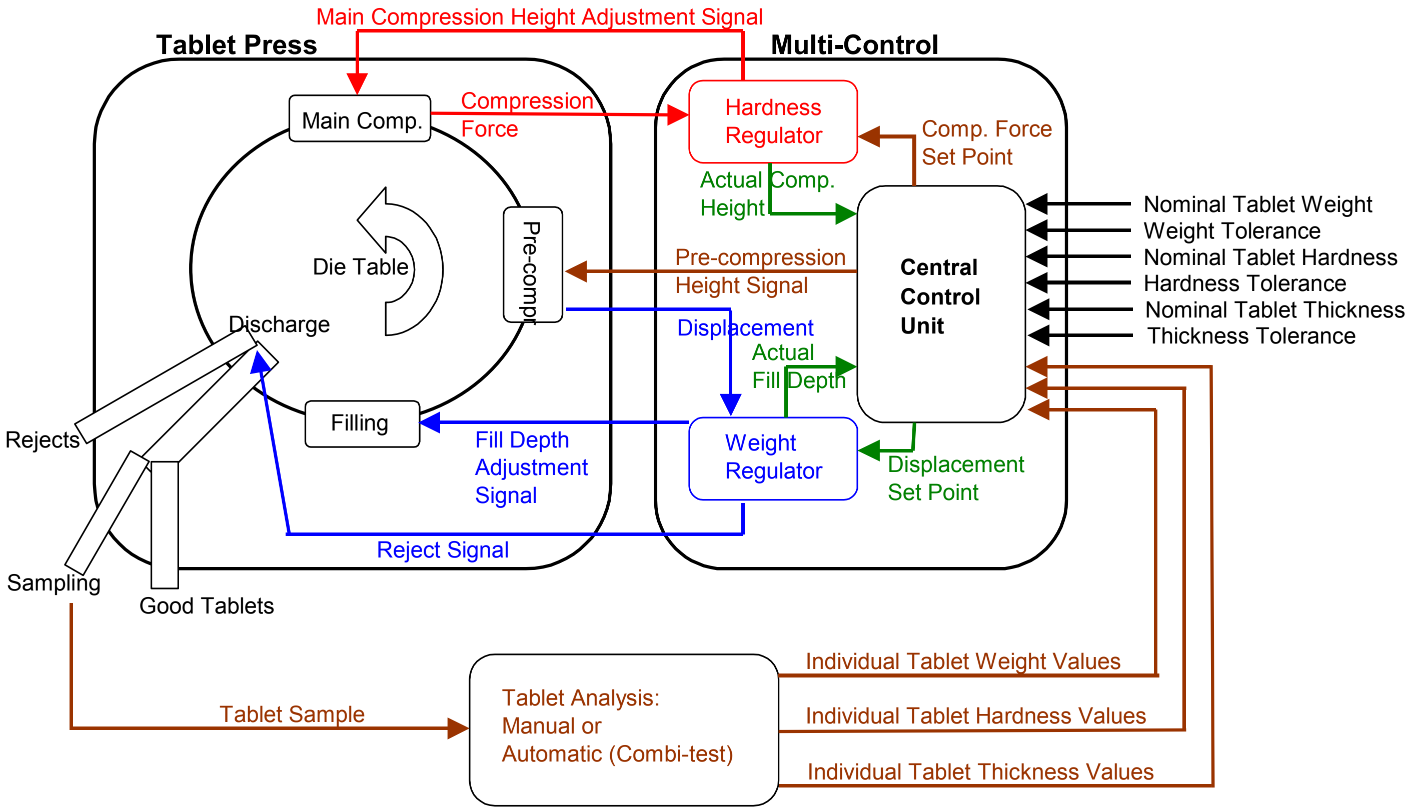
This extra control loop will thus correct the tablet thickness with the aim to keep the main compression force – and subsequently the tablet hardness – stable. This additional primary control loop is therefore called the “hardness control loop”.

It is clear that any thickness variations are only allowed within the pre-set tolerance limits of the tablet thickness. An alarm message and machine stop are generated when these tablet thickness limits would need to be crossed in order to maintain the compression force within its tolerance limits. Such a situation would mean that the powder characteristics have changed to such an extent during the production run, that it is impossible to maintain all three relevant tablet parameters – weight, hardness and thickness – within their pre-set tolerance limits. The process needs to be stopped and powder characteristics & quality checked.

The hardness control loop is re-calibrated after manual or automatic sampling & analysis, by changing the set point of the main compaction force. The change in force set point is calculated on the basis of the difference between the real average hardness and its target – i.e. nominal - value. The re-calibration of the hardness control loop is carried out in parallel with the re-calibration of the weight control loop.

When the hardness control loop is switched off (i.e. constant thickness operation mode), the individual compression forces and their average value can still be displayed graphically on the OIP of the MC4. A stop function is then available, stopping the press when the average compression force goes outside the pre-set stop limits. The graphical display & stop functionality are available in the optional feature “Compression Force Monitoring”. In case the availability of the primary and secondary hardness control loop is required, the optional feature “Hardness Control Loop” must be selected.

Diagram 3 shows the two primary and secondary control loops in case of the combined weight & hardness control.



<u>Diagram 3</u>: dual weight/hardness control system

The table below gives a survey of the two control loops available in the MC4 of the MODUL tablet press:

	Directly measured output variable of the compression process, controlled to a certain set-point	Directly controlled input parameter of the compression process, to control the output variable	Indirectly controlled tablet property	Directly controlled input parameter for re-calibration of the primary control loop (i.e. secondary control loop)
Primary control loop 1	Thickness variations under constant compaction force at pre-compression station	Die fill depth	Average tablet weight	Distance between pre-compression rollers
Primary control loop 2	Main compaction force at final compression station	Distance between final compression rollers	Average tablet hardness	Set-point of compaction force at final compression station

The above clearly shows that the weight control loop and the hardness control loop are totally separated loops, as they are measuring process variables at different compression stations and acting on independent parameters of the compression cycle.

Because the two loops are separated and both are running continuously, there is an independent, continuous and simultaneous control of both tablet weight and tablet hardness. Courtoy's ability to control separate loops creates a true "**Dual Weight / Hardness Control System**".