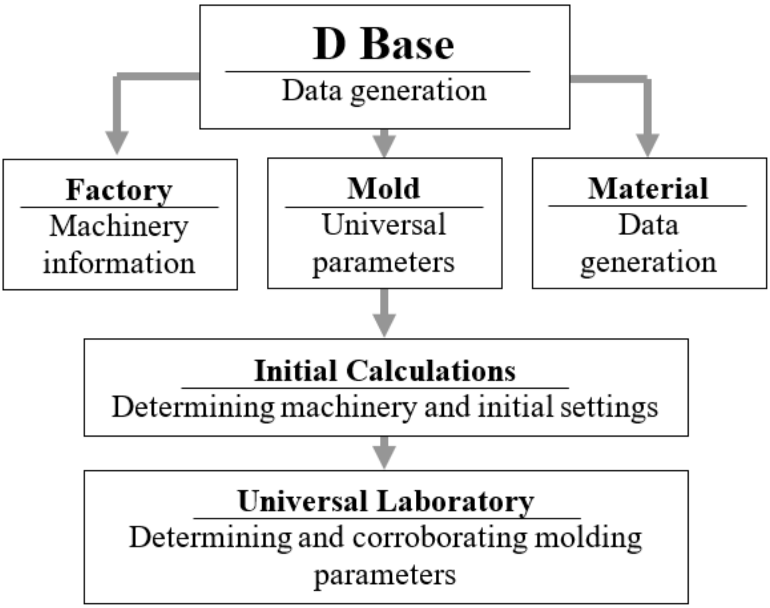
VIII. Determining Injection Speed

- **Laboratory I - Understanding Fill and Its Limitations, Determining Minimum Injection Time and Injection Pressure Limit**
- **Laboratory II - Procedure for Determining Minimum Injection Time and Injection Pressure Limit**
- **Laboratory III – Determining Injection Time and Injection Speed**
- **Laboratory IV - Graph of Rheology and Determination of Ideal Injection Time and Speed**
- **Laboratory V - Approximated Graph**
- **Laboratory VI - Injection Time Prediction**

In order to maximize the use of this molding discipline, you must have a clear understanding of the fundamentals of ***Universal Molding***^{TM} and "Molding from the Desk". Understand and identify the needs of your process, and address those needs with well thought-out solutions. ***Universal Molding***^{TM} is a discipline that promotes a structure of organized events.



VIII-1. Flow chart of ***Universal Molding***^{TM} *events*

Collect all the information, organize a database, and make that information accessible to everyone in your molding factory.

Include the following:

<u>Molding machine data:</u>

- minimum and maximum clamping forces
- ejector pattern
- space between the bars
- minimum and maximum mold width
- maximum mold weight
- injection volume
- maximum injection pressure
- intensification ratio

- special options such as sprues, nozzle valves, etc.

Auxiliary equipment data:

- dryer (drying flow, hopper volume, ...)
- TCU (flow, pressure, ...)
- additive feeder
- grinders
- robots
- conveyors
- hot runner control, etc.

Mold data:

- ejector pattern
- dimensions and opening
- weight
- fill volume
- hot runner
- operational limits
- material or materials to be molded
- mold temperatures
- water flow and pressure drop
- diameter and radius of the sprue bushing, etc.

Data of the material being used:

- name of the material and its distributors
- specific melt density
- specific density to environmental conditions
- bulk density of resin
- if hygroscopic, the drying time and temperature
- melt temperature
- suggested barrel temperature profile
- suggested mold temperature
- semi-crystalline or amorphous
- suggested plastic injection pressure, etc.

Once you have all the data of your process, complete your "Molding from the Desk", performing the calculations for drying, the press, the injection unit, cooling, etc.

Finally, determine the optimal molding parameters by performing the ***Universal Molding™*** procedures.

Again, before proceeding with this ***Universal Molding™*** laboratory remember that:

- You must perform the "Molding from the Desk ".
- All auxiliary equipment should be properly installed and operational.
- Temperatures should already have been reached, such as water temperature, injection barrel temperature profile and corresponding melt temperature, hot runner heat zones (if any), etc.
- Barrel adjustments should have been programmed, such as recovery and transfer position, decompression, recovery speed, etc.
- The appropriate nozzle tip should be installed.
- The required clamping force should be set.
- The opening of the platens, their movements, speeds and the mold protection must be carefully and precisely set.
- Extended cooling time must be programmed. Remember that this has to be set to more than is required. To prevent it from interfering with previously determined parameters, it will be optimized at the end.

Important -- Only qualified personnel who have read the operational manuals of the equipment and understand the functionality of the equipment should operate and/or adjust them.

Laboratory I - Understanding Fill and Its Limitations, Determining Minimum Injection Time and Injection Pressure Limit

The goal of this lab is to understand the fill's behavior, determining how fast the mold can be filled without causing defects. The maximum speed is determined, its corresponding maximum injection pressure is obtained, and fill limitations, if any, are identified. These fill limitations could be:

- Material degradation or burning as a result of excess speed. For example, PVC tends to burn if the injection speed is high.

- A problem with the vents, such as burns that can occur due to gas combustion, or dieseling. This defect can be corrected by cleaning the vents or, in the worst case, repairing or modifying the mold.
- Equipment limitations, such as an injection unit unable to reach high injection speeds, a limitation that could be a result of an injection unit that is inadequate for the mold, etc.

The idea is to identify in advance any defects or limitations that may arise. If any of these occur in the equipment when increasing the injection speed, you must decide whether the modification is simple or complicated. If the remedy is simple, do it. However, if the modification or change is not viable, or is not economically feasible, you will have to carry out the laboratory with that condition. Ideally it would be better to correct the situation before continuing; unfortunately, it is not always possible. For example, in the case of limited injection speed, it would be better to switch to an appropriate injection unit, but if that is economically prohibitive, you will have to work with a limited injection speed.

It is important to understand that not every parameter programmed in the equipment's control can be reached; therefore, you must ensure that the entered value is being achieved.

The programmed speed may be limited by an inadequate injection unit, as a result of a low % of utilization. For example, a utilization of 5% might not have the acceleration displacement required by the speed that was entered. Verify that the programmed speed is always being reached.

Procedure for Determining Minimum Injection Time and Injection Pressure Limit

a) Verify that the transfer position from injection to hold was entered. Do you remember how? This procedure was explained in the "Injection Unit Calculations" section.

With machines under 400 metric tons

% of Utilization	35% or less	65% or more	Between 35% and 65%
Transfer	6 mm (0.25 in)	12 mm (0.5 in)	Interpolate

With machines 400 metric tons or larger

% of Utilization	35% or less	65% or higher	Between 35% and 65%
Transfer	12 mm (0.5 in)	25 mm (1.0 in)	Interpolate

VIII-2. Tables to select the injection-to-hold transfer position

b) Turn off the hold stage so that it does not interfere with the determination of the minimum injection time. This could be done by setting the hold pressure to zero. Some injection machines come with the hold stage divided into two, pack and hold. Turn off one of them.

c) Adjust the injection unit to produce parts that are 20% incomplete. This is done to prevent damage to the mold and the machine.

Recovery position =
transfer position + 80% of injection displacement

Notes:

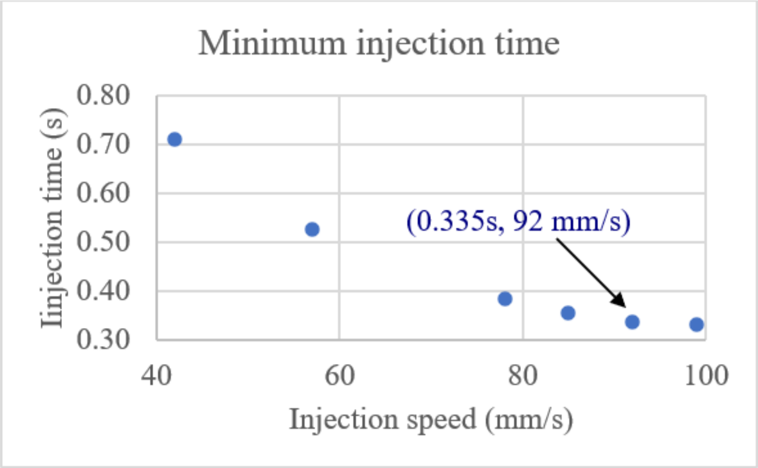
- It is important to maintain a cooling time that is longer than required while determining the minimum injection time.
- You should also be alert during mold closure, to prevent the mold from closing with unreleased parts.
- Turn off alarms that could stop the laboratory, such as the alarm that limits the maximum injection time. Caution: never turn off mold closure protection (*mold protect*).

d) Find the mold's minimum injection time and maximum injection speed. The idea is to increase the injection speed until the injection time stops decreasing. A safe and practical method is to increase the injection speed and injection pressure limit at the same time, until the injection time stops decreasing. Be cautious and, even if it's easier, don't set the pressure limit to its maximum. It may cause breakage.

During the experiment:

- Verify that parts do not remain trapped in the cavities. You may need to perform this step with the control set to semi-automatic.
- If you turned off the hold stage by adjusting the hold time to zero, verify the demolding. If the parts are extremely hot, increase cooling time until the parts demold at a lower temperature.

It is advisable to perform this experiment with a graph of injection time versus injection speed, which will help you determine the minimum injection time. See below.



Pressure (mPa)	Time Inj. (s)	Vel (mm/s)
--------	--------	7
--------	--------	14
--------	--------	21
--------	--------	28
--------	--------	35
151	0.711	42
--------	--------	50
166	0.526	57
--------	--------	64
--------	--------	71
189	0.384	78
196	0.354	85
204	0.335	92
211	0.330	99

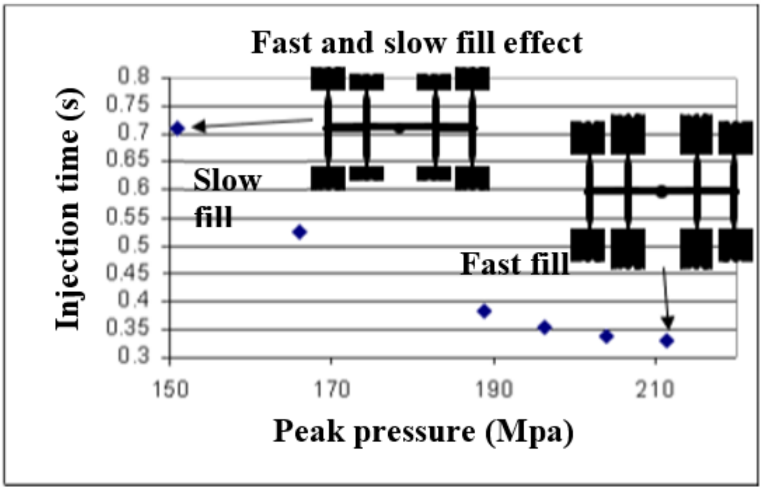
VIII-3. Determination of minimum injection time and maximum injection pressure (example)

The graph of injection time versus injection speed illustrates how, at a pressure of 204 mPa and at 92mm/second, the decrease in time becomes insignificant.

e) Inspect the parts. Although they will be incomplete, make sure you obtain parts that are free of defects due to degradation.

If the defect requires a simple mold repair, do it and repeat the exercise. However, if the repair is not feasible, the speed at which the defect appeared should be your maximum speed.

Observation: the fill of the parts increases with an increase in injection speed.



VIII-4. Effect of injection time on parts fill

This is a normal effect that will not affect the experiment; a slow fill produces incomplete parts and a fast fill will produce parts that might appear to be totally full. Even though the recovery position was adjusted to 80% of the fill (parts and runner), the parts could fill more than 80% with fast fillings.

Remember that at the end of the injection, transfer position, the screw is being stopped by the plastic in front of the check ring. The screw, just like the plastic, will continue to travel with its own kinetic energy. In other words, the melt will continue to fill the mold until it consumes all that energy in the form of speed. That is why the higher the injection speed the higher the energy at transfer and, consequently, the higher the fill volume.

Continue determining the minimum injection time.

f) Write down the maximum pressure and the maximum speed obtained.

V_{max} = maximum speed
PH_{max} = maximum hydraulic pressure

If you are working with ***Universal*** parameters, it will be:

F_{max} = maximum flow
PP_{max} = maximum plastic pressure

Summary of the steps:

a) Adjust the transfer position to hold.
b) Turn off the hold stage so that it does not interfere with the determination of the injection time.
c) Adjust the injection unit to produce parts that are 20% incomplete.

Recovery position =
transfer position + 80% of injection displacement

d) Find the minimum injection time and maximum injection speed for the mold being used.
e) Although the parts will be incomplete, verify they are free of defects due to degradation.
f) Write down the maximum pressure and the maximum speed obtained.

V_{max} = maximum speed or F_{max} = maximum flow
PH_{max} = maximum hydraulic pressure or
PP_{max} = maximum plastic pressure

Notes:

- Disabling the hold stage by setting pressure or time to zero can be challenging on some machines because they do not allow precisely zero values. Additionally, certain machines may become unstable if the hold pressure is set to zero. It is essential to have a clear understanding of your machine's controls or consult with its manufacturer if you have any doubts.
- If any equipment limitation or defect arises, evaluate the situation, and if the limitation requires a modification or a simple change of equipment, do so. However, if the modification or change is not feasible, you will have to carry out the laboratory with what you have.
- The programmed injection speed might not be reached by the injection unit; verify that it does.
- This lab is performed with the hold stage off. You could do this by adjusting the hold pressure or time to zero.
- In order to avoid damage to the mold and the machine, this laboratory is carried out by adjusting the injection unit to produce parts that are 20% incomplete.
- The weight of the parts increases with an increase in injection speed or flow.

Laboratory II - Determination of Injection Time and Injection Speed

a) Set the injection speed or speeds to 95% of $V_{max,}$ the maximum speed found and call it $V_{95.}$

$$V_{95} = 0.95 \text{ x } V_{max}$$

Use only one fill speed. Previous chapters explained that, if the recovery and transfer positions are adjusted correctly, most molds can be filled with a single injection speed. Family molds, with cavities of different volumes and distinct geometries, may require more than one speed. Now, most molds can be filled with a single injection speed; do not use a speed profile if you don't need it.

b) Adjust the pressure limit equal to P_{max}.

c) Using velocity V_{95}, adjust the recovery position so that the mold (including parts and runner) fills to approximately 95% of its total weight.

At first glance, the parts may appear completely filled, since molten thermoplastics are compressible and will expand to occupy a significant portion of the volume; even so, it is still missing material.

Even when the velocity is reduced by 5%, it’s possible to reach the set pressure limit, since P_{Max} was found with incomplete filling (around 80%). Always verify that the pressure limit is never reached; keep it 5% to 10% above the required pressure.

Some molds present significant filling challenges. For instance, in micro-molding or with long thin parts (thin wall values exceeding 250), it’s necessary to fill over 95% during the injection stage. To accomplish this in those distant and uncomfortable spaces, it’s crucial for the melt to have the lowest possible viscosity and flow rapidly toward the end of fill.

Notes:

- Do not try to maximize the fill during the injection stage; only guarantee about 95%. Trying to get to the maximum can result in problems with flash and screw bounceback.
- Be sure to produce parts without flash.
- Ensure that the pressure during injection remains at least 5% lower than the set pressure limit.

d) Without changing the transfer position and continuing with the hold stage off (hold time = 0 or hold pressure = 0), create a rheology table with different injection speeds.

Remember that this laboratory can be performed:

- With machine rheology by power or by viscosity.
- With complete or approximated rheology.

We ***Universal*** molders prefer and recommend approximated rheology by power, since the equations represent the evaluated effects.

Include in the header:

- For machine parameters: injection speed, fill time, hydraulic transfer pressure and plastic transfer pressure.
- For rheology by power: flow and power.
- For conventional rheology: shear rate and viscosity.

Remember to write the corresponding units.

Machine Parameters				Rheo. by Power		Rheo. by Viscosity	
Speed (mm/s)	T_{inj} (s)	$P_{hydraulic}$ (bar)	$P_{plastic}$ (bar)	Flow (bar*cc/s)	Power (bar*c/s)	Sh. Rate (1/s)	Viscosity (bar*s)

VIII-5. Rheology table headers

With rheology by power, use the following equations:

Average injection flow =
injection volume / injection time

Injection volume =
screw area ($D^2\pi/4$) x injection displacement

Peak power =
average injection flow x pressure at the transfer position

Plastic pressure =
hydraulic pressure x intensification ratio

Each of these equations was explained in detail in the "Machine Rheology" chapter.

With approximated power rheology, perform the laboratory using the first and last data points. The initial velocity will be equal to 95% of the maximum velocity found in the previous lab (V_{95} = 0.95 x V_{max}).

The second and last speed will be equal to 10% of the V_{95} speed.

$$= 0.1 \times V_{95}$$

Speed (mm/s)	T_{inj} **(s)**	$P_{hydraulic}$ **(bar)**	$P_{plastic}$ **(bar)**	**Flow (cc/s)**	**Power (bar*cc/s)**
V_{95}					
$0.1V_{95}$					

VIII-6. Table of approximated rheology by power

If you work with complete rheology, calculate and enter 10 descending speed values, the first equal to the V_{95} speed, and the next 9 in 0.1 x V_{95} decrements.

Rheology by Power					
Speed (mm/s)	**T_{inj} (s)**	**$P_{hydraulic}$ (bar)**	**$P_{plastic}$ (bar)**	**Flow (cc/s)**	**Power (bar*cc/s)**
V_{95}					
0.9 x V_{95}					
0.8 x V_{95}					
0.7 x V_{95}					
0.6 x V_{95}					
0.5 x V_{95}					
0.4 x V_{95}					
0.3 x V_{95}					
0.2 x V_{95}					
0.1 x V_{95}					

VIII-7. Table showing conventional rheology by power

e) Without turning on the hold stage and without changing the transfer position, inject at the different injection speeds, taking readings of:
- Maximum hydraulic pressure: Take the reading in the position where the injection ends. If the machine gives plastic pressure readings, then eliminate or leave the hydraulic pressure spaces blank.
- Fill time: Take the reading of the time it takes from the start of injection to the transfer position.

f) Calculate and fill the table with its corresponding values. Remember that the maximum plastic pressure = $P_{hydraulic}$ x R_i. If the machine gives a plastic pressure reading, ignore this calculation or assume that $R_i = 1$.

Summary of the steps:

a) Adjust the injection speed or speeds to 95% of the maximum speed (V_{max}) that was found and call it V_{95}:

$$V_{95} = 0.95 \text{ x } V_{max}$$

b) Adjust the pressure limit equal to P_{max}.

c) Using the V_{95} speed, adjust the recovery position so that it fills the mold (parts and runner) to about 95% of its total weight. Ensure that the adjusted pressure limit is at least 5% higher than the maximum injection pressure.

d) Without changing the transfer position and continuing with the hold stage off, create a rheology chart at different injection speeds.

e) With the hold stage still turned off and without changing the transfer position, inject using the different injection speeds, taking readings of:

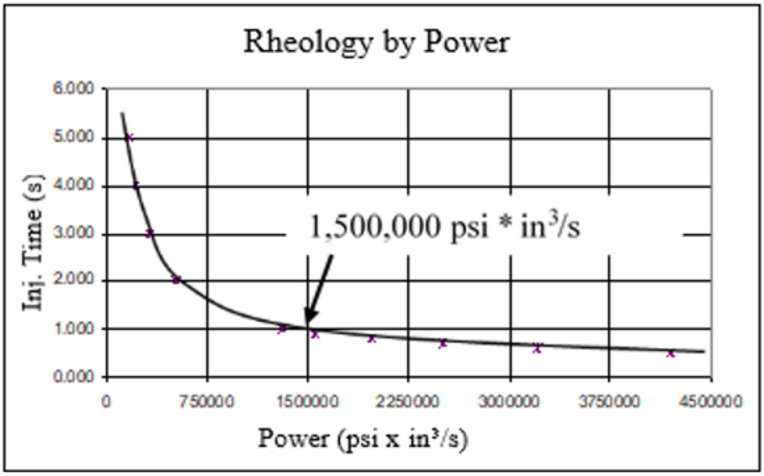
- Maximum hydraulic pressure: Take the reading in the position where injection ends. If the machine gives plastic pressure readings, then eliminate these spaces or leave them blank.
- Fill time: Take the reading of the time it takes from the start of injection to the transfer position.

f) Calculate and fill the table with its corresponding values. Remember that the maximum plastic pressure = $P_{hydraulic}$ x R_i. If the machine gives a plastic pressure reading, ignore this calculation or assume that $R_i = 1$.

Laboratory III - Rheology Graph and Determination of Ideal Injection Time and Speed

Using the rheology table already completed, make a rheology graph. If you work with rheology by power, your rheological table will look something like this:

Rheology by Power, $R_i = 6.41$, Vol = 273 in^3					
Speed (in/s)	T_{inj} (s)	$P_{hydraulic}$ (psi)	$P_{plastic}$ (psi)	Flow (in^3/s)	Power ($psi*in^3/s$)
3.2	0.50	1200	7692	546	4199832
2.9	0.60	1100	7051	455	3208205
2.6	0.70	1000	6410	390	2499900
2.3	0.80	900	5769	341	1968671
1.9	0.90	800	5128	303	1555493
1.6	1.00	750	4808	273	1312448
1.3	2.00	600	3846	137	524979
1.0	3.00	550	3526	91	320821
0.6	4.00	500	3205	68	218741
0.3	5.00	461	2955	55	161344



VIII-8. Example of a table and graph of conventional rheology by power

According to this graph, the power stops contributing significantly to the injection time after a power greater than 1,500,000 psi * in^3/s.

Laboratory IV - Approximated Graph

As explained in the previous chapter, developing an injection molding rheology laboratory consumes time and resources. With approximated rheology, a mathematical prediction technique, the laboratory can be performed in less than a third of the time.

In the previous example, we used velocity V_{95} and 10% of V_{95} to find the readings for injection time and pressure at the moment of transfer. If we work with rheology by power, you will notice that there is a relatively linear relationship between average injection flow and peak power of injection. Using the equation of a line, $Y = Y_o + MX$, where Y is the peak power, Y_o is the intercept in the coordinate of the peak power, M is the slope, and X is the average flow.

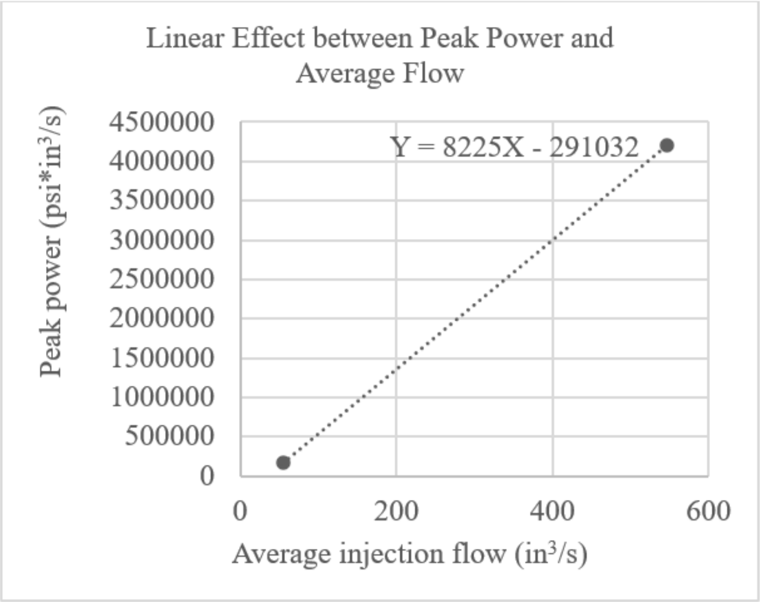
The value of these constants can be found with simple math or Excel.

Using the values of the fastest velocity and the slowest velocity from the previous example, we get:

Rheology by Power, R_{i} x 6.41, Vol 273 in^3					
Speed (in/s)	**T_{inj} (s)**	**$P_{hydraulic}$ (psi)**	**$P_{plastic}$ (psi)**	**Flow (in^3/s)**	**Power (psi*in^3/s)**
3.2	0.50	1200	7692	546	4199832
0.3	5.00	461	2955	55	161344

VIII-9. Example of a table of approximated rheology by power

Using the Graphing Trendline tool in Excel, we find the linear equation between the maximum and minimum points.



VIII-10. Graph with linear equation between peak power and average injection flow

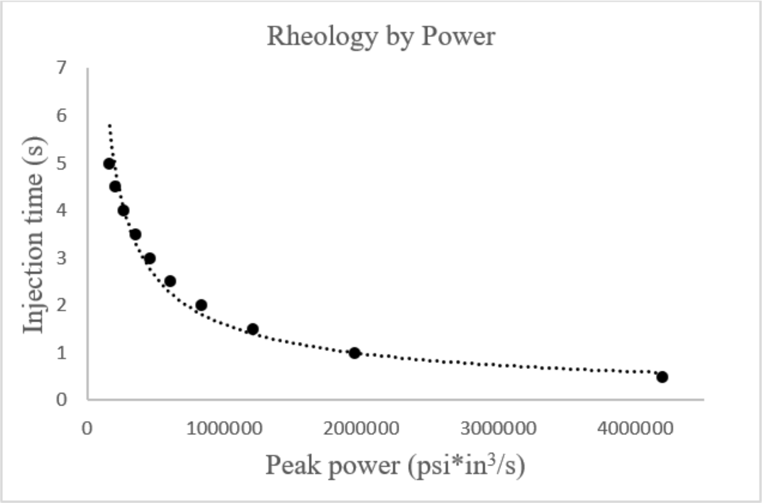
$$\text{Peak power} = 8225 \text{ x (average flow)} - 291032$$

Knowing that the injection volume required is 273 in^3 and using the equation for average flow (required volume/injection time), we get:

$$\text{Average flow} = 273 \text{ in}^3\text{/ injection time}$$

With these two equations, we can now approximate the intermediate values of the graph. With ten equidistant injection times, between the minimum and maximum injection times, we calculate their corresponding average injection flow and peak injection power.

$T_{injection}$ (s)	Flow (in^3/s)	Power (psi*in^3/s)
0.5	546.0	4199832
1	273.0	1954393
1.5	182.0	1205918
2	136.5	831681
2.5	109.2	607138
3	91.0	457443
3.5	78.0	350518
4	68.3	270324
4.5	60.7	207951
5	55	161344



VIII-11. Table and graph of approximated rheology by power

Laboratory V. Injection Time Prediction

In the chapter on machine rheology, it was established that the ideal injection time would depend on the type of industry.

Conventional molding industries, where much of the industry is found:

$$T_{Intermediate} = T_{min} + (T_{max} - T_{min}) / 18$$

Industries that mold sensitive materials, such as rigid PVC:

$$T_{sensitive\ mat.} = T_{min} + (T_{max} - T_{min}) / 12$$

Industries with a high volume of injection, such as cap molding and micro-molding:

$$T_{fast} = T_{min} + (T_{max} - T_{min}) / 36$$

In addition, $T_{plateau}$ was defined as a time when the contribution of power to the injection time begins to be insignificant.

$$T_{plateau} = T_{min} + (T_{max} - T_{min}) / 9$$

Where:

T_{min} = injection time for the maximum injection speed
T_{max} = injection time for the minimum injection speed

Using the previous example, we find that T_{min}, is 0.5 seconds, which corresponds to the speed of 3.2 in/s (V_{95}) and T_{max} is 5.0 seconds, which corresponds to the speed of 0.3 in/s (10% of V_{95}).

Rheology by Power, R_i x 6.41, Vol 273 in^3					
Speed (in/s)	**T_{inj} (s)**	**$P_{hydraulic}$ (psi)**	**$P_{plastic}$ (psi)**	**Flow (in^3/s)**	**Power (psi*in^3/s)**
3.2	0.50	1200	7692	546	4199832
0.3	5.00	461	2955	55	161344

VIII-12. Table of approximated rheology by power

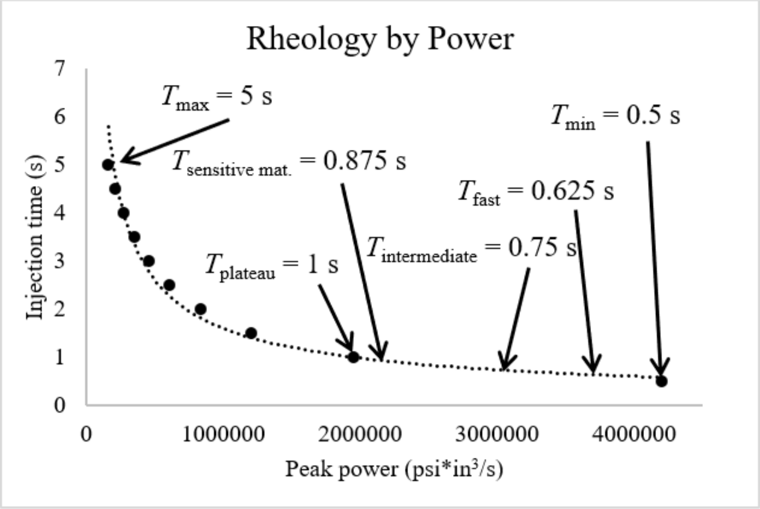
a) After identifying the industry type, select its corresponding equation, and replace the values of T_{min} and T_{max}, in order to determine the ideal injection time.

$$T_{Intermediate} = T_{min} + (T_{max} - T_{min}) / 18$$
$$= 0.5s + (5s – 0.5s) / 18 = 0.75 \text{ seconds}$$

$$T_{Sensitive\ mat.} = T_{min} + (T_{max} - T_{min}) / 12$$
$$= 0.5s + (5s – 0.5s) / 12 = 0.875 \text{ seconds}$$

$$T_{fast} = T_{min} + (T_{max} - T_{min}) / 36$$
$$= 0.5s + (5s – 0.5s) / 36 = 0.625 \text{ seconds}$$

$$T_{plateau} = T_{min} + (T_{max} - T_{min}) / 9$$
$$= 0.5s + (5s – 0.5s) / 9 = 1.0 \text{ seconds}$$



VIII-13. Rheology graph indicating injection times by industry type

These equations help standardize the selection of injection time; even so, they are only a reference.

c) Determine the ideal injection speed.

Once you have determined the injection time, find the corresponding injection speed. This is done by adjusting the injection speed until it approximately equals the ideal injection time found.

With the ideal speed found, verify that the mold (parts and runner) fills **close to 95%** of its total weight or volume. If not, adjust the recovery position until both the ideal injection time and a fill of about 95% are achieved. Keep in mind that once the pack stage is optimized, the final position could come close to zero if the injection volume is significantly below 95%.

Remember that not every mold can be filled to around 95% during the injection stage; some because of a condition of their design and in some cases, because the mold must be repaired. For example, in molds with filling difficulties, such as in micro-molding or long and thin parts, it is necessary to achieve over 95% filling during the injection stage. To accomplish this, in those distant and uncomfortable spaces, it is crucial for the molten material to have the lowest possible viscosity and flow rapidly toward the end of fill.

Injection speed may cause defects. There are several scenarios:

- Burns at the end of fill - the vents are likely to be plugged or defective.
- Burns around edges or corners - could be caused by an edge or flash of metal in the mold.
- Burns in the form of streaks that extend along the fill or from the gate - it is likely that the material is degrading by friction, etc.

Consult the mold maintenance department; it will probably recommend some type of maintenance or repair. Follow the recommendations and return to molding at the determined injection speed.

Unfortunately, not every material, mold, and molding equipment is at its best design condition. What is worse, for whatever reason, is being forced to mold with these deficiencies.

In the event of not being able to do the rheology as a result of material limitations (e.g. degradation) or equipment limitation (e.g. inability to rapidly inject), if parts must be molded under these conditions, follow this simple procedure:

- Inject by incrementing the speed until it reaches the specific limitation.
- Then reduce the maximum speed found by 5%, and inject with this new speed; if the defect disappears this will be your injection speed or time.

d) Note the values found for:

- injection time
- injection speed and its corresponding injection flow
- transfer position and its corresponding transfer volume

- plastic pressure limit and hydraulic pressure limit (if applicable)
- recovery position and its corresponding recovery volume.

Summary of the steps:

a) Using the completed rheology table, create the rheology graph.
b) Select the ideal injection time for your application.
c) Select the ideal injection speed corresponding to the injection time found.
d) Note the values found for:
- injection time
- corresponding injection flow
- corresponding transfer volume
- plastic pressure limit
- corresponding recovery volume

Notes:

- Do not try to maximize the fill, just guarantee something close to 95%. Trying to get to the maximum can result in flash problems.
- Be sure to produce parts without flash.
- Ensure that pressure during injection is maintained at least 5% lower than the set pressure limit.
- There is a relatively linear relationship between injection flow and peak power.
- Remember that you are working with expensive equipment: do not rush the work and follow the safety rules established by your factory and government agencies.

Questions

1) During a ***Universal Molding***^{TM} lab, what do you do if some limitation or defect in equipment appears, such as limited injection speed?
   a. If the limitation requires a modification or a simple change of equipment, do it. If the modification or change is not feasible, or is economically unsustainable, you will have to run the laboratory with the equipment you have.
   b. If the limitation requires a modification, do it. The laboratory must be carried out under ideal conditions.

2) All programmed injection speeds, whether slow or fast, are always reached by the injection unit.
   a. True.
   b. False, the speed entered may be limited by an inadequate injection unit.

3) While determining the injection speed, hold pressure should be set to an average pressure.
   a. True, hold is used during the determination of injection time.
   b. False, hold is turned off so that it does not interfere with the determination of injection speed.

4) While determining the minimum injection time, the injection unit should be adjusted to produce parts that are 20% incomplete.
   a. True, this is done to prevent damage to the mold, the machine, or both.
   b. False, it is necessary to fill the total volume.

5) With fill of incomplete parts, for example to 80%, you will notice that the weight of the parts decreases with an increase in injection speed.
   a. True.
   b. False, the weight of the parts increases with an increase in injection speed.

6) Select all the correct statements:
   a. The fastest speed used in the rheology table is 95% of the maximum speed (V_{max}) found during the determination of the minimum injection time.

b. The rheology table is created by injecting at different speeds, all with an incomplete fill of 80%.
c. Ensure that the pressure during injection is maintained at least 5% lower than the set pressure limit.

7) Select the correct statement:
a. The power rheology graph coordinates are viscosity versus changing speed.
b. The power rheology graph coordinates are injection time versus peak power.
c. The conventional rheology graph coordinates are fill flow versus peak power.

8) Select all the correct statements:
a. There is a relatively linear relationship between viscosity and injection flow.
b. There is a relatively linear relationship between injection flow and power.
c. With approximated rheology by power we use the equation of a line, $Y = Y_o+MX$, where Y is the flow, Y_o is the intercept in the injection flow coordinate, M is the slope and X is the injection's peak power.

9) Materials sensitive to injection speed, such as rigid PVC, need an injection time
a. between $T_{plateau}$ and T_{min}.
b. close to T_{min}.
c. close to $T_{plateau}$.

10) Once you have determined the ideal injection time, find the corresponding injection speed.
a. Also, verify that the mold (parts and runner) fills to about 80% of its total weight.
b. Hold continues to be turned off until this part of the lab.
c. Ensure that the pressure during injection is maintained to at least 5% lower than the set pressure limit.
d. All the above are correct.