Intensification Ratio (R_i)
What is it?
And How to Calculate

By John Bozzelli

In all hydraulic injection-molding machines, hydraulic power is converted, multiplied or intensified, into plastic pressure (melt pressure in the nozzle). The law of physics involved is F = P x A. That is force (F) is equal to pressure (P) times area (A). The large hydraulic piston pushes the screw where the non-return valve or check valve acts as a plunger pushing plastic through the nozzle into the mold. The hydraulic piston has a large surface area, for example 100 cm^2. The non-return valve during injection forward acts like a smaller area piston, for example 10 cm^2. This large to small ratio of ram areas causes the hydraulic pressure to be intensified to plastic pressure in the nozzle of the injection barrel. In this specific case hydraulic pressure is "intensified" or multiplied by a factor of 10. This is the machine's intensification ratio and explains how hydraulic pressure can provide tens of thousands of psi plastic-pressure inside the nozzle. That is, 800 psi of hydraulic pressure provides ~8,000 psi of melt pressure inside the nozzle. Today you can buy machines with intensification ratios ranging from 6:1 to 43:1. Custom machines can be even larger. ***Most machines are NOT 10:1***. It is plastic pressure that pushes plastic into the sprue, runner, gate and mold cavity, NOT hydraulic pressure. This "plastic" pressure must be duplicated as you go from to machine to machine with the same mold. If your plant has different size or makes of machines, most likely they have different intensification ratios. That is 800-psi pack and hold pressure on one machine with an intensification of 10:1 develops 8,000-psi plastic pressure in the nozzle, but on another machine with a different intensification ratio of 12.75:1; 800-psi hydraulic pressure develops 10,200-psi plastic packing pressure in the nozzle. You will not make the same part. To make the same part you must pack out the cavity with the same cavity pressure. See Figure 1 for an illustration.

How to Calculate:

Ideally, you should find the screw diameter and the functional hydraulic ram diameter to calculate the ratio of areas. Unfortunately, you would spend hours looking for the hydraulic ram area and in some cases, it cannot be found in the machine manuals. While this is the best way, it is not practical. An easier method is to find the machine specifications, identify which diameter screw you have in the machine and from the machine specifications find the maximum plastic or melt pressure the machine can develop. Then go to the machine and find what the maximum hydraulic pressure you are allowed to set for injection or first stage. Once you have these two numbers you can calculate the machines intensification number with the following equation

Ri = Maximum injection (plastic) pressure/maximum hydraulic pressure for the injection unit.

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Example:
From machine specifications, we find that for the maximum injection or plastic pressure possible is 26,500 psi. From the machine controller we find that the maximum hydraulic pressure we can set the injection cylinder to is 2,250 psi

Ri = 26,500 psi/2,250 psi = 11.78:1.

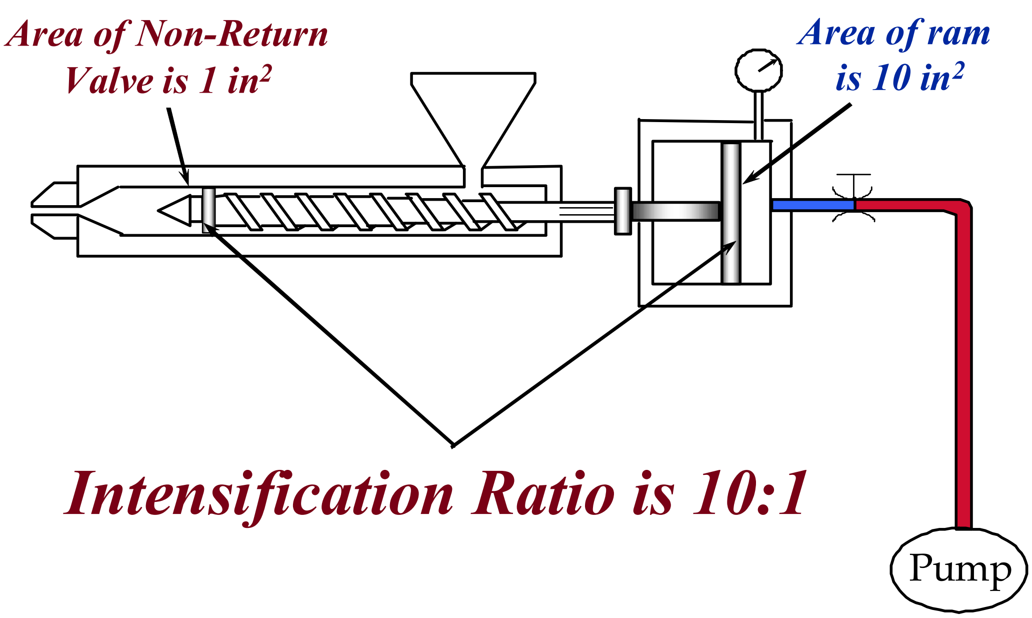
To calculate the plastic pressure for backpressure during screw run with a machine setting of 75 psi hydraulic, multiply the hydraulic pressure times the intensification ratio. In this case:

Ri = 75 psi x 11.78 = 883 psi

If you transferred this process to an electric machine, you would have to set 883 psi on input for backpressure.

Figure 1: Intensification Ratio Diagram:

Hydraulic vs Plastic Pressure



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