## Increase Productivity & Reduce Costs with Ketoprix™ Polyketone Resins


The rheological characteristics of any thermoplastic resin directly impact the final costs of a molded part in multiple ways. These characteristics define the limits of design flexibility achievable with a resin as well as the costs incurred when converting the resin to the finished part. Ketoprix™ polyketone compounds reduce product costs by offering increased product design flexibility, reduced processing costs and increased productivity. These benefits are due to the wide range of melt viscosities (generally low) exhibited by these compounds combined with their inherently rapid crystallization rate and resistance to hydrolytic degradation in the melt state.

Two basic trends have become increasingly common in plastic part designs in recent years and these trends are accelerating with the advancements in the electronics industry. These trends are to design parts with ever thinner nominal wall sections in combination with longer flow lengths and increasing geometric complexity with ever more detail density. This is especially evident in the electronics, medical and aerospace industries.

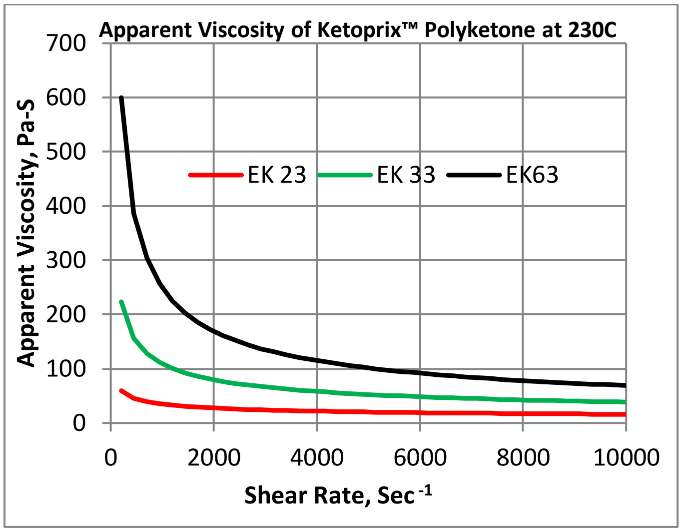
As nominal wall thickness decreases while flow lengths and design complexity increase, production costs are increasingly correlated with the rheological characteristics of the resin used to produce these parts. This is simply because it becomes increasingly difficult to produce these parts with many resins. However, with standard grades available which exhibit Melt Flow Index values as high as 200 g/10 minutes, Ketoprix™ polyketone resins offer a cost effective solution to this challenge.

Table 1. Standard Ketoprix™ Grades Melt Flow Index Values

| Ketoprix™ Grade | MFI, g/10 minutes, 240C,2.16kg | Viscosity, @240C, Pa-S |
|---|---|---|
| **EK93** | 200 | 65 |
| **EK33** | 60 | 220 |
| **EK63** | 6 | 2200 |
| **EK73** | 3 | - |

Although the Melt Flow Index value is a useful screening tool which is widely used in the plastics industry, it is well known that to understand how a material will behave in the molding process it is helpful to consult an apparent viscosity plot for the material. The reason for this is that the MFI value is generated at a single low shear rate while the injection molding process typically involves much higher shear rates. Due to their non-Newtonian nature, all thermoplastics exhibit a behavior known as shear thinning which is to say that a resins' resistance to flow is dependent upon the shear rate to which it is subjected. More specifically, the higher the shear rate the lower any given resin's apparent viscosity will be. Note however, that the magnitude of this shift in viscosity is not the same for all resins. Therefore, it is helpful to understand how the material behaves over a range of shear rates. Apparent viscosity as a function of shear rate is provided for these grades in Figure 1 below.

Figure 1. Apparent Viscosity of 3 Grades of Ketoprix™ Polyketone resins




As is shown here the apparent viscosity of all of these grades of Ketoprix™ is quite low (<200 Pa-s) at shear rates typical of the injection molding process and even the more viscous extrusion grade (EK63) at low shear rates exhibits an apparent viscosity which is only about 600 Pa-s at low shear and less than 200 Pa-s at high shear rates. One practical benefit from this characteristic for OEMs is that it is feasible to mold parts with longer flow lengths for any given wall thickness using Ketoprix ™ polyketone resins than it is with many other resins. The ratio of maximum flow length to optimum wall thickness will vary from one grade of a particular type of resin to another; however, Table 2 provides the general guidelines for several common thermoplastic resin families and Ketoprix™ polyketone resin. ABS and PE are included here for reference purposes.

Table 2. Ratio of flow length to optimum wall thickness for several resins

| Resin | Flow Length: Wall Thickness Ratio |
|---|---|
| Nylon 6,6 | 175:1 |
| Nylon 6/12 | 100:1 |
| Acetal | 140:1 |
| ABS | 150:1 |
| Polycarbonate | 100:1 |
| Polyethylene | 250:1 |
| Polyketone | 400:1 |

In addition to making it feasible to produce parts with high flow length to wall thickness ratios, this characteristic also makes it feasible to produce parts with greater detail density than is feasible with many other materials. This is particularly beneficial in micro molding applications.

This material characteristic also means that the minimum clamp tonnage required to injection mold Ketoprix ™ polyketone is lower than is the case with many other resins. Since molding machine costs are typically proportionate to the clamp capacity of the molding machine required to mold any given part, this translates to reduced processing costs per part. Molding machine rates vary widely for a number of reasons and it's not our intent to suggest that these rates correspond to any particular size molding machine in any particular market. However, for example if the size press required to mold a particular part in type 6,6 nylon or acetal costs $100/hr and this trait permits reducing machine size to a press for which the cost is $80/hr, then this equates to a 20% reduction in machine costs per part! Savings would likely be even more in larger molding machines.

In addition to offering a means to reduce part costs through material utilization and reduced molding machine size, the inherent characteristics of Ketoprix™ resins offer another significant means of reducing part costs through cycle time reduction.

There are many variables which affect the rate at which an injection molded part will cool and thus how much cooling time is required for any given part. However, the rapid crystallization rate of Ketoprix™ resins combined with its relatively low specific heat value results in a material which requires significantly less cooling time than do many competitive materials. Since cooling time is typically the largest portion of the overall cycle time required to produce an injection molded part, this can result in a significant reduction in the total cycle time. As compared to type 66 and type 6 nylon, cycle time reductions of 25% are common with reductions of as much as 40% in some instances. Reductions in cooling time and thus cycle time can be even larger relative to type 6/12 nylon.

If the hourly rate for the molding machine required to produce a particular part is $100/hr., and the total cycle time is 45 seconds of which 30 is cooling time, this equates to a machine cost per part of $1.25 with 80 parts produced per hour. If cooling time (and in turn total cycle time) is reduced by 10 seconds using Ketoprix™ polyketone resin then if the same press (and hourly rate) are used, this equates to a machine cost of $0.98/part with approximately 103 parts produced per hour. This is a 27% reduction in machine cost per part as well as a corresponding 29% increase in productivity!

Now if we factor in the potential to reduce the size of molding machine required to produce the part as outlined previously and are able to utilize a smaller molding machine for which the hourly rate is $80 rather than $100/hr., the total cost reduction realized by virtue of the low melt viscosity and rapid crystallization of Ketoprix™ resins is approximately 38% - *before* taking into account the increased productivity arising from the use of Ketoprix™ resins! Note too that this does not take into account the material usage reduction which may be possible in some parts due to the high flow length to minimum wall thickness ratio achievable with Ketoprix™ resins.

Finally, there is one more way in which the characteristics of Ketoprix™ resins can reduce processing costs for your parts. Since the material is not subject to hydrolytic degradation due to moisture content in the resin when molten, these compounds can tolerate much higher levels of moisture when processed than can many other resins. Therefore little to no pre-drying of the resin is required before molding which of course translates into reduced handling and in turn processing costs while providing yet another increase in productivity. That said, if the material has been exposed to a humid environment for an extended period of time, it can be beneficial to dry the material for 2 hours at 60C to improve process stability.

To summarize then, Ketoprix™ polyketone resins offer the OEM and molding communities an opportunity to reduce costs in multiple ways:

- Potential reduction of material usage
- Reduced clamp tonnage requirements
- Reduced cooling/cycle times
- Increased productivity
- Eliminated or reduced drying requirements

When all of these benefits are taken into account it's easy to see how specifying Ketoprix™ polyketone resins can increase your productivity and create significant savings!

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Want to know more about Ketoprix™ polyketone resins? Have an application with which you need some assistance? Please visit our website at www.esprixtech.com for product information or contact Mr. Dang Le at dle@esprixtech.com or 281-969-8763.